

## **Name of Work**

**Construction of Major Bridge on Damanganga River at Aslona Bilona Mohapada Near Davleshwar Mahadev Temple**

### **Item No. 1**

**Clearing and grubbing road land including uprooting rank vegetation grass bushes, shrubs, sapling and trees girth up to 300 mm removal of stumps of trees cut earlier and disposal of unserviceable materials(D) By mechanical means in area of thorny jungle**

**MORTH V<sup>th</sup> REVISION CI. No. 201, Pg. no. 37**

## **201.1 Scope**

This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, rubbish, top organic soil, etc. to an average depth of 150 mm in thickness, 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 with all leads and lifts. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

## **201.2 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 cost, 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 306. 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 306.3.

## **201.3. Methods, Tools and Equipment**

Only such methods, tools and equipment as are approved by the Engineer and which will not affect any 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 bottom of the subgrade. Also, all vegetation such as roots,

under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/subgrade shall be removed between fill lines to the satisfaction of the Engineer. 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. Ant-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,

#### **201.4 Disposal of Materials**

All materials arising from clearing and grubbing operations shall be taken over and shall be disposed of by the Contractor at suitable disposal sites with all leads and lifts. The disposal shall be in accordance with local, State and Central regulations

#### **201.5 Measurements for Payment**

Clearing and grubbing for road embankment, drains and cross-drainage structures shall be measured on area basis in terms of **hectares**. Cutting of trees upto 300 mm in girth and removal of their stumps, including removal of stumps upto 300 mm in girth left over after trees have been cut by any other agency, and trimming of branches of trees extending above the roadway and backfilling to the required compaction shall be considered incidental to the clearing and grubbing operations. Clearing and grubbing of borrow areas shall be deemed to be a part of works preparatory to 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.

Ground levels shall be taken prior to and after clearing and grubbing. Levels taken prior to clearing and grubbing shall be the base level and will be accordingly used for assessing the depth of clearing and grubbing and computation of quantity of any unsuitable material which is required to be removed. The levels taken subsequent to clearing and grubbing shall be the base level for computation of earthwork for embankment.

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

1. Above 300 mm to 600 mm
2. Above 600 mm to 900 mm
3. Above 900 mm to 1800 mm
4. Above 1800 mm

Removal of stumps and roots including backfilling with suitable material to required compaction shall be a separate item and shall be measured in terms of number according to the sizes given below:-

1. Above 300 mm to 600 mm
2. Above 600 mm to 900 mm
3. Above 900 mm to 1800 mm
4. Above 1800 mm

For the purpose of cutting of trees and removal of roots and stumps, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than one meter from the ground.

## **201.6 Rates**

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 girth excavation and back-filling to required density, where necessary, and handling, giving credit towards salvage value disposing of the cleared Materials with all lifts and leads. Clearing and grubbing done in excess of 150 mm by the Contractor shall be made good by the Contractor at his own cost as per Clause 301.3.3 to the satisfaction of the Engineer prior to taking up earthwork. Where clearing and grubbing is to be done to a level beyond 150 mm, due to site considerations, as directed by the Engineer, the extra quantity shall be measured and paid separately. The Contract unit rate for cutting trees of girth above 300 mm shall include handling, giving credit towards salvage value disposing of the cleared materials with all lifts and leads.

The Contract unit rate for removal of stumps and roots of trees girth above 300 mm shall include excavation and backfilling with suitable material to required compaction, handling, giving credit towards salvage value disposing of the cleared materials with all lifts and leads,

The Contract unit rate is deemed to include credit towards value of usable materials, salvage value of unusable materials and off-set price of cut trees and stumps belonging to the Forest Department. The off-set price of cut trees and stumps belonging to the Forest Department shall be deducted from the amount due to the Contractor and deposited with the State Forest Department. In case the cut trees and stumps are required to be deposited with the Forest Department the Contractor shall do so and no deduction towards the off-set price shall be effected. The offset price shall be as per guidelines / estimates of the State Forest Department.

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.

### **Item No. 2**

**Marking out the center line of the Bridge and various other component structures and complete lining out and leveling with theodolite, levels, including constructing necessary masonry pillars**

**for lines and levels and establishing necessary bench marks etc. complete as directed.**  
**MORTH V<sup>th</sup> REVISION: Cl. No. 109 Pg. no. 30**

## **109 Setting Out**

**109.1** The Contractor shall establish working bench marks tied with the Reference bench mark in the area soon after taking possession of the site. The Reference bench mark for the area shall be as indicated in the Contract Documents and the values of the same shall be obtained by the Contractor from the Engineer. The working bench marks shall be at the rate of four per km and also at or near all drainage structures, over-bridges and underpasses. The working bench marks/levels should be got approved from the Engineer. Checks must be made on these bench marks once every month and adjustments, if any, got approved from the Engineer and recorded. An up-to-date record of all bench marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Engineer for his record.

**109.2** The lines and levels of formation, side slopes, drainage works, carriageways and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained everywhere.

**109.3** In order to facilitate the setting out of the works, the centre line of the carriageway or highway must be accurately established by the Contractor and approved by the Engineer. It must then be accurately referenced in a manner satisfactory to the Engineer, at every 50 m intervals in plain and rolling terrains and 20 m intervals in hilly terrain and in all curve points as directed by the Engineer, with marker pegs and chainage boards set in or near the fence line, and a schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer. These markers shall be maintained until the works reach finished formation level and are accepted by the Engineer.

**109.4** On construction reaching the formation level stage, the centre line shall again be set out by the Contractor and when approved by the Engineer, shall be accurately referenced in a manner satisfactory to the Engineer by marker pegs set at the outer limits of the formation.

**109.5** No reference peg or marker shall be moved or withdrawn without the approval of the Engineer and no earthwork or structural work shall commence until the centre line has been referenced.

**109.6** The Contractor will be the sole responsible party for safe-guarding all survey monuments, bench marks, beacons, etc. The Engineer will provide the Contractor with the data necessary for setting out the centre line. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Engineer of any apparent errors or discrepancies in such dimensions and levels. The Contractor shall, in connection with the staking out of the centre line, survey the terrain along the road and shall submit to the

Engineer for his approval, a profile along the road centre line and cross-sections at intervals as required by the Engineer. The construction staking shall be done by personnel who are trained and experienced in construction layout and staking of the type and kind required in the Contract. Field notes shall be kept in standard, bound field notebooks as approved by the Engineer. Field notes shall be subject to inspection by the Engineer and shall be the property of the Employer. The Contractor shall correct any deficient staking or construction work which resulted from inaccuracies in the staking operations or from the Contractor's failure to report inaccuracies in the plans or survey data furnished by the Department.

**109.7** After obtaining approval of the Engineer, work on earthwork can commence. The profile and cross-sections as per Section 305, shall form the basis for measurements and payment. The Contractor shall be responsible for ensuring that all the basic traverse points are in place at the commencement of the contract and, if any, are missing, or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A "survey File" containing the necessary data will be made available for this purpose. If in the opinion of the Engineer, design modifications of the centre line or grade are advisable, the Engineer will issue detailed instructions to the Contractor and the Contractor shall perform the modifications in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required. There will be no separate payment for any survey work performed by the Contractor. The cost of these services shall be considered as being included in the rate of the items of work in the Bill of Quantities.

**109.8** Precision automatic levels, having a standard deviation of  $\pm 2$  mm per km, and fitted with micrometer attachment shall be used for all double run levelling work. Setting out of the road alignment and measurement of angles shall be done by using Total Station with traversing target, having an accuracy of one second. Measurement of distances shall be done preferably using precision instruments like Distomat. The work of setting out shall be deemed to be a part of general works preparatory to the execution of work and no separate payment shall be made for the same

The measurement and mode of payment shall be on the basis of the **Job**.

**Item No. 3**

**"Diversion of water course, providing cofferdam and bund or island as may be necessary for foundation and maintaining the same for the period as may be necessary.  
(V) Pier Nos., (F) Abutment Left (including returns/wing walls)"**

**MORTH V<sup>th</sup> REVISION: Cl. No. 2500, Pg. no. 703**

**2501 Description**

River training and protection work shall include construction of guide bunds, guide walls, spurs, groynes, bank protection, flooring, cut-off walls, apron and approach embankment protection, as required for ensuring safety of the bridge structure and its approaches against damage due to flood/flowing water. Construction of various components shall conform to IRC: 89 and these Specifications or as directed by the Engineer.

## **2502 Guide Bund**

**2502.1** This work shall consist of construction of embankment of guide bund and provision of pitching/revetment on slopes, apron and toe protection, etc., as indicated on the drawing, in accordance with these Specifications or as approved by the Engineer.

The provisions given hereunder are applicable only to guide bunds for bridges across alluvial rivers. Guide bunds for bridges across submontane rivers will require supplemental specifications.

**2502.2** The alignment and layout of guide bund shall be as indicated on the drawing or as approved by the Engineer. The construction of embankment for guide bund shall conform to provisions of Section 300 of these Specifications. Pitching, filter underneath pitching and turfing, apron, toe protection, curtain walls, etc., shall be as per these Specifications.

**2502.3** Guide bunds shall be made of locally available materials. Trial pits shall be Taken in borrow areas to examine suitability of soil for construction and also to decide the types of earth moving machinery to be used. No borrow pits should be dug on the river side of the guide bunds.

Construction of guide bund shall be taken in hand along with the construction of the bridge. Every effort shall be made to complete the work of the guide bund in one working season. Where this is not possible, suitable measures shall be planned and executed for protection of completed work. In such cases, the construction of guide bund shall be started from abutment towards upstream.

**2502.4** Construction of apron and pitching of the guide bunds shall conform to Clauses 2503 and 2504 of these Specifications. Sufficient area along the side of the guide bund shall be ready within one to two months of commencement or. Work, so that the placing of stones in the apron and in the slope pitching can be commenced. As a guideline, earth work should be completed within 80 percent of the working season. Also, about 70 percent of the working season shall be available for laying apron and pitching. No portion of the guide bund should be left incomplete below high flood level before the onset of the monsoon. Bottom of apron pit shall be as low as permitted by subsoil water/lowest water level. Sufficient labor and appropriate earth moving machinery and trained staff shall be deployed in construction so as to complete the work in the required time.

**2502.5** The Contractor shall furnish for approval of the Engineer, his methodology for transport of stones from the quarries to the site of work taking into account the quantities of stone required to be transported every day, type of transport to be used (train, truck, ferry, boats) and labour for loading, unloading and laying within the time frame for construction of guide

bund. Adequate reserve of stones should be maintained for major works as decided by the Engineer. Reserve stones shall be stacked away from the main channel of the river.

**2502.6** Where the alignment of guide bund or the approach embankment crosses branch channel of the river, the branch channel shall be either diverted to the main channel of the river with the help of spurs, etc. or closed by a properly designed closing dyke or closure bund, before taking up construction of guide bund.

## **2503 APRON**

### **2503.1 General**

This work shall consist of laying boulders directly or in wire crates on the bed of rivers for protection against scour.

The stones used in apron shall be sound, hard, durable and fairly regular in shape. Stones subject to marked deterioration by water or weather shall not be used.

Quarry stones having angular shapes shall be preferred to round boulders.

Where the stones of required size are not economically available, cement concrete blocks in minimum M15 grade conforming to Section 1700 of these Specifications or stones in wire crates shall be used.

### **2503.2 Boulder Apron**

The size of stone shall conform to Clause 5.3.7.2 of IRC: 89.

The size of stone shall be as large as possible and no stone shall weigh less than 40 kg. The specific gravity of stones shall be as high as possible and not less than 2.4.

To ensure regular and orderly disposition of the full intended quantity of stone in the apron, template cross walls in dry masonry shall be built about a metre thick and to the full height of the specified thickness of the apron, at intervals of 30 metres all along the length and width of the apron. Within these walls, the stone shall be hand packed.

The surface on which the apron is to be laid shall be levelled and prepared for the length and width, as shown on the drawings. In case the surface is below the low water level, the ground level may be raised upto low water level by dumping earth and the apron laid thereon. In such cases, the quantity of stone required in apron shall be re-worked by taking the toe of pitching at higher level.

### **2503.3 Wire Crates and Mattresses for Apron**

Wire Crates and Mattresses shall be any of two types mechanically woven and hand woven. River Training and Protection Work Section 2500

#### **2503.3.1 Mechanically Woven Crates (Gabions and Mattresses)**

##### **2503.3.1.1 Description**

Mechanically woven wire crates shall be made of hot dipped galvanized mild steel wire of diameter not less than 22 mm having minimum tensile strength 350 MPa conforming to IS:280. The galvanisation shall be heavy coating for soft condition conforming to IS:4826. For corrosive

environment, an additional PVC coating of 0.5 mm thickness shall be provided over the galvanisation, or zinc alloy coating as per EN 10244-2 shall be provided in place of galvanisation. The mesh of the crate shall be of type 10 x 12, 8 x 10, and 6 x 8 as per EN 10223. Mesh shall be given double twist at each intersection and shall be mechanically selvage all along the edges of the boxes. Wire crates standard sizes shall be as per ASTM A975. The wire crates shall be divided into compartments by diaphragms placed at 1 m centre to centre.

### 2503.3.1.2 Mesh and Box Characteristics

Mesh types and shapes shall be as given in Table 2500-1. The mesh and box characteristics of gabions and mattresses shall be as per Tables 2500-2 and 2500- 3 respectively.

**Table 2500-1 : Mesh Types and Sizes**

| Meshtype | 'd' nominal size, mm | tolerances    |
|----------|----------------------|---------------|
| 10 x 12  | 100                  | + 16% to – 4% |
| 8 x 10   | 80                   |               |
| 6 x 8    | 60                   |               |

**Table 2500-2 : Mesh & Box Characteristics For Gabions**

| Meshtype   | 10 x 12   |      |                                  | 8 x 10 |      |                                  |
|--|---|------|----------------------------------|--------|------|----------------------------------|
| 'D', mm  | 100   |      |                                  | 80     |      |                                  |
| Wire Type  | Only  | Zinc | Zinc + PVC                       | Only   | Zinc | Zinc + PVC                       |
| Mesh Wire Dia, mm                                    | 2.70  | 3.00 | 2.70/3.70*                       | 2.70   | 3.00 | 2.70/3.70*                       |
| Edge/Selvage wire Dia, mm                            | 3.40  | 3.90 | 3.40/4.40*                       | 3.40   | 3.90 | 3.40/4.40*                       |
| Lacing wire dia, mm                                  | 2.20  | 2.20 | 2.20/3.20*                       | 2.20   | 2.20 | 2.20/3.20*                       |
| PVC coating thickness,                               | N. A  |      | Nominal – 0.50<br>Minimum – 0.38 | N. A   |      | Nominal – 0.50<br>Minimum – 0.38 |
| Typical Sizes Length x Width x Height (m)/ Number of | 4 x 1 x 1 / 3 Nos, 3 x 1 x 1 / 2 Nos, 2 x 1 x 1 / 1 No, 1.5 x 1 x 1 / 0 No, 2 x 1 x 0.5 / 1 No , 3 x 1 x 0.5 / 2 Nos, 4 x 1 x 0.5 / 3 Nos, 2 x 1 x 0.3 / 1 No, 3 x 1 x 0.3 / 2 Nos, 4 x 1 x 0.3 / 3 Nos |      |                                  |        |      |                                  |
| Tolerances in Size of                                | Length & Width... +/- 5%: Height > 0.3m... +/- 5% and Height <= 0.3m... +/- 10%   |      |                                  |        |      |                                  |

**Table 2500-4 : Permitted Tolerances On Galvanized Steel Wire Diameters**

| nominal diameter of Galvanized Wire, mm | Permitted tolerances (+/-) on Wire diameters, mm |
|---|--|
| 2.00                                    | 0.05   |
| 2.20                                    | 0.06   |
| 2.40                                    | 0.06   |
| 2.70                                    | 0.07   |
| 3.00                                    | 0.08   |
| 3.40                                    | 0.09   |
| 3.90                                    | 0.10   |



The diameter of galvanized steel wire shall conform to the values as per Table 2500-2 for Gabions and Table 2500-3 for Revet mattresses. The diameter of the wires shall also conform to the tolerance limits plus and minus the values as shown in Table 2500-4.

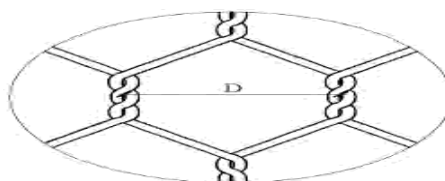
**Table 2500-4 Permitted Tolerances on Galvanized Steel Wire Diameters**

| <b>nominal diameter of Galvanized Wire, mm</b> | <b>Permitted tolerances (+/-) on Wire diameters, mm</b> |
|--|---|
| 2.00   | 0.05  |
| 2.20   | 0.06  |
| 2.40   | 0.06  |
| 2.70   | 0.07  |
| 3.00   | 0.08  |
| 3.40   | 0.09  |
| 3.90   | 0.10  |

Note :

1. The minimum and nominal thickness of PVC coating uniformly applied in a quality workmanlike manner shall be as shown in Tables 2500-2 and 2500-3.
2. Gabions shall be manufactured with a 10 x 12 or 8 x 10 mesh type (Fig. 2500-1) having a nominal mesh opening size as per Table 2500-2. Dimensions are measured at right angles to the center axis of the opening and parallel to the twist along the same axis.
3. Revet mattresses shall be manufactured with a 6 x 8 mesh type (Fig. 2500-1) having a nominal mesh opening size as per Table 2500-2. Dimensions are measured at right angles to the center axis of the opening and parallel to the twist along the same axis.
4. The width and length of the gabions and revet mattresses as manufactured shall not differ more than +/- 5% from the ordered size prior to filling. Typical gabion and revet mattress sizes are shown in Tables 2500-2 and 2500-3 respectively.
5. The height of the gabions and revet mattresses as manufactured shall not differ more than +/- 10% if the height is less than or equal to 0.3 m and shall not differ more than +/- 5% if the height is more than 0.3 m from the ordered size prior to filling.
6. Mesh Opening Tolerances — Tolerances on the hexagonal, double-twisted wire mesh opening shall not exceed +16% to —4% on the nominal dimension D values mentioned in Table 2500-1.

Fig 2500-1 : Mesh Type & Nominal Size 'D'



**503.3.1.4** Terminology, mechanical properties, physical properties, number of tests and test methods related to mechanically woven wire crates shall be as per Appendix-2500/I.

### **2503.3.2 Hand Woven Wire Crates**

Wire crates shall be made from hot dipped galvanized mild steel wire of diameter not less than 4 mm in annealed condition having tensile strength of 300 MPa-450 MPa conforming to IS:280. The galvanizing shall be heavy coating for soft condition conforming to IS:4826.

The mesh size of the crate shall not be more than 150 mm.

Wire crates for shallow or accessible situations shall be 3 m x 1.5 m x 1.25 m in size. Where these have to be deposited and there is a possibility of overturning, the crate shall be divided into 1.5 m compartments by cross netting

For deep or inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer.

Wire crates built shall not be larger than 7.5 mx3mx 0.6 m, nor smaller than

2mx1 mx 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1.50 m to prevent bulging.

The netting shall be made by fixing a row of spikes on a beam at a spacing equal to the mesh. The beam must be a little longer than the width of netting required. The wire is to be cut to lengths about three times the length of the net required. Each piece shall be bent at the middle around one of the spikes and the weaving commenced from the corner.

8, double twist shall be given at each intersection. The twisting shall be carefully done by means of a strong iron bar, five and half turns being given to the bar at each splice,

the bottom and two ends of the crate or mattress shall be made at one time. The other two sides shall be made separately and shall be secured to the bottom and the ends by twisting adjacent wires together. The top shall be made separately and shall be fixed in the same manner as the sides after the crates or mattress have been filled.

### **503.3.3 Laying of Wire Crates**

wherever possible, crates shall be placed in position before filling with boulders. Undulations the bed shall be levelled prior to placement of wire crate units. The crates shall be filled by carefully hand-packing the boulders as tightly as possible and not by merely throwing in the stones or boulders. Where the crates are to be laid on the sides and bed of the stream in underwater conditions, they shall be prefilled on dry area, lifted by cranes using suitable size frames with lifting slings every 0.5 m to 1 m maximum spacing and placed at designated locations. Sacrificial steel of diameter 20 mm to 25 mm may also be used, in place of frame, by tying them to the slings and lifting directly with closely spaced slings. Once placed, divers shall lace the crates together at all contact surfaces. For sides of the banks a tilting platform, pantoon or barge may be used where mattresses are filled with stones on the level platform, resting at one end the bank and has the other edge hinged to the pantoon/barge. One end of the filled wire is anchored to the dry edge of the slope and then the pantoon/barge is moved River Training and Protection Work from the bank, thus lowering and sliding out the tilted platform under the crate gradually placing the crate on the slopes while the tilted platform rotates around its hinges.

## **2504 PITCHING/REVTMENT ON SLOPES**

### **2504.1 Description**

The work shall consist of covering the river side slopes of guide bunds, training works and road embankments with stone, boulders, cement concrete blocks or stones in wire crates over a layer of granular material which will act as a filter. The rear slopes, not subjected to direct attack of the river, may be protected by 300 mm - 600 mm thick cover of clayey or silty earth and turfing.

### **2504.2 Pitching and Filter Medium**

#### **2504.2.1 Pitching**

The pitching shall be provided with stones of thickness and shape as indicated on the drawings.

The stones shall be obtained from quarries and shall be sound, hard, durable and fairly regular in shape. Round boulders shall not be allowed. Stones showing marked deterioration by water or weather shall not be accepted.

The size and weight of stone shall conform to Clause 5.3.5.1 of IRC: 89. No stone, shall weigh less than 40 kg. The size of spalls shall be a minimum of 25 mm and shall be suitable to fill the voids in the pitching.

Where the stones of required size are not economically available, cement concrete blocks in minimum M15 grade concrete conforming to Section 1700 of these Specifications or stones in wire crates, shall be used.

Geosynthetics, if used in pitching, shall conform to Section 700 of these Specifications.

#### **2504.2.2 Filter Medium**

The material for the filter shall consist of coarse sand, gravel or stone. One or more layers of graded materials, to act as a filter medium, shall be provided underneath the pitching, to prevent loss of the embankment material and build up of uplift head on the pitching.

Notes :

Filter design may not be required if embankment consists of CH or CL soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its D 85 size shall be at least twice the maximum void size in pitching in the foregoing, D 15 means the size of that sieve which allows 15 percent by weight of the filter material to pass through it and similar is the meaning of D 50 and D 85 (15 being replaced with 50 and 85 respectively).

If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as base material for selection of coarser filter.

The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.

### **2504.3 Construction Operations**

Before laying the pitching, the side of banks shall be trimmed to the required slope and profiles by means of lines and pegs at intervals of 3 m. Depressions shall be filled and thoroughly compacted.

The filter granular material shall be laid over the prepared base and compacted to the thickness specified on the drawings by means of suitable equipment.

The lowest course of pitching shall be started from the toe wall and built up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 1405.3, of these Specifications in case of dry rubble pitching. It shall be in nominal mix cement concrete (M 15) conforming to Clause 1704.3, of these Specifications in case of cement concrete block pitching.

The stone pitching shall commence in a trench below the toe of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the drawings. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching.

The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

In hand placed pitching, the stone of flat stratified nature should be placed with the principal bedding plane normal to the slope. The pattern of laying shall be such that the joints are broken and voids are minimum by packing with spalls, wherever necessary, and the top surface is as smooth as possible.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spalls of the proper size wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals all along the length and width of the pitching. Within these walls the stones shall be hand packed as specified.

#### **2504.4 Toe Protection**

A toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to prevent the slope pitching from sliding down. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Section 1400 of these Specifications or in cement concrete of M15 grade. The pitching/revetment shall be of stones in wire crates or cement concrete blocks in M15 grade. For protection of ties of bank slopes terminating either in short aprons at bed levels or anchored in flooring/rocky bed, the provision of Clause 8.2.2 of IRC:89 may be complied with.

#### **2505 Rubble Stone/Cement Concrete Block Flooring Over**

Cement Concrete Bedding

**25051** The work shall consist of constructing rubble stone/cement concrete block flooring laid over a bedding of cement concrete (M15).

#### **2505.2 Construction Operations**

Excavations for laying the bedding and floor protection works shall be carried out as per specifications under proper supervision. Before laying the foundation and protection walls, the excavated trenches shall be inspected by the Engineer to ensure that:

There are no loose pockets and unfilled depressions left in the trench.

The soil at the founding level is properly compacted to true lines and level So as to have an even bedding.

All concrete and other elements are laid in dry bed.

Bedding of cement concrete nominal mix (grade M15) of 300 mm thickness shall then be laid in accordance with Section 1700 of these Specifications except that the surface of the concrete shall not be given a smooth finish.

Flooring shall consist of 150 mm thick flat stone/cement concrete block M15 grade conforming to Section 1700 of these Specifications. It shall be bedded on a layer of cement mortar (1:3) prepared to Section 1300 of these Specifications. Spalls shall be used to fill in the voids. The joints shall be filled with cement mortar and finished neat. The stone shall break joints and the thickness of joints shall not exceed 20 mm. The top of flooring shall be kept 300 mm below the lowest bed level.

### **2506 DRY RUBBLE FLOORING**

Dry rubble flooring shall be provided for relatively less important works such as cross drainage structures.

The base for the flooring shall be prepared to the specified levels and slopes and compacted suitably with hand rammers or other means to have even bedding.

The stones shall be laid closely on the prepared base in one or more layers with appropriate bond as specified by the Engineer.

### **2507 CURTAIN WALL AND FLEXIBLE APRON**

#### **2507.1 Curtain Wall**

The rigid flooring shall be enclosed by curtain walls (tied to the wing walls) with minimum depth below floor level of 2 m on upstream side and 2.5 m on downstream side. The curtain wall shall be in cement concrete M15 grade or stone masonry in cement mortar 1:3.

#### **2507.2 Flexible Apron**

A flexible apron 1 m thick comprising loose stone boulders (weighing not less than 40 kg) shall be provided beyond curtain walls for a minimum distance of 3 m on upstream side and 6 m

### **2508 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.

### **2509 Measurements For Payment**

The earth work in construction of embankment for guide bund shall be measured in cubic metres unless otherwise specified.

The boulders/cement concrete block and boulder/block filled wire crates in apron shall be measured in cubic metres.

The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.

Rubble stone/cement concrete block flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

Preparation of base for laying the flooring shall be deemed incidental to the work,

For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as per Section 300 of these Specifications.

If directed by the Engineer, the materials shall have to be stacked at site before laying and such stacking shall be considered incidental to the work.

### **2510 RATE**

The contract unit rate for the construction of embankment for guide bund shall cover the cost of all materials including transportation, laying, compacting, all labour, tools, equipment, sampling and testing, supervision and all incidentals necessary for completing the work according to these Specifications.

The contract unit rate for apron shall include the cost of all material, labour, tools and plant for completing the work according to these Specifications. Excavation up to an average depth of 150 mm shall also be deemed to be included in the rate as dressing of the bed. Excavation beyond the depth of 150 mm shall be paid for separately unless otherwise specified.

The contract unit rate for stone/cement concrete block pitching on slopes shall include the cost of preparing the bases, laying and compacting the filter and placing of stone pitching of dry rubble/cement concrete block revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour and materials as well as tools and plant required for the work.

The contract unit rate for rubble stone/cement concrete block flooring shall include the cost of all material, labour and tools and plant for completing the work as per specifications for the relevant item.

The measurement and mode of payment shall be on **numbers basis**.

**Item No. 4**

"Carry out Geo-technical investigation work including exploratory drilling of 150mm dia bore holes in all sorts of soil, ordinary rock and hard rock, upto maximum depth as mentioned, collecting undisturbed samples and conducting standard penetration tests alternate at an interval of 1.5m.depth, conducting necessary laboratory tests for all type of classification and determination of soil parameters like density, shear and consolidation parameters if required, including submission of report in three copies covering investigation data and recommendation for SBC and the pile capacity considering the design criteria, all as per specification. Including of submitting soil investigation report in three sets in hard copy as well soft copies and all materials with contractor's labour, tools & plants, machineries, as required, The Geotech bore locations shall be provided by consultant, The rate is including of all taxes.

• For Water Portion"

**Item No. 5**

"Carry out Geo-technical investigation work including exploratory drilling of 150mm dia bore holes in all sorts of soil, ordinary rock and hard rock, upto maximum depth as mentioned, collecting undisturbed samples and conducting standard penetration tests alternate at an interval of 1.5m.depth, conducting necessary laboratory tests for all type of classification and determination of soil parameters like density, shear and consolidation parameters if required, including submission of report in three copies covering investigation data and recommendation for SBC and the pile capacity considering the design criteria, all as per specification. Including of submitting soil investigation report in three sets in hard copy as well soft copies and all materials with contractor's labour, tools & plants, machineries, as required, The Geotech bore locations shall be provided by consultant, The rate is including of all taxes.

• For Land Portion"

1.Relevant Specifications of MORT&H fifth revision Section – 1102 & 2400 shall apply to this item.

2.The measurement shall be in Rmt. basis.

3.The rate includes of submitting soil investigation report in three sets in hard copy as well soft copies.

4.The rate is inclusive of all materials with contractor's labour, tools & plants, machineries, as required. The rate is inclusive of all taxes including services tax..

The mode of payment shall be in per **Rmt.** basis.

**Item No. 6**

**Providing flood gauge marks on substructure as per design including painting complete.**

**2808 Protective Surface Coating Of Concrete By Acrylic Elastomeric Coating**

**2808.1** The acrylic elastomeric coating shall be water based (solvent free), modified with selected mineral fillers applied over the prepared surface. The coating should have anti-carbonation and water vapor diffusion property and should be resistant to action of ultra violet (UV) radiation. It should be waterproof and capable of bridging crazings and cracks. The shelf life for such coatings shall not be more than 6 months.

**2808.2** It is necessary that the system should be capable of protecting the surfaces

of pre-stressed and reinforced concrete members from all deleterious elements such as chlorides and sulphates. The protective treatment should allow excess water vapour in the concrete to evaporate out (breathing) without rupturing itself due to vapour pressure. The protective system itself should not deteriorate from exposure to UV rays and weathering.

The acrylic elastomeric coating system shall satisfy the requirements given in Table 2800-2.

Table 2800-2: Properties of Acrylic Elastomeric Coating

| Sl.No. | Parameter   | Requirement                                  | Reference                 |
|--------|---|--|---------------------------|
| 1)     | Specific Gravity  | 1.4±0.05                                     | IS:345                    |
| 2)     | Solid contents  | 70±3%  | IS:345                    |
| 3)     | UV resistance   | No colour change                             | ASTM-G-53/DIN-EN- 150-105 |
| 4)     | IR-Spectrum   | As per Acrylic Polymer                       | IR-Spectrometer standards |
| 5)     | Adhesion with concrete                                  | 1.5 N/m <sup>2</sup>                         | ASTM-D-4541-02/ DIN500014 |
| 6)     | Dry film thickness                                      | 200-225 Microns (for minimum 2 coats)        |                           |
| 7)     | Coverage  | 400-450 gm /m <sup>2</sup> (2 Coats)         |                           |
| 8)     | Physical properties Diffusion resistance against carbon | Equivalent air layer thickness S CO shall be | DIN 53122 Part –I         |



|     |   |   |           |
|-----|---|---|-----------|
|     | dioxide                                   | D 2<br>>50 m  |           |
| 9)  | Diffusion resistance against water vapour | Equivalent air thickness<br>S H 0 <4 m<br>D 2   | DIN 52615 |
| 10) | Water proofing characteristics            | Percentage reduction in flux should be >50%   |           |
| 11) | Re-coatability                            | Min. 2h to 72 h or as per manufactures specification with the approval of the Engineer in charge. |           |

### 2808.3 Quality Assurance

The Acrylic elastomeric material should be tested in GUI accredited laboratories where such laboratories are available, otherwise in other standard laboratories where similar facilities exist for properties specified above. Random samples during execution shall be taken from consignments brought to site to verify that the test results match with the earlier certificates produced before approval of the product. Both the test results (prior to approval and during execution), shall conform to the requirements as per Table 2800-1, failing which the consignment shall be rejected. It shall be made mandatory that the stock register for the materials are maintained at site and signed by the Engineer periodically.

### 2808.4 Surface Preparation

The work shall commence after carrying out any repair to the concrete surface as directed by the Engineer. The concrete surface shall be free from all adhesion inhibiting substances such as oil, grease release agents as well as laitance and dust. The surface shall be cleaned by wire brushing, mechanical scraping and any loose material shall be removed by chiselling with small hammer and washed with clean water. The substrata shall be structurally sound for effective bond of the acrylic polymer with the concrete surface. All pin holes shall be filled with non-shrink polymer modified fine repair mortar

### 2808.5 Application

After preparing the surface and filling the pin holes, primer coat (75-100 gm/sq.m.) shall be applied with brush/lambskin roller/spray gun and shall be cured for 60 minutes or as specified by the manufacturer.

Subsequently, 1st and 2nd coats of polymer coating shall be applied with brush/spray gun/roller keeping the time between coats not less than 2 h and not more than 72 h. Consumption per coat shall be 200-225 gm/m<sup>2</sup>. The total dry film thickness of the protective coating for all coats shall be in the range of 200-225 microns. The wet film thickness shall be measured at a number of selected locations at the time of application with painting gauges. For measuring the dry film thickness, suitably located painting gauge shall be used. At least one gauge shall be located on each face of superstructure in each span but not less than one gauge/100 sqm. For the given solid content in the application, the dry film thickness to wet film thickness ratio should be established by prior testing in the laboratory using appropriate panels like glass plates, flat concrete, steel plates (300 x 300 mm) with similar coatings. Alternatively, the dry film thickness may be calculated from the measured wet film thickness by multiplying with the solid contents per unit volume.

#### **2808.6 Performance Guarantee**

This type of protective coating shall be executed only through authorized technical applicators of standard manufactures who have requisite work experience for having carried out similar type coating works. The Engineer shall take performance guarantee from the agency responsible for the execution of the work for a minimum period of 5 years.

#### **2814 Measurements For Payment**

The mode of payment shall be in per **Rmt.** basis.

#### **2815 Rate**

The contract unit rate for application of epoxy mortar/protective surface coating for specified thickness shall include cost of all materials, labour, tools and plant, placing in position, testing and other incidental expenses including surface preparation for the satisfactory completion of the work as per these Specifications and as shown on the drawings.

**Item No. 7**

**Excavation in large boulders and soft rock by welding including shoring, strutting and dewatering as necessary and disposing of the excavated stuff as directed.**

**Item No. 8**

**Excavation in hard rock by dry-wet blasting and chiselling including dewatering preparing foundation base by proper benching and stepping and disposing of the excavated stuff as directed.(A) General blasting**

**MORTH V<sup>th</sup> REVISION Cl. No. 301, Pg. no. 45**

**301      Excavation For Roadway And Drains****301.1      Scope**

This work shall consist of excavation, removal and disposal of 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, with all leads and lifts, reuse of cut materials as may be deemed fit, trimming and finishing of the road to specified dimensions or as directed by the Engineer.

**301.2      Classification of Excavated Material**

301.2.1    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 equipment. Removal of gravel or any other modular material having dimension in any one direction not exceeding 75 mm 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 sandstone 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 bound; soling of roads, cement concrete pavement, cobble stone, etc. compacted moorum or stabilized soil requiring use of pick axe or shovel or both.
- iii)    lime concrete, stone masonry and brick work in lime/cement

mortar below ground level, reinforced cement concrete which may be broken up with crow bars or picks and stone masonry in cement mortar below ground level; and

iv) boulders which do not require blasting 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 below ground level and in bridge/ ROB/RUB/flyover piers and abutments,

iii) boulders requiring blasting.

d) Hard Rock (using controlled blasting) :

Hard rock requiring blasting as described under (c) but where controlled blasting is to be carried out in locations where built-up area, huts, and are situated at within 200 m of the blast site.

e) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason like people living within 20 m of blast sites etc. and excavation has to be carried out by chiselling, wedging or any other agreed method.

f) 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.

### **301.2.2 Authority for Classification**

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.

## **301.3 Construction Operations**

### **301.3.1 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. Clause 109 shall be applicable for the setting out operations.

### **301.3.2 Stripping and Storing Topsoil**

When so directed by the Engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired in accordance with Clause 305.3.3. Prior to stripping the topsoil, all trees, shrubs etc. shall be removed along with their roots, with approval of the Engineer.

### **301.3.3 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 deemed fit or as approved by the Engineer.

While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc. as per Clause 306, and take appropriate drainage measures to keep the site free of water in accordance with Clause 311.

The excavations 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 305.

All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required 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 appropriate manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimize erosion and ponding, allowing for natural drainage to take place.

### **301.3.4 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.

### **301.3.5 Rock Excavation**

Rock, when encountered in road excavation, shall be removed up to the formation level or as otherwise indicated in 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 on cut formations the rock protrudes above the specified levels. Rocks and boulders which are likely to cause differential settlement and also local drainage problems shall be removed to the extent of 500 mm below the formation level in the formation width including side drains.

Where excavation is done to levels lower than those specified, the excess excavation shall be made good as per Clauses 301.3.3 and 301.6 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 302 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 as per Clause 303.

### **301.3.6 Marsh excavation**

The excavation of soil 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 with materials like boulders, sand moorum, bricks bats, dismantled concrete as approved by the Engineer. 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 indicated on the drawings or as staked by the Engineer.

### **301.3.7 Excavation of Road Shoulders/Verge/Median for Widening of Pavement or Providing Treated Shoulders**

In the works involving widening of existing pavements or providing paved shoulders, the existing shoulders/verge/median shall be removed to its full width and upto top of the subgrade. The subgrade material within 500 mm from the bottom of the pavement for the widened portion or paved shoulders shall be loosened and recompacted as per Clause 305. Any unsuitable material found in this portion shall be removed and replaced with the suitable material. 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.

### **301.3.8 Excavation for Surface/Sub-surface Drains**

Where the Contract provides for construction of surface/sub-surface drains, the same shall be done as per Clause 309. Excavation for these drains shall be carried out in proper sequence with other works as approved by the Engineer.

### **301.3.9 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.

#### **301.3.10 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.

#### **301.3.11 Use and Disposal of Excavated Materials**

All the excavated materials shall either be reused with the approval of the Engineer or disposed off with all loads and lifts as directed by the Engineer.

#### **301.3.12 Backfilling**

Backfilling of masonry/concrete hume pipe or drain excavation shall be done with approved material with all loads and lifts 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 backfilled to the original surface making due allowance for settlement, in layers not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as trench compactor, mechanical tamper, rammer or plate compactor as directed by the Engineer.

#### **301.4 Plying of Construction Traffic**

Construction traffic shall not use the cut formation and finished subgrade without the prior permission of the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own cost.

#### **301.5 Preservation Of Property**

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers, 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 cost. 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 prior notice to the effect.

### **301.6 Preparation of Cut Formation**

The cut formation, which serves as a sub-grade, shall be prepared to receive the sub-base/base course as directed by the Engineer.

Where the material in the subgrade has a density less than specified in Table 300-1, the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 305 adding fresh material, if any required, to maintain the formation level as shown on the drawings. Any unsuitable material encountered in the subgrade level shall be removed as directed by the Engineer, replaced with suitable material and 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 301.3.11. After satisfying the density requirements, the cut formation shall be prepared to receive the sub-base/base course in accordance with Clauses 310 and 311.

### **301.7 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 (ordinary or hard) 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 902. Where directed, the topsoil removed and conserved (Clauses 301.3.2 and 305.3.3) shall be spread over cut slopes, shoulders 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.

### **301.8 Measurements for payment**

Excavation for roadway shall be measured by taking cross-sections at suitable intervals before the excavation starts (after clearing and grubbing/stripping etc. as the case may be) 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 indicators 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-sections 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 measurement of stacks of excavated rubble allowing a deduction of 35% therefrom. When volume is calculated on the basis of measurement of stacks of the excavated material other than rock, a deduction of 16% of stacked volume shall be allowed.

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 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 |

### **301.9 Rates**

301.9.1 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 for use or disposal with all leads and lifts by giving suitable credit towards the cost of re-usable material and salvage value of unusable material;
- iii) trimming bottoms and slopes of excavation;
- iv) dewatering;
- v) keeping the work free of water as per Clause 311;
- vi) arranging disposal sites; and
- vii) all labour, materials, tools, equipment., safety measures, testing and incidentals necessary to complete the work to Specifications.

Where presplitting of rock is prescribed it shall be governed by Clause 303.5.

301.9.2 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.

301.9.3 Clauses 301.9.1 and 305.8 shall apply as regards Contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

301.9.4 The Contract unit rate for item of preparing rocky sub-grade as per Clause 301.6 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.

301.9.5 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 and leads.

## **302 Blasting operations**

### **302.1 General**

Blasting shall be carried out in a manner that completes the excavation to the lines indicated in drawings, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer. All the statutory laws, regulations, rules, etc., pertaining to the acquisition, transportation, storage, handling and use of explosives shall be strictly followed by the contractor.

The Contractor may adopt any method or methods of blasting consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

The magazine for the storage of explosives shall be built to the designs and specifications of the Explosives Department concerned and located at the approved site. The storage places shall be clearly marked "DANGER-EXPLOSIVES". The Contractor shall be liable for property damage, injury or death resulting from the use of explosives. All permits shall be obtained by the Contractor. No unauthorized person shall be admitted into the magazine which, when not in use, shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine shall have an effective lightning conductor. The following shall be hung in the lobby of the magazine:

- a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar,
- b) A statement of up-to-date stock in the magazine,
- c) A certificate showing the last date of testing of the lightning conductor, and
- d) A notice that smoking is strictly prohibited.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be marked. Where no local laws or ordinances apply, storage shall be provided to the satisfaction of the Engineer and in general not closer than 300 m from the road or from any building or camping area or place of human occupancy. In addition to these, the Contractor shall also observe the following instructions and any further additional instructions which may be given by the Engineer and shall be responsible for damage to property and any accident which may occur to workmen or public on account of any operations connected with the storage, handling or use of explosives and blasting. The Engineer shall frequently check the Contractor's compliance with these precautions.

### **302.2 Materials, tools and equipment**

All the materials, tools and equipment used for blasting operations shall be of approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be sufficiently water-resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach safely before explosion takes place. Detonators shall be capable of giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed from the site immediately.

### **302.3 Personnel**

The blasting operation shall remain in the charge of competent and experienced supervisor and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations.

### **302.4 Blasting Operations**

The blasting shall be carried out during the pre-determined hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity.

The Contractor shall notify each public utility company having structures in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury. In advance of any blasting work within 50 m of any railway track or structures, the Contractor shall notify the concerned Railway Authority of the location, date, time and approximate duration of such blasting operation.

Red danger flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area and all persons including workmen shall be kept away from the flagged area, and all persons including workmen shall be removed from the flagged area at least 10 minutes before the firing. A warning siren shall be sounded for the above purpose.

Only controlled blasting shall be resorted to along with the safeguard above at locations where built-up area, huts and structures in use lie within 200 m. Similarly excavation of hard rock without blasting is mandatory where people live within 20 m of blast site.

The charge holes shall be drilled to required depths and at suitable places. Blasting should be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

When blasting is done with powder, the fuse cut to the required length shall be inserted into the hole and the powder dropped shall be gently tamped with copper rods with rounded ends. The explosive powder shall then be covered with tamping material which shall be tamped lightly but firmly.

When blasting is done with dynamite and other high explosives, dynamite cartridges shall be prepared by inserting the square cut end of a fuse into the detonator and finishing it with nippers at the open end, the detonator gently pushed into the primer leaving 1/3<sup>rd</sup> of the copper tube exposed outside. The paper of the cartridge shall then be closed up and securely bound with wire or twine. The primer shall be housed into the explosive. Boreholes shall be cleared of all debris and explosives inserted. The space of about 200 mm above the charge shall then be gently filled with dry clay, pressed home and the rest of the tamping formed of any convenient material gently packed with a wooden rammer.

At a time not more than 10 such charges will be prepared and fired. The man in charge shall blow a siren in a recognized manner for cautioning the people. All the people shall then be required to move to safe distances. The charges shall be lighted by the man-in-charge only. The man-in-charge shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operation, the Contractor shall compact the loose residual material below subgrade and replace the material removed below subgrade with suitable material.

### **302.5 Misfire**

In case of misfire, the following procedure shall be observed:

- (i) Sufficient time shall be allowed to account for the delayed blast. The man-in-charge shall inspect all the charges and determine the missed charge.
- (ii) If it is the blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. In case, it does not blast the old charge, the procedure shall be repeated till the old charge is blasted.
- (iii) In case of charges of gelignite, dynamite, etc., the man-in-charge shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 300 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the

misfired hole should explode at the same time. The man-in-charge shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

If a misfire has been found to be due to defective detonator or dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority directed by the Engineer for inspection to ascertain whether all the remaining materials in the box are also defective.

### **302.6 Account**

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times.

## **303 Presplitting Rock Excavation Slopes**

### **303.1 General**

Presplitting is defined as the establishment of a specified excavation slope in rock by the controlled use of explosives and blasting accessories in properly aligned and spaced drill holes.

The presplitting technique shall be used for forming rock excavation slopes at locations shown on the drawings or as otherwise decided by the Engineer.

### **303.2 Construction Operations**

Prior to starting drilling operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's method have produced an acceptable slope.

All overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the drilling limits, or to the end of the excavation, as decided by the Engineer shall be removed before drilling the presplitting holes. Particular care and attention shall be directed to the beginning and end of excavations to ensure complete removal of all overburden soil and weathered rock and to expose fresh rock to an elevation equal to the bottom of the adjacent lift of the presplitting holes being drilled.

Slope holes for presplitting shall be drilled along the line of the planned slope within the specified tolerances. The drill holes shall not be less than 60 mm nor more than 75 mm in diameter. Drilling operations shall be controlled by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-third of the planned horizontal spacing between holes.

The length of presplit holes for any individual lift shall not exceed 9 m.

The spacing of presplit holes shall not exceed 900 mm on centres and shall be adjusted to result in a uniform shear face between holes.

Auxiliary drill holes along the presplit line, not loaded or stemmed, may be ordered by the Engineer. Except for spacing, auxiliary drill holes shall conform to the provisions for presplit holes.

The line of production holes shall be placed inside the presplit lines in such a manner as to avoid damage to the presplit face.

If necessary, to reduce shatter and overbreak of the presplit surface, the first line of the production holes shall be drilled parallel to the slope line at the top of the cut and at each bench level thereafter.

Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

No portion of any production holes shall be drilled within 2.5 m of a presplit plane except as approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the presplit holes.

A maximum offset of 600 mm will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern. The drilling operations shall be adjusted to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane.

The maximum diameter of explosives used in presplit holes shall not be greater than one-half the diameter of the presplit hole.

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in presplit holes. These shall be fired as recommended by the manufacturer. Ammonium nitrate composition blasting agents will not be permitted in presplitting operations.

Stemming may be required to achieve a satisfactory presplit face. Stemming material shall be dry free-running material all of which passes 11.2 mm sieve and 90 percent of which is retained on 2.80 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

All charges in each presplitting pattern shall be detonated simultaneously.

### **303.3 Tolerances**

The presplit face shall not deviate more than 300 mm from the plane passing through adjacent drill holes, except where the character of the rock is such that, as determined by the Engineer, irregularities are unavoidable. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 300 mm. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the side drains.

As long as equally satisfactory presplit slopes are obtained, then either the slope face may be presplit before drilling for production blasting or presplitting the slope face and production blasting may be done at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit lines, which row shall be delayed at least 50 milliseconds. In either case the presplitting holes shall extend either to the end of the excavation or for a distance of not less than 15 m beyond the limits of the production holes to be detonated.

### **303.4 Measurements For Payment**

The area of presplitting to be paid for, will be measured as square metres of acceptable presplit slope surface.

### **303.5 Rates**

The Contract unit rate for presplitting work shall be payment in full for carrying out the required operations for obtaining acceptable presplit slope surfaces. The quantity of rock excavated through the production/presplit holes shall be paid for as per Clause 301.9.1.

## **304 Excavation For Structures**

### **304.1 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 obstruction, necessary for placing the foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

### **304.2 Classification of Excavation**

All materials involved in excavation shall be classified in accordance with Clause 301.2.

### **304.3 Construction Operations**

#### **304.3.1 Setting Out**

After the site has been cleared according to Clause 201, the limits of excavation shall be set out true to lines, curves and slopes to Clause 301.3.1.

#### **304.3.2 Excavation**

Excavation shall be taken to the width of the lowest step of the footing including additional width as required for construction operation. 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 at his own cost 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 302 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.

### 304.3.3 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 the 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 for the quality and safety of the works.

Where cofferdams are required, these shall be carried to 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 beforehand 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 and for a 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.



#### 304.3.4 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 as per Clause 2104.1 at the cost of the Contractor. Ordinary filling shall not be permitted to bring the foundation to the design level as shown in the drawing.

When rock or other hard strata is encountered, it shall be freed of all soft and loose material, cleaned and cut to a firm surface either level or 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 excavation in rock, annular space around footing shall be filled with lean concrete M 15 up to the top level of rock.

If the depth of fill required is more than 1.5 m in soft rock or 0.6 m in hard rock above the foundation level, the filling up to this level shall be done with M-15 concrete and portion above shall be filled by concrete or by boulders grouted with cement.

When foundation piles are used, the excavation for pile cap shall be done after driving/casting of all piles forming the group. After pile driving operations in a given pit are completed, all loose and displaced materials therein shall be removed to the level of the bottom of the pile cap.

#### 304.3.5 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.

#### 304.3.6 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.

#### 304.3.7 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 trench compactor, mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve the maximum dry density.

#### 304.3.8 Disposal Of Surplus Excavated Materials

Clause 301.3.11 shall apply.

### **304.4 Measurements For Payment**

Excavation for structures 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, production/support to the existing structures shoring, shuttering and planking shall be deemed as incidental to the main work and shall not be measured and paid separately.

Preparation of rock foundation shall be measured in square metres.

### **304.5 Rates**

304.5.1 The Contract unit rate for the items of excavation for structures shall be payment in full for carrying out the required operations including full compensation for:

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

304.5.2 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.

## **305 Embankment Construction**

### **305.1 General**

#### **305.1.1 Description**

These Specifications shall apply to the construction of embankments including sub-grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. All embankments sub-grades, earthen shoulders and miscellaneous backfills shall be constructed 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.

## **305.2 Materials And General Requirements**

### **305.2.1 Physical Requirements**

The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as 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.

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

- a) Materials from swamps, marshes and bogs;
- b) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS:1498;
- c) Materials susceptible to spontaneous combustion;
- d) Materials in a frozen condition;
- e) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; And
- f) Materials with salts resulting in leaching in the embankment.

305.2.1.2 Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 percent when tested as per IS:2720 – Part 40) shall not be used as a fill material. Where an expansive clay having "free swelling index" value less than 50 percent is used as a fill material, subgrade and top 500 mm portion of the embankment just below sub-grade shall be non-expansive in nature.

305.2.1.3 Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as  $\text{SO}_4$ ) per litre when tested in accordance with BS:1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementitious material.

Materials with a total sulphate content (expressed as  $\text{SO}_4$ ) exceeding 0.5 percent by mass, when tested in accordance with BS:1377, Part 3 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

305.2.1.4 The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the sub-grade. 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 in such cases, however, shall not be more than two-thirds of the compacted layer thickness.

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

Table 300-1 : Density Requirements Of Embankment And Sub-Grade Materials

| sl. no. | type of work  | Maximum laboratory dry unit weight when tested as per is:2720 (part 8) |
|---------|---|--|
| 1)      | Embankments up to 3 m height, not subjected to extensive flooding                                   | Not less than 15.2 kN/cu.m   |
| 2)      | Embankments exceeding 3 m height or embankments of any height subject to long periods of inundation | Not less than 16 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 material to be used in subgrade shall be non-expansive and shall satisfy design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer shall be followed.

305.2.1.6 The material to be used in subgrade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fails to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer or by the IRC Accreditation Committee shall be followed.

305.2.1.7 The material to be used in high embankment construction shall satisfy the specified requirements of strength parameters.

### 305.2.2 General Requirements

305.2.2.1 The materials for embankment shall be obtained from approved sources with preference given to acceptable materials becoming available from nearby roadway 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.

### 305.2.2.2 Borrow Materials

The arrangement for the source of supply of the material for embankment and sub-grade and compliance with the guidelines, and 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 the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width of a minimum of 10 m.

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.

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 stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

#### 305.2.2.3 Fly-Ash

Use of fly-ash shall conform to the Ministry of Environment and Forest guidelines. Where fly-ash is used the embankment construction shall conform to the physical and chemical properties and requirements of IRC:SP:38-2001, "Guidelines for Use of Flyash in Road Construction". The term fly-ash shall cover all types of coal ash such as pond ash, bottom ash or mound ash.

Embankment constructed out of fly ash shall be properly designed to ensure stability and protection against erosion in accordance with IRC guidelines. A suitable thick cover may preferably be provided at intervening layers of pond ash for this purpose. A thick soil cover shall bind the edge of the embankment to protect it against erosion. Minimum thickness of such soil cover shall be 500 mm.

#### 305.2.2.4 Compaction Requirements

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 specified design CBR value of the sub-grade.

**Table 300-2 : Compaction Requirements For Embankment And Sub-Grade**

| s.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 | Not allowed |
| b) Remaining portion of embankment                     | 90–95%      |

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

- (i) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 8), appropriate for each of the fill materials he intends to use.
- (ii) A graph of dry density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

### **305.3 Construction Operations**

#### **305.3.1 Setting Out**

After the site has been cleared to Clause 201, the work shall be set out to Clause 301.3.1 The limits of embankment/sub-grade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/sub-grade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

#### **305.3.2 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 for the damage at his own cost.

If the embankment is to be constructed under water, Clause 305.4.6 shall apply.

#### **305.3.3 Stripping And Storing Topsoil**

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 subjected to traffic 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.

#### **305.3.4 Compacting Ground Supporting Embankment/Sub-Grade**

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 in accordance with Clauses 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the sub-grade level (top of the sub-grade 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 sub-grade level, watered and compacted in layers in accordance with Clauses 305.3.5 and 305.3.6 to achieve dry density not less than 97 percent relative compaction as given in Table 300-2.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation (500 mm portion just below the sub-grade) shall be removed, suitably disposed and replaced by approved materials laid in layers to the required degree of compaction.

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 such material types (a) to (f) in Clause 305.2.1.1 at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

### 305.3.5 Spreading Material In Layers And Bringing To Appropriate Moisture Content

305.3.5.1 The embankment and sub-grade material shall be spread in layers of uniform thickness in the entire width with a motor grader. The compacted thickness of each layer shall not be more than 250 mm when vibratory roller/vibratory soil compactor is used and not more than 200 mm when 80-100 kN static roller is used. 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.

305.3.5.2 Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed 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 variable widths of surface but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, using disc harrow 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 percent above to 2 percent below

the optimum moisture content determined in accordance with 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 graders, harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

Clods or hard lumps of 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 sub-grade.

305.3.5.3 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 construction vehicles. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength of the material before it was damaged.

Embankments and unsupported fills shall not be constructed with steeper side slopes or to greater widths than those shown in the drawings, 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 to 4 horizontal, such faces shall be benched as per Clause 305.4.1 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill 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.

### 305.3.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self-propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, 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 self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the 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 the site trials shall 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 903.2.2 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 provided the gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/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 using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

#### 305.3.7 Drainage

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

#### 305.3.8 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 305.3.6. 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.

#### 305.3.9 Finishing Operations

Finishing operations shall include the work of shaping 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 902. 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 (Clauses 301.3.2 and 305.3.3) 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 307. If seeding and mulching of slopes is prescribed, this shall be done to the requirements of Clause 308.

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.

### **305.4 Construction Of Embankment And Sub-Grade Under Special Conditions**

#### **305.4.1 Earthwork For Widening Existing Road Embankment**

When an existing embankment and/or sub-grade 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/sub-grade 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 light weight vibratory roller, double drum walk behind roller, vibratory plate compactor or vibratory tamper 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.

#### **305.4.2 Earthwork For Embankment And Sub-Grade 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 305.4.1 before placing the embankment/sub-grade 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 309 in proper sequence with the embankment and sub-grade work as approved by the Engineer.

#### **305.4.3 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:

If the existing road surface is of granular type and lies within 1 m of the new formation levels, it shall be scarified to a depth of 50 mm or as directed so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new sub-grade level is compacted to the desired density;

If the existing road surface is of bituminous type or cement concrete and lies within 1 m of the new formation level, the bituminous or cement concrete layer shall be removed completely;

If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be roughened after ensuring that the minimum thickness of 500 mm of subgrade is available.

#### **305.4.4 Embankment And Sub-Grade 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 sub-grade 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 for 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 IRC:78. 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 2504 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.

#### **305.4.5 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 geosynthetic 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 305.3.

#### **305.4.6 Embankment Construction Under Water And Waterlogged Areas**

##### **305.4.6.1 Embankment 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 be of GW, SW, GP, SP as per IS:1498 and 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.

##### **305.4.6.2 Embankment Construction In Waterlogged And Marshy Areas**

The work shall be done as per IRC:34.

#### **305.4 Earthwork For High Embankment**

The material for high embankment construction shall conform to Clause 305.2.1.7. In the case of high embankments (more than 6 m), the Contractor shall normally use fly ash in conformity with Clause 305.2.1.1 or the material from the approved borrow area.

Where provided, stage construction of embankment and 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 the Contractor shall bring the resultant level up to formation level with acceptable material for use in fill.

##### **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, wing wall, 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.

#### **305.5 Plying of Traffic**

Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or sub-grade 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 cost as directed by the Engineer.

## surface finish and Quality control of work

The surface finish of construction of sub-grade shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised in accordance with Clause 903.

## sub-grade strength

It shall be ensured prior to actual execution that the material to be used in the sub-grade satisfies the requirements of design CBR.

Sub-grade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed sub-grade shall be determined on remoulded samples, compacted to the field density at the field moisture content and tested for soaked/unsoaked condition as specified in the Contract.

## Measurements for payment

Earth embankment/sub-grade construction shall be measured separately by taking cross sections at intervals given in Sub-Section 113.3 after completion of clearing and grubbing and after completion of embankment/sub-grade. The volume of earthwork shall be computed in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought 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.

The embankment constructed with fly ash will be measured in cu.m, separately for the fly ash portions and for the soil cover and intervening layers of soil, unless otherwise specified in the Contract.

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 top soil shall be measured in cu.m.

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

Removal of unsuitable material at embankment/sub-grade 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 202.6.

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

## rates

The Contract unit rates for the items of embankment and sub-grade construction shall be payment in full for carrying out the required operations including full compensation for:

- i) Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;
- ii) Setting out;
- iii) Compacting ground supporting embankment/sub-grade except where removal and replacement of suitable material or loosening and recompacting is involved;
- iv) Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and sub-grade as applicable;
- v) Cost of watering or drying of material in borrow areas and/or embankment and sub-grade during construction as required;
- vi) Spreading in layers, bringing to appropriate moisture and compacting to Specification requirements;
- vii) Shaping and dressing top and slopes of the embankment and sub- grade including rounding of corners;
- viii) Restricted working at sites of structures;
- ix) Working on narrow width of embankment and sub-grade;
- x) Excavation in all soils from borrow pits/designated borrow areas including clearing and grubbing and transporting the material to embankment and sub-grade site with all leads and lifts unless otherwise provided for in the Contract;
- xi) All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;
- xii) Dewatering; and
- xiii) Keeping the embankment/completed formation free of water as per Clause 311.
- xiv) Transporting unsuitable excavated material for disposal with all leads and lifts.

Clause 301.9.5 shall apply as regards Contract unit rates for items of stripping and storing top soil including reapplication of topsoil.

Clause 301.9.2 shall apply as regards Contract unit rate for the item of loosening and recompacting the embankment/sub-grade foundation.

Clauses 309.1.1 and 305.8 shall apply as regards Contract rates for items of removal of unsuitable material and replacement with suitable material, respectively.

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 also comprise of handling, giving credit towards salvage value and disposal of the dismantled materials with all leads and lifts or as otherwise specified.

Clause 202.7 shall apply as regards Contract unit rate for dismantling and removal of existing cement concrete pavement.

The Contract unit rate for providing and laying filter material 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.

The Contract unit rate for providing and compacting backfill material behind abutments and retaining walls 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.

Clause 305.4.6 shall apply as regards Contract unit rate for construction of embankment under water.

Clause 305.4.7 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.

## **306 soil erosion and sedimentation control**

### **306.1 description**

This work shall consist of measures as shown on drawings or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, dikes, sediment basins, fibre mats, mulches, grasses, slope drains, and other devices.

### **306.2 Materials**

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work

### **306.3 construction operations**

Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and borrow pits and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor shall provide immediate permanent or temporary erosion, slope protection and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as shown on the drawings.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion/sedimentation and pollution control measures shall be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the Project.

Where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion or sedimentation control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion or sedimentation control measures may be required between successive construction stages. Under no conditions shall a large surface area of erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer.

The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion/sedimentation control measures shall be taken immediately to the extent feasible and justified.

In the event temporary erosion, sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own cost. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the Engineer.

Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as a result of road construction such as borrow pit operations, service roads and equipment storage sites.

The temporary erosion, sedimentation and pollution control features installed by the Contractor shall be acceptably maintained by him till these are needed, unless otherwise agreed by the Engineer.

#### **306.4 Measurement for payment**



The soil erosion, sedimentation and pollution control works shall be measured in terms of units specified in the Bill of Quantities for the respective items.

### **306.5 Rates**

The Contract unit rate for different items of soil erosion, sedimentation and pollution control works shall be payment in full for carrying out all required operations including full compensation for all labour, materials, tools, equipment and incidentals to complete the works to the Specifications.

## **307 Turfing With Sods**

### **307.1 Scope**

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favourable for establishment of the sod.

### **307.2 Materials**

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent tearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

### **307.3 Construction operations**

#### **preparation of the earth Bed**

The area to be sodded shall have been previously constructed to the required slope and cross-section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the drawings. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the drawings. After spreading, the

materials shall be incorporated in the soil by using disc harrow or other means to the depths shown on the drawings.

### **placing the sods**

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

### **staking the sods**

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sods strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

### **top dressing**

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

### **watering and Maintenance**

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

### **307.4 Measurements for payment**

Turfing with sods shall be measured as finished work in square metres.

### **307.5 Rate**

The Contract unit rate for turfing with sods shall mean paying in full for carrying out all the required operations explained above including compensation for

- i) furnishing all the materials to be incorporated in the Works with all leads and lifts; and

- ii) all labour, tools, equipment and incidentals to complete the work in accordance with these Specifications.

The Contract unit rate for application of topsoil shall be as per Clause 301.9.5.

## **308 Seeding and Mulching**

### **308.1 Scope**

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting, coir netting, or polymer netting and placing and incorporating the same on embankment slopes or other locations designated by the Engineer or shown in the Contract documents.

### **308.2 Materials**

#### **seeds**

The seeds shall be of approved quality and type suitable for the soil on which these are to be applied, and shall give acceptable purity and germination to requirements set down by the Engineer.

Fertilizers shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully putrified organic matter such as cow dung.

Mulching materials shall consist of straw, hay, wood shavings, or sawdust and shall be delivered in dry condition suitable for placing with a mulch blower. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as a mulch or be injurious to the plant growth.

#### **topsoil**

Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicide or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall not contain less than 2 percent and more than 12 percent organic matter.

#### **Bituminous emulsion**

A suitable grade of bituminous emulsion used as a tie down for mulch shall be as described in the Contract document or as desired by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

#### **netting**

Jute netting shall be undyed jute yarn woven into a uniform open weave with approximate 25 mm square openings.

Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 20 mm x 20 mm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sqm.

A layer of biodegradable mulching material sandwiched between two layers of polymer netting or non-woven coconut fibre coir netting can also be used.

### **308.3 Seeding operations**

#### **seed-Bed preparation**

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, medians etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the drawings, unless otherwise approved by the Engineer. The seed-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods larger than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer. Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes of the roller or approved equipment.

#### **fertilizer application**

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seed-bed preparation.

#### **planting of seeds**

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm.

The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

#### **soil Moisture and watering requirements**

Soil moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting.

Watering of the seeded areas shall be carried out as determined by the Engineer.

Mulching, applying Bituminous emulsion and Jute netting/geonetting/ netting of coir

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 litres per hectare. Any mulch disturbed or displaced following

application shall be removed, reseeded and remulched as specified. Jute netting/geonetting or netting of coir shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the drawings or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting/Geonetting /coir netting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil.

#### **308.4 Maintenance**

The Contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and repairing any areas damaged following the seeding and mulching operations. If mulched areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

#### **308.5 Measurements of payment**

Seeding and mulching shall be measured as finished work in square metres.

#### **308.6 Rate**

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all the required operations including full compensation for all materials, labour, tools and incidentals.

### **309 surface/sub-surface drains**

#### **309.1 Scope**

The work shall consist of constructing surface and/or sub-surface drains in accordance with the requirements of these Specifications and to the lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

#### **309.2 Surface drains**

Surface drains shall be excavated to the specified lines, grades, levels and dimensions to the requirements of Clause 301. The excavated material shall be removed from the area adjoining the drains and if found suitable, utilized in embankment/sub-grade construction. All unsuitable material shall be disposed of as directed.

The excavated bed and sides of the drains shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes.

Where so indicated, drains shall be lined or turfed with suitable materials in accordance with details shown on the drawings.

All works on drain construction shall be planned and executed in proper sequence with other works as approved by the Engineer, with a view to ensuring adequate drainage for the area and minimizing erosion/sedimentation.

sub-surface drains

scope

Sub-surface drains shall be of close-jointed perforated pipes, open-jointed unperforated pipes, surrounded by granular material laid in a trench or aggregate drains to drain the pavement courses. Sub-surface drains designed using Geosynthetics and approved by the Engineer can also be used.

Materials

309.3.2.1 pipe

Perforated pipes for the drains may be metal/asbestos cement/cement concrete/Poly Vinyl Chloride (PVC)/Poly Propylene (PP)/Poly Ethylene (PE) and unperforated pipes of metal vitrified clay/cement concrete/asbestos cement PVC/PP/PE. The type, size and grade of the pipe to be used shall be as specified in the Contract. In no case, however, shall the internal diameter of the pipe be less than 100 mm. Holes for perforated pipes shall be on one half of the circumference only and conform to the spacing indicated on the drawings. Size of the holes shall not ordinarily be greater than half of D85 size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm. D85 stands for the size of the sieve that allows 85 percent of the material to pass through it.

Backfill Material

Backfill material shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the Contract specifies any particular gradings for the backfill material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Engineer, the backfill material shall be provided on the following lines:

Where the soil met with in the trench is of fine grained type (e.g., silt, clay or a mixture thereof), the backfill material shall conform to Class I grading set out in-Table 300-3;

Where the soil met with in the trench is of coarse silt to medium sand or sandy type, the backfill material shall correspond to Class II grading of Table 300-3; and

Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class III grading of Table 300-3.

Geosynthetics for use with subsurface drain shall conform to the requirements as per Section 700.

### **309.3.3 Trench Excavation**

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the drawings provided that width of trench at pipe level shall not be less than 450 mm. The excavation shall begin at the outlet end of the drain and proceed towards the upper

end. Where unsuitable material is met with at the trench bed, the same shall be removed to such depth as directed by the Engineer and backfilled with approved material which shall be thoroughly compacted to the specified degree.

#### Laying of Pipe and Backfilling

Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified.

**Table 300-3 : Grading Requirements For Filter Material Percent Passing By Weight**

| sieve designation | class i | class ii | class iii |
|-------------------|---------|----------|-----------|
| 53 mm             | -       | -        | 100       |
| 45 mm             | -       | -        | 97-100    |
| 26.5 mm           | -       | 100      | -         |
| 22.4 mm           | -       | 95-100   | 58-100    |
| 11.2 mm           | 100     | 48-100   | 20-60     |
| 5.6 mm            | 92-100  | 28-54    | 4-32      |
| 2.8 mm            | 83-100  | 20-35    | 0-10      |
| 1.4 mm            | 59-96   | -        | 0-5       |
| 710 micron        | 35-80   | 6-18     | -         |
| 355 micron        | 14-40   | 2-9      | -         |
| 180 micron        | 3-15    | -        | -         |
| 90 micron         | 0-5     | 0-4      | 0-3       |

Before placing the pipe, backfill material of the required grading(s) shall be laid for full width of the trench bed and compacted to a minimum thickness of 150 mm or as shown on the drawings. The thickness of the backfill material on the sides of the pipe shall be as shown on the drawings subject to a minimum of 150 mm. The pipe shall then be embedded firmly on the bed.

Perforated pipes, unless otherwise specified, shall be placed with their perforations down to minimize clogging. The pipe sections shall be joined securely with appropriate coupling fittings or bands.

Non-perforated pipes shall be laid with joints as close as possible with the open joints wrapped with suitable pervious material (like suitable Geosynthetics of not less than 150 mm width) to permit entry of water but prevent fines entering the pipes. In the case of non-perforated pipes with bell end, the bell shall face upgrade.

Upgrade end sections of the pipe installation shall be tightly closed by means of concrete plugs or plugs fabricated from the same material as the pipe and securely held in place to prevent entry of soil materials.

After the pipe installation has been completed and approved, backfill material of the required grading (s) (see Clause 309.3.2.2) shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm in thickness and thoroughly compacted. The minimum thickness of material above the top of the pipe shall be 300 mm.

Unless otherwise provided, sub-surface drains not located below the road pavement shall be sealed at the top by means of 150 mm thick layer of compacted clay so as to prevent percolation of surface water.

#### Use of Geosynthetics in Laying of Pipe and Backfilling

After excavating the trench for subsurface drain, the filter fabric shall be placed, the pipe installed and the trench backfilled with permeable material according to dimensions and details shown on the drawings. Surfaces to receive filter fabric prior to placing shall be free of loose or extraneous material and sharp objects that may damage the filter fabric during installation. Adjacent rolls of the fabric shall be overlapped a minimum of 450 mm. The preceding roll shall overlap the following roll in the direction the material is being spread.

Damage to the fabric resulting from Contractor's vehicles, equipment or operations shall be replaced or repaired by the Contractor at his Cost.

#### Drain Outlet

The outlet for a sub-surface drain shall not be under water or plugged with debris but should be a free outlet discharging into a stream, culvert or open ditch. The bottom of the pipe shall be kept above high water level in the ditch and the end protected with a grate or screen. For a length of 500 mm from the outlet end, the trench for pipe shall not be provided with granular material but backfilled with excavated soil and thoroughly compacted so as to stop water directly percolating from the backfill material around the pipe. The pipe in this section shall not have any perforations.

#### Aggregate Drains



Aggregate drains shall be placed within the verge/shoulders after completion of the pavement. Depth, thickness and spacing of the aggregate drains shall be as shown on the drawings.

Trenches for aggregate drains shall be excavated to a minimum width of 300 mm and to the depth shown on the drawings or ordered by the Engineer. The bottom of the trench shall be sloped to drain and shall be free from loose particles of soil. The trench shall be excavated so as to expose clearly the granular pavement courses to be drained.

Aggregate for the drains shall be durable gravel, stone or slag and shall be free from vegetable matter and other deleterious substances. The grading requirements are given in Table 300-4. Grading to be adopted shall be indicated in the drawings.

table 300-4 : grading requirements for aggregate drains

| <b>Sieve Designation</b> | <b>Percent Passing by Weight</b> |               |
|--------------------------|----------------------------------|---------------|
|                          | <b>Type A</b>                    | <b>Type B</b> |
| 63mm                     | -                                | 100           |
| 37.5mm                   | 100                              | 85 – 100      |
| 19mm                     | -                                | 0 - 20        |
| 9.5mm                    | 45 – 100                         | 0 – 5         |
| 3.35mm                   | 25 – 80                          | -             |
| 600 micron               | 8 - 45                           | -             |
| 150 micron               | 0 – 10                           | -             |
| 75 micron                | 0 - 5                            | -             |

Measurements for payment

Measurement for surface and sub-surface drains shall be per running metre length of the drain.

Rates

The Contract unit rates for surface and sub-surface drains shall be payment in full for all items such as excavation, dressing the sides and bottom; providing lining, turfing, pitching, masonry, concrete and plastering; providing, laying and jointing pipes including wrapping with geosynthetic fabric; providing, laying and compacting backfill around the pipe, granular bedding; providing, fixing and painting of cover etc. including full compensation for all materials, labour, tools, equipment and other incidentals to complete the work as shown on drawings with all leads and lifts including removal of unsuitable material. Provision of inlets, gratings, sumps, outlet pipes, bedding, disburers etc. wherever required shall be incidental to construction of drain.

## Preparation And Surface Treatment Of Formation

Preparation and surface treatment of the formation, shall be carried out only after completion of any specified sub-grade drainage and unless otherwise agreed by the Engineer, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows:

Full formation, after reinstatement of any soft areas to the required

Specifications shall be well cleaned and freed of all mud and slurry.

The surface shall be compacted to the required density by a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required.

c) the formation shall be finished to the requirements of Clause 305.3.9.

The entire work of surface treatment of formation shall be deemed as incidental to the work of sub-base/base course to be provided for the same.

## Works To Be Kept Free Of Water

The Contractor shall arrange for the rapid dispersal of water collected/ accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangements shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a prescribed crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

## Water Courses At Culverts

Excavation carried out in the diversion, enlargement, deepening or straightening water courses at culverts, where necessary, shall include the operations such as clearing, grubbing,

removal of vegetation, trimming of slopes, grading of beds, disposal of excavated materials, pumping, timbering etc. necessary for dealing with the flow of water.

The beds and sloping sides of water courses shall, where shown on the drawings, be protected against the action of water by rubble paving to form a flat or curved surface as indicated. The protection shall consist of large smooth faced stones or of blocks of precast concrete. Stones for rubble paving shall be roughly dressed square. No stone shall be less than 225 mm in depth nor less than 0.02 cu.m in volume and no rounded boulders shall be used. After completion of construction of culverts, temporary diversion of water course, if any, shall be closed and water course restored for flow through the culvert as per the direction of the Engineer.

#### Measurements for payment

The work for water courses at culverts as stated above shall be measured in terms of units specified in the Bill of Quantities for respective items. The temporary diversion of channel to facilitate construction of culverts, its closure and restoration to original water course shall be considered incidental to the work of construction of culverts and no extra payment shall be made for the same.

#### Rates

The Contract unit rates for different items of water courses at culverts shall be payment in full for carrying out all required operations including full compensation for all cost of materials, labour, tools, equipment and other incidentals to complete the work to the Specifications.

#### Rockfill Embankment

##### Scope

The work covers embankment constructed with pieces of rock and shall be in accordance with the lines, grades and cross-sections as shown in drawings or as directed by the Engineer.

There shall be a minimum of 500 mm thick earthen cushion over the rockfill. The construction of earth fill/ subgrade does not form part of scope of this work.

##### Materials

The size of rock pieces used in rockfill embankments shall be such that they can be deposited in layers so as to suit the conditions evaluated in the field compaction trials or as directed by the Engineer. The rockfill shall consist of hard, durable and inert material, preferably maximum size not exceeding 300 mm and percent finer than 125 mm not exceeding 10 percent.

Argillaceous rocks (clay, shales etc.), unburnt colliery stock and chalk shall not be used in rockfill.

The rock fragments and blinding material required for filling the voids shall also satisfy the above requirements.

##### Spreading And Compaction

The material shall be tipped, spread and levelled in layers extending to the full width of embankment by a suitable dozer. Fragments of rock shall then be spread on the top of layer to the required extent and layer compacted by minimum of 5 passes of vibratory roller having static weight 8-10 tonnes. The compacted thickness of each layer shall not exceed 500 mm. After compaction of each layer, the surface voids shall be filled with broken fragments. Next layer, where required, shall be placed in the same manner, above the earlier compacted layer.

The top layer of rockfill, on which normal earth fill will rest shall be thoroughly blinded with suitable granular material to seal its surface.

#### Measurements for payment

Measurement shall be made by taking cross-sections at intervals in the original position before the work starts and after its completion and computing the volume in cu.m by the method of average end areas.

#### rate

The Contract unit rate shall be paid in full for carrying out all the above operations including cost of rockfill, broken fragments and blinding material and shall provide full compensation for all items as per clause 305.8.

### Ground Improvement For Weak Embankment Foundation Using Geosynthetic Drains And Stone Columns

#### scope

The scope for improving the ground of problematic sub-soil conditions comprises of several alternatives and combination of more than one of the following alternatives. The improvement may be chosen based on the sub-soil conditions :

Using geosynthetic drains [Prefabricated Vertical Drain (PVD)] with surcharge involving design and installation of PVD to achieve 90% consolidation of sub-soil within a prescribed time.

Rammed stone columns.

iii) Stone columns formed by vibroflot technique.

Where specified in the Contract the scope of the work shall also cover the design of the ground improvement works by the Contractor.

#### prefabricated Vertical drain (pVd) with surcharge

The design and construction of this drain shall generally comply with the requirements of IS:15284 (Part 2) and the requirements given below. In the case of conflict between the requirements of IS:15284 and this Specification, the requirements of this Specification shall prevail.

#### Materials

**geosynthetic drain:** Geosynthetic strip or band drain shall be manufactured by an ISO 9001 certified manufacturer. It shall consist of a corrugated or studded or 3-d mesh consisting of an inner core of thick polyester fused at intersection, wrapped in a non-woven geotextile. Band drain shall be of width and thickness as specified in the design and shall be a minimum of 100 mm width and 5 mm thickness. The core shall serve as the drainage medium conveying the core water from the soft subsoil to the drainage layer at the top. The core shall be of three-dimensional mesh, made of polyester or equivalent. The filter should be non-woven needle punched adhesive-bonded fabric. The filter and the core shall be ultrasonically welded together at edges to produce a fully integrated product. The drain shall meet the properties specified in Table 700-3.

The drains shall be installed to depths and at spacing as per the design and drawings. The Contractor shall submit to the Engineer the complete scheme for installation of vertical band drains alongwith the particulars and test results from the manufacturer showing conformance to the specifications. Unless specified otherwise, the design of the ground improvement measures shall be to achieve 90 percent consolidation in the time prescribed by the employer. The equipment and the methodology for installation of the drains shall satisfy the specified requirement of prescribed degree of consolidation and the time for achieving the same.

**granular sand Blanket :** After installation of the vertical band drains in the sub-soil, a blanket of well draining granular material/coarse sand (natural or crushed) conforming to Class I grading given in Table 300-4 of specified thickness compacted to a density of 75 to 80 percent of maximum dry density obtained by heavy compaction (IS:2720-Part 8) shall be provided. The granular sand blanket shall be exposed to atmosphere at its periphery for dissipation of pore water pressure

**geotextile fabric for separation and drainage :** The requirements of synthetic geotextile shall be as given in Table 700-1.

construction and installation requirements

**shipment and storage :** The Geosynthetic Band Drain shall be dry and wrapped such that it is protected from the exposure to ultraviolet light during shipping and storage. At no time shall the band drain be exposed to ultraviolet light for a period exceeding fourteen days. If stored outdoor, they shall be elevated and protected with a waterproof

cover. The Geo-synthetic Band Drain shall be labeled as per ASTM D 4873, "Guide for identification, storage, and handling of geotextile.

**drain installation :** Band Drains in roll shall be installed using an installation rig/sticher mounted on a base machine (Hydraulic or Mechanical). The end of the drain shall be attached to a hollow rectangular mandrel or shoe, which will be driven into the soft clay by appropriate mechanism, such as lance. On reaching the refusal strata (stiff soil), the mandrel with the drain shall be left behind and the lance withdrawn. The top of the drain above the ground level shall be cut off at design level (150 mm into the drainage blanket). The rig/sticher moves on to the next location.

iii) After installation of vertical band drains, a blanket of granular coarse sand as mentioned above shall be spread over the entire area and covered with geotextile layer on top and bottom as directed by the Engineer.

installation of geotextile fabric for separation and drainage :

**shipment and storage** : The geotextile shall be kept dry and wrapped such that it is protected from the exposure to ultraviolet light during shipping and storage. At no time shall the paving fabric be exposed to ultraviolet light for a period exceeding fourteen days. Geotextile rolls shall be stored in a manner, which protects them from elements. If stored outdoor, they shall be elevated and protected with a waterproof cover. The geotextile shall be labeled as per ASTM D 4873, "Guide for identification, storage and handling of geotextiles".

**fabric placement** : The geotextile shall be laid smooth without wrinkles or folds on the sand blanket in the direction of construction traffic. Adjacent geotextile rolls shall be overlapped, sewn or jointed, (Preferably sewn or joined). On curves the geotextile may be folded or cut & overlap to conform to the curves. The fold or overlap shall be in the direction of construction and held in place by pins, staples, or piles of fill or rock. Prior to covering, the geotextile shall be inspected by the Engineer to ensure that the geotextile has not been damaged (i.e. holes, tears, rips) during installation. Damaged geotextiles, as identified by the Engineer, shall not be allowed. The surcharge shall be placed such that atleast the minimum specified lift thickness shall be between the geotextile and the equipment tyres or tracks at all times. Turning of vehicles shall not be permitted on the first lift above the geotextile.

**seaming** : A sewn seam is to be used for the seaming of the geotextile. The thread used shall consist of high strength polypropylene or polyester. Nylon thread shall not be used. The thread shall also be resistant to ultraviolet radiation. The thread shall be of contrasting color to that of the geotextile itself. For seams which are sewn in the field, the Contractor shall provide at least a 2 m length sewn seam for sampling by the Engineer before the geotextile is installed. For seams which are sewn in the factory, the Engineer shall obtain samples of the factory seams at random from any roll of geotextile which is used on the project. For seams that are field sewn, the seams sewn for sampling shall be sewn using the same equipment and procedures as will be used for the production seams. If seams are sewn in both the machine and cross machine direction, samples of seams from both directions shall be provided. The seam assembly description shall be submitted by the Contractor along with the sample of the seam. The description shall include the seam type, stitch type, sewing thread and stitch density.

**addition of surcharge** : Addition of surcharge load by approved embankment material shall be placed over the geotextile layer upto a height as per the design requirement. The addition of surcharge shall be placed with adequate side slope to avoid any slope failure. The addition of surcharge shall be kept in place for a period as per the design to achieve desired degree of consolidation. After ascertaining that the desired degree of consolidation is achieved, the addition of surcharge which is not forming part of permanent work/ embankment shall be removed to the required level as per drawings. Removal of additional surcharge material shall be done without damaging the road embankment. After removal of additional surcharge, the damaged embankment top, if any, shall be made good as instructed by the Engineer. The addition and removal of surcharge shall be incidental to the work except for payment of additional surcharge quantity forming part of permanent embankment. The quantity for payment will be determined based on the settlements readings observed through instrumentation.

**instrumentation and Monitoring the Behaviour of sub-soil/ embankment** : Monitoring the behavior of the sub-soil/ embankment construction shall form part of the work. The design

shall be based on the gain in the shear strength of the subsoil due to consolidation process. The following critical parameters shall be monitored :

Monitoring the Build up and dissipation of pore pressure:

Casagrande open standpipe type piezometers shall be used for the measurement of changes in pore pressure. The specifications for the Casagrande piezometer shall be as follows.

The piezometer shall be 38 mm in dia and 300 mm in length; The air entry value shall be of the order of  $0.3 \text{ kg/cm}^2$ .

The standpipe shall be more than 16 mm in diameter;

The piezometer shall be installed in 150 mm borehole, at specified depths. Sand cover around the piezometer tip and bentonite seal above shall be provided; and

Suitable electronic sensor shall be used to record the water level Piezometers including dummy piezometers shall be installed at locations specified by the Engineer.

**rate and Magnitude of Vertical settlements of the subsoil under the surcharge load :** Settlements shall be measured by installing platform type settlement gauges, which consist of the following :

Wooden base plate 1000 mm square and 50 mm thick;

GI pipe of 25 mm dia fitted to the base plate with a suitable sleeve arrangement and nuts and bolts;

Outer loose fitting sleeve, to prevent soil from coming into contact with the inner pipe;

The pipe and the sleeve consist of 1.5 m long sections, which can be screwed on at the top, so that as the surcharge is built up, the top of the pipe is well clear of the fill;

Settlement gauges shall be installed at the ground level, before the starting of the fill construction. These shall be installed locations specified by the Engineer. The readings of settlement gauges also form the basis to estimate the quantity of surcharge forming part of permanent work. The number of settlement gauges shall be decided by the Engineer keeping in view this aspect.

**Measurement of shear strength :** The shear strength parameters of the subsoil [unconfined compressive strength (UCS)] shall be measured at locations specified by the Engineer at the end of each stage of surcharge loading in order to compare the actual details with the design assumptions. For the recovery of undisturbed samples from the subsoil for determining UCS, before start of construction of surcharge, 100 mm dia casing pipe shall be installed into the ground to 3 m depth, preferably by driving; the top of the casing pipe shall have provision for adding extensions.

at top by screw coupling; and as the surcharge construction proceeds the casing pipe shall be extended. This procedure ensures avoiding drilling through the surcharge already

placed as well as any damage to the installed band drains. Undisturbed samples (UDS) are recovered and UCS is determined in the site laboratory (sending UDS sample to distant laboratories would result in loss of water content and disturbance of the samples leading to erroneous values of UCS). Undisturbed samples shall be recovered at every 1.5 m depth at the specified locations, so that complete strength profile of subsoil is obtained.

During the placing of the surcharge and compaction, the Contractor shall take utmost care so that the monitoring instruments are not damaged. Compaction by small vibratory rollers shall be done for 1.5 m around the monitoring instruments and bigger rollers shall not be used near the monitoring instruments. Similarly care shall be taken that movement of dumpers does not damage the monitoring instruments.

**frequency of observations :** The readings of the piezometers and the settlement gauges shall be recorded at the following frequency.

Daily reading shall be taken in stretches where filling/ surcharge operations are in progress. Weekly readings shall be taken in stretches, where no filling/ surcharge is being done.

Weekly readings shall be taken after the desired fill/ surcharge height is achieved, till the next stage filling commences. All data shall be recorded in a register and maintained properly.

The Data from the monitoring instruments provides the background for regulating the rate of placing the fill/ surcharge as well as the waiting period between stages.

**precautions against pilferage:** The observation data shall be recorded during construction and for three months thereafter. It is therefore essential that the instruments are not tampered and stolen. Suitable precautions shall be taken in this regard by the Contractor.

**drainage of ground water :** The water which will come out from the subsoil through vertical drains will be accumulated at temporary ditches to be dug at nearby areas and the accumulated water will be dewatered regularly from the ditches to the outfalls as directed by the Engineer.

Certification from the Manufacturer of Band Drain and Geotextile

fabric for separation and drainage :

The Contractor shall provide to the Engineer, a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filament or yarns and other pertinent information to fully describe the material. Each roll shall be labelled or tagged to protect product identification as well as inventory and quality control.

b) The manufacturer shall be responsible for establishing and maintaining a quality control programme to assure compliance with the requirement of the specification. Documentation describing the quality control programme shall be made available upon request.

c) The manufacturer's certificate shall state that the furnished material meets minimum averages roll values (MARV) requirements of the specifications as evaluated under the Manufacturer's quality control programme. The certificate shall be attested by a person having legal authority to bind the Manufacturer.

Measurements for payment



The Geosynthetic Band Drains (or geodrain) shall be measured in linear metre of its length.

The granular sand blanket shall be measured in cubic metre.

iii) The geo-synthetic fabric shall be measured in square metre of plan area of final finished work.

iv) Instrumentation and monitoring the behaviour of sub-soil/ embankment shall be measured in number of locations.

v) The additional surcharge quantity forming part of permanent embankment shall be measured in cum.

The overlaps, patches, sewn seams and securing pins shall not to be measured.

#### Rate

Rate shall include cost of design, materials, installation, operations involved in pre-loading/ additional surcharge, dewatering, labour, plant hire, material storage and handling expenses for completing the work including submission of construction drawings and provision of specialist attendance & supervision at site for (i) geodrain; (ii) sand blanket; (iii) geofabric;

(iv) instrumentation and monitoring; and (v) permanent embankment part of surcharge as described above.

rammedstone columns using non-displacement Method of construction

The design and construction of this column shall generally comply with the requirements of IS:15284 (Part 2), including the requirements given below. In the case of conflict between the requirements of IS:15284 and these Specifications the requirements of these Specifications shall prevail.

Stone columns shall be formed from well-graded crushed stone and gravel compacted to a dense state. The size of the well graded crushed aggregate shall vary from 2 mm to 75 mm conforming to the gradation given below.

| size of the crushed aggregate | % passing |
|-------------------------------|-----------|
| 75 mm                         | 90-100    |
| 50 mm                         | 80-90     |
| 38 mm                         | 55-75     |

|       |       |
|-------|-------|
| 20 mm | 10-20 |
| 12 mm | 5-13  |
| 2 mm  | 5     |

The crushed aggregate shall be chemically inert, hard and resistant to breakage. The diameter of the stone columns shall be as shown in the drawings.

#### granular Blanket

A compacted and well draining layer of gravel or coarse sand, of specified thickness, compacted in layers to a relative density of 75 to 80 percent shall be provided above the existing ground. This blanket shall be exposed to atmosphere at its periphery for pore water pressure dissipation.

#### construction and installation requirements

The "Rammed Stone Columns" shall be constructed by non-displacement technique namely "Bailer and Casing Method" as given in IS:15284 (Part 1). After ensuring complete removal of slush deposited during boring operations, a minimum depth of 0.5 m, preferably 0.75 below the granular blanket shall be compacted by other suitable means such as rolling/ tamping to the specified densification criteria.

#### field controls

In the above method, the following minimum field controls shall essentially be observed. The set criteria and the consumption of granular fill form the main quality control measures

for the columns constructed by the non-displacement technique. The set criteria shall be established as given in IS:15284 (Part 1). For ascertaining the consumption of fill, the diameter of the column as formed during field trials shall be measured in its uppermost part along the four diameters and average of these observations taken as the column diameter.

#### field loading tests

Initial and routine tests shall be carried out as given in IS:15284 (Part 1).

Recording of Data shall be done as given in IS:15284 (Part 1).

#### load test results

The ultimate load capacity of single column shall be determined from load tests. The settlement of a stone column obtained at safe/ working load from load test results on a single column shall not be directly used in forecasting the settlement of the structure unless experience from similar foundations in similar soil conditions on its settlement behaviour is available. The average settlement may be assessed on the basis of sub-soil data and loading details of the structures as a whole using the principles of soil mechanics.

#### 314.3.9 Certification

The Contractor shall be responsible for establishing and maintaining a quality control programme to assure compliance with the requirements of the specifications.

#### Measurement for payment

The rammed stone column of the specified diameter shall be measured in linear metre of its compacted length.

The sand blanket shall be measured in cu.m.

The initial and routine load tests, unless otherwise specified in the contract, shall be measured in numbers and paid.

#### rate

The rate shall include the cost of providing all materials, tools, equipment, labour, supervision and incidentals necessary to complete the work as per these specifications.

#### Stone Columns using Vibro-replacement (Vibroflot) Method of construction scope

The scope of the work shall consist of:

construction of stone columns, complete in-place including layout;

supplying crushed stone, equipment, electrical power, water and any other necessary items for stone column and its installation;

Control and disposal of surface water resulting from stone column construction operations;

Construction and removal of silt settling ponds or similar facilities as required, and the regrading of the site as required;

Stockpiling and disposal of silt from the site if necessary; and Load testing of stone columns as specified

The design and construction of stone columns shall comply with IS:15284 (Part I) subject to certain modifications incorporated in these Specifications or any other modification suggested by the Engineer. The construction of sand (or stone) working platform and necessary access to site shall not form part of the scope of this work. Stone Column with maximum compacted density shall extend to the full depth of the compressible stratum and reach the Dense Sand Layer/Stiff Clay Layer.

The Contractor shall (i) meet all applicable laws and regulations concerning surface runoff, siltation, pollution and general disposal of the effluent from the construction of the stone columns and general site work, (ii) construct and relocate temporary ditches, swales, banks, dams, and similar facilities as necessary to control the flow of surface water during the work, remove them when no longer required, and regrade the affected areas for acceptable drainage as specified for site grading, (iii) construct silt settling ponds as required in locations indicated or approved, ensure that earth banks and water control devices are safely designed and prevent inadvertent discharge into watercourses off the site, stockpile and dispose of all silt as approved by the Engineer, (iv) remove settling ponds and other structures when no longer required and regrade the areas for acceptable drainage as specified for site grading.

#### Materials

**stone aggregate for compacted column :** The crushed stone and gravel for column backfill shall be clean, hard, angular, chemically inert, resistant to breakage and free from organic, trash, or other deleterious materials. It shall be well-graded stones of 75 mm down to 2 mm size.

The uniformity co-efficient shall be greater than 3. The Aggregate Impact Value shall not be more than 30 percent.

**drainage Blanket :** Sand/crushed stone, which is hard, inert, resistant to chemical change and free from organic, trash, or other deleterious materials shall only be used in drainage blanket. The blanket shall be well graded and free draining granular material of thickness 500 mm or more, compacted in layers to a relative density of 75 to 80 percent. This blanket shall be exposed to atmosphere at its periphery for pore water pressure dissipation.

construction and installation

The stone columns shall be installed by Vibroflot method given in IS:15284 (Part 1). Stones shall be fed by mechanical means i.e. use of loader/ hopper/ chute etc. The slush, muck and other loose materials at work site shall be removed/ disposed off suitably by the Contractor as instructed by the Engineer. The Contractor shall take adequate measures to ensure stability of bore holes made for installation of stone column.

A detailed installation procedure/method statement shall be submitted by the

Contractor including:

Type and number of Vibroflots and general method of operation including construction schedule.

Mechanical arrangement for placing stones (s) around the probe point Quality control, Quality Assurance Procedure covering details on automatic recording devices to monitor and record stone consumption

Type of equipment to be deployed.

Manpower to be engaged

The proposed sequence and timing for constructing stone columns along with a bar chart for the entire ground improvement work.

Stone column installation procedure shall be as approved by the Engineer. The construction technique and probe shall be capable of producing and/or complying with the following:

The holes shall be close to circular.

The probe and follower tubes shall be of sufficient length to reach the elevations shown on the plans. The probe, used in combination with the flow rate and available pressure to the tip jet, shall be capable of penetrating to the required tip elevation. Preboring of stiff lenses, layers or strata is permitted.

The probe shall have visible external markings at suitable increments

to enable measurement of penetration and re-penetration depths

Sufficient quantity of wash water shall be provided to the tip of the probe to widen the probe hole to a diameter to allow adequate space for stone backfill placement around the probe. The flow of water from the bottom jet shall be maintained at all times during backfilling to

prevent caving or collapse of the hole and to form a clean stone column. The flow rate will generally be greater as the hole is jetted in, and decrease as the stone column comes up

After forming the hole, the vibrator shall be lifted up a minimum 3 m, dropped at least twice to flush the hole out. The probe shall not, however, be completely removed from the hole

The column shall be formed by adding stone in lifts having each lift height between 600 cm and 1000 cm. The stone aggregate in each lift shall be compacted by re-penetrating it at least twice with the horizontally vibrating probe so as to densify and force the stone radially into the surrounding in-situ soil. The stone in each increment shall be re-penetrated a sufficient number of times to develop a minimum ammeter reading on the motor of at least 40 amps more than the free-standing (unloaded) ampere draw on the motor, but no less than 80 amps total

Stone columns shall be installed so that each completed column will be continuous throughout its length

Data captured shall be continuously displayed on a LCD unit and graphical output (plots of depth versus time and power consumption) generated by automated computerized recording device throughout the process of stone column installation for each point shall be submitted to the Engineer.

The equipment to be used shall be instrumented with sensors and the data processed by a micro-processing unit to enable continuous monitoring and data capture of the following during construction of each stone column:

depth of vibrator and vibrator movements (depth of penetration)

power consumption (compaction effort)

If erosion of upper granular working platform material occurs, the depressions shall be backfilled with sand/ granular material which meets the specification for the working platform. Such backfilling shall be at the Contractor's expense. The working surface shall be cleaned at the completion of the stone column construction of all unsuitable materials washed up from the stone column holes. Such unsuitable materials include clay or silt lumps, wood fragments or other organic matter. If, in the opinion of the Engineer, these materials create "soft spots" or zones of compressibility or weakness in connection with the placement of overlying embankment materials, such unsuitable materials shall be disposed of in a manner approved by the Engineer

In the event of obstructions preventing the penetration of the Vibrofloat, the Contractor shall stop work, move to another compaction point and immediately notify the Engineer. The Engineer may at his option authorize one or several of the following:

(i) position the compaction point a short distance away from the original position, (ii) additional compaction points to bridge the obstruction, (iii) remove the obstruction, replace removed soils, and again jet the column hole in the indicated location, (iv) perform other removal or relocation operations or (v) any other method.

field controls

In the above method, the following minimum field controls shall be observed.

Vibrofloat penetration depth including the depth of embedment in firm strata.

Monitoring of volume of backfill added to obtain an indication of the densities achieved, and

Monitoring of ammeter or hydraulic pressure gauge readings to verify that the maximum possible density has been achieved in case of Vibrofloated columns.

Recording of Data shall be done as given in IS:15284 (Part 1).

#### field loading tests

The Initial load tests shall be performed at a trial test site approved by the Engineer to evaluate the load-settlement behaviour of the soil-stone column system. The tests shall be conducted on a single and also on a group of minimum three columns in accordance with IS:15284 (Part-1). The number of initial tests shall be as follows:

Single column tests – 1 test per 500 or part thereof stone columns.

Three column group tests – 1 test per 1000 or part thereof stone columns.

The Routine load tests shall be carried out on a single job column in accordance with IS:15284 (Part-1). The job columns shall be loaded for a test load of

1.1 times the design load intensity with kentledge minimum 1.3 times the design load pattern.

The number of routine tests shall be as follows:

Single column tests – 1 test per 500 or part thereof stone columns.

The test load shall be applied at increments of one-tenth to one-fifth of the design load upto a maximum of 1.5 times the design load. Each load stage shall be maintained till the settlement rate is less than 0.1 mm/30 min.

The test load shall be maintained for a minimum period of 24 hours. The ultimate load on the stone column shall be determined by double tangent diagram. The test load shall be removed in five to six stages. Each unloading stage shall be maintained till the rebound attains a rate of 2.0 mm/30 min.

Safe and efficient working of the loading arrangements is entirely the Contractor's responsibility and any impediment resulting in the failure of the test arrangement may debar the Contractor from payment for the test. Alternatively, it may make the Contractor liable to repeat the test on separate column/columns without any extra cost.

The construction of stone columns shall be carried out using the same procedure as adopted for the test column to the satisfaction of the Engineer. The stone columns under the test shall be a part of a larger stone column group. The interpretation of the results shall be free from ambiguity and shall be subject to the Engineer's approval. No works shall proceed unless the Contractor shall satisfy the Engineer beyond reasonable doubt that the performance of the stabilized soil material will be compliant with the Specification.

#### Tolerances

## Setting Out

Setting out shall be carried out from reference lines and points shown in the drawings. Immediately before installation of the stone columns, the stone column positions shall be marked with suitable identifiable markers.

## Position

No vibration center or stone column shall be more than 150 mm off its correct center location in any direction at the working platform level as shown on the approved plans.

## Verticality

Stone Columns shall be constructed as vertical as possible. The axis of the stone column shall not be inclined from the vertical by more than 1h: 20v as indicated by the tilt of vibrator and follower tubes.

## personnel

The Contractor shall employ suitable personnel having experience in the construction of stone columns.

## **Quality control**

The Contractor shall establish and maintain a quality control programme to assure compliance with the requirements of the specifications.

## **Measurements for payment**

The stone column by Vibrofloat method shall be measured in linear metre of its compacted length.

Item No. 8 and Item No. 9 shall be measured in cu.m. whereas item No. 10 shall be measured in Rmt.

The initial and routine load tests, unless otherwise specified in the Contract, shall be measured in numbers and paid.

## **Rate**

The rate shall include the cost of providing all materials, tools, equipment, labour, supervision and incidentals necessary to complete the work as per these Specifications.

Payment shall be made on the basis of cu.m.

**Item No. 9**

Providing and filling in foundation with ordinary Cement concrete M-15 mix and providing necessary vertical pin headers including formwork, vibrating, ramming and curing complete. And Providing and filling trenches of Labour charges - Excavator in rocky strata with ordinary cement concrete M-15

**Item No. 10**

Providing and casting in-situ Reinforced Cement Concrete M35 grade controlled cement concrete in pier, abutment & retaining walls foundations (piers, abutments and retaining wall shall be cast in single lift or as per direction of Engineer in charge) etc. using 6mm to 20mm machine crushed well graded stone aggregate, sand of approved quality, OPC53 grade cement with contractor's own concrete mix design, etc. complete. The rate is inclusive of all materials, including necessary mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, scaffolding, staging, shuttering, formworks, deshuttering carefully, making good the damages, fixing embedment, inserts, pockets, wherever necessary, with all lead and lift with contractor's labour, tools & plants, machineries, as required, with F3 type exposed concrete finish and form mark. Any honeycombing / Undulation found shall be rectify to match F3 class finish.

**Item No. 12**

Providing and casting in situ controlled cement concrete M-35 for R.C.C. return as per drawings including centering shuttering, scaffolding where necessary, laying vibrating, curing and finishing complete. (1) Piers (2) Abutment (3) RCC return (A) Height from 0.0 M to 5.0 M.

**Item No. 13**

Providing and casting in situ controlled cement concrete M-35 for R.C.C. return as per drawings including centering shuttering, scaffolding where necessary, laying vibrating, curing and finishing complete. (1) Piers (2) Abutment (3) RCC return (A) Height from 5.0 M to 10.0 M.

**Item No. 14**

Providing and casting in situ controlled cement concrete M-35 for R.C.C. return as per drawings including centering shuttering, scaffolding where necessary, laying vibrating, curing and finishing complete. (1) Piers (2) Abutment (3) RCC return (A) Height from 10.0 M and above

**Item No. 15**

Providing and casting in situ controlled cement concrete M-35 for R.C.C. work in pier cap, abutment cap and dirt wall of required size below bearings as per detailed drawings, centering, shuttering, scaffolding, wherever necessary, laying vibrating, curing and finishing complete. (A) Pier Cap, Abutment Cap & Dirt wall incl. Inspection Platform Slab

**Item No. 16**

Providing and casting in situ controlled cement concrete M-40 for pedestal and arresters of required size below bearings as per detailed drawings, centering, shuttering, scaffolding, wherever necessary, laying vibrating, curing and finishing complete. (A) Pedestals & Seismic Arresters in M-40

**Item No. 24**

Providing and Casting in situ controlled Cement Concrete M-200 for R.C.C. Raft and cutt-off walls including necessary shuttering laying, vibrating, ramming and curing complete. (Toe Wall)



**Item No. 25**

**Providing and casting in situ controlled cement concrete M-35 for R.C.C. work in superstructure including centering, shuttering scaffolding, ramming, vibrating curing and finishing complete.(A) T-Beam and Deck slab type of superstructure (II) Main and cross Girder**

**Item No. 31**

**Providing and casting in situ controlled cement concrete M-40 for Crash Barriers & Friction slab including formwork curing and finishing, complete**

**Item No. 32**

**Providing and casting in situ controlled cement concrete concrete M-35 for approach slab including formwork curing and finishing complete.**

**Item No. 33**

**"Providing and casting in situ controlled cement concrete M-25 for architectural pylons including necessary formwork, vibrating, curing and finishing complete.  
(a) Concrete."**

**MORTH V<sup>th</sup> REVISION: Cl. No. 1000,1500,1700 & 2100, Pg. no. 439,519, 535 & 663**

**1001 General**

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work.

If any material, not covered in these Specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer.

**1002 Sources of Materials**

The Contractor shall identify the sources of materials like coarse aggregate and fine aggregate and notify the Engineer regarding the proposed sources prior to delivery.

Samples of materials from the source shall be tested in the presence of Engineer for conformity to specifications. It shall also be ensured that the variation in test results of different samples, is within acceptable limits.

For manufactured items like cement, steel reinforcement and pre-stressing strands, the contractor shall intimate the Engineer the details of the source, testing facilities available with the manufacturer and arrangements for transport and storage of material at site. If directed by the Engineer, the contractor shall furnish samples and test results of recently received material. The Engineer, at his discretion, in case of doubt, may require the contractor to test the materials in an independent laboratory approved by the Engineer and furnish test certificates. The cost of these tests shall be borne by the contractor. The sampling and testing procedures shall be as laid down in the relevant Indian Standards and where they are not available, the same shall be carried out as per the directions of the Engineer. Only materials from sources approved by the Engineer shall be brought to the site. If the material from the approved source proves unacceptable at any time, the contractor shall identify new sources of acceptable materials conforming to specifications.

If any proprietary items are proposed to be used in the works, they shall be governed by the provisions of Clause 115.4 of these Specifications.

### **1003 Bricks**

Burnt clay bricks shall conform to the requirements of IS:1077, except that the minimum compressive strength when tested flat, shall not be less than 8.4 MPa for individual bricks and mean strength not less than 10.5 MPa for a group of 5 specimens. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of  $\pm 5$  percent.

### **1004 Stones and Blocks**

Stones shall be of the type specified. They shall be hard, sound, free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stones with round surface shall not be used.

The stones, when immersed in water for 24 hours, shall not absorb water of more than 5 percent of their dry weight when tested in accordance with IS:1124.

The length of stone shall not exceed three times its height and the width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

#### **Blocks**

Solid concrete blocks made of cement and suitable aggregates shall conform to relevant provisions of IS:2185 Part 1 in respect of dimension, mix, manufacturing, curing, drying and physical requirements. The minimum compressive strength of solid concrete blocks when tested as per IS:2185 Part 1 shall not be less than 10.5 MPa. Hollow light weight concrete blocks shall not be used in works.

The thickness of concrete block shall not be less than 200 mm and the width shall not be less than 200 mm. The density of concrete block shall not be less than 2.2 ton/cu.m.

### **1005 Cast Iron**

Cast iron shall conform to IS:210. The grade number of the material shall not be less than 14.

### **1006 Cement**

Cement to be used shall be any of the following types with the prior approval of the Engineer.

- a) Ordinary Portland cement, 33 Grade, conforming to IS:269.
- b) Ordinary Portland cement, 43 Grade, conforming to IS:8112.
- c) Ordinary Portland cement, 53 Grade, conforming to IS:12269.
- d) Sulphate resisting Portland cement, conforming to IS:12330.
- e) Portland Pozzolana cement (fly ash based) conforming to IS:1489 (Part 1)
- f) Portland slag cement conforming to IS:455

- g) Rapid Hardening Portland cement, conforming to IS:8041.
- h) Low heat Portland cement conforming to IS:12600

Cement of 33 grade conforming to IS:269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 450 Kg/cum of concrete (excluding any mineral admixture).

Cements of 43 and 53 grades conforming to IS:8112 and IS:12269 respectively may be used provided the minimum cement content mentioned elsewhere from durability considerations, is not reduced.

Sulphate resisting cement conforming to IS:12330 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. The recommended threshold values as per IS:456 are: sulphate concentration in excess of 0.2 percent in surrounding soil or 300 ppm (0.03 percent) in ground water. Cement conforming to IS:12330 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 450 kg/cum (excluding any mineral admixture).

Alternatively, Portland slag cement conforming to IS:455 with slag content more than 50 percent can be used instead of sulphate resisting cement when the sulphate content in the surrounding soil is less than 1 percent or the sulphate content in the ground water is less than 2500 ppm.

Cement conforming to IS:8041 shall be used only for precast concrete products after specific approval of the Engineer.

Total chloride content shall be 0.1 percent by mass of cement for the cement to be used in structures other than prestressed concrete structures and 0.05% by mass of cement in prestressed concrete structures. Also, total sulphur content calculated as sulphuric anhydride ( $\text{SO}_3$ ) shall in no case exceed 3.5 percent.

Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with  $\text{C}_3\text{A}$  content from 5 to 8 percent shall be preferably used in concrete, instead of sulphate resisting cement.

Manufacturer's test certificate shall be submitted to the Engineer by the contractor for every consignment of cement. The certificate shall cover all the tests for chemical requirements, physical requirements and chloride content as per relevant codes as applicable.

Independent tests of samples drawn from the consignment, shall be carried out at the site laboratory or in an independent laboratory approved by the Engineer, immediately after delivery. The following properties shall be tested:

- i) Compressive strength.
- ii) Setting time.

The cost of the tests shall be borne by the Contractor.

Cement in bags in local storage for more than 3 months after completion of tests, may be re-tested for compressive strength and setting times (initial and final) before use and may be rejected if it fails to conform to any of the requirements.

Lot size for independent testing of cement at site shall be the quantity received at site on any day, subject to a maximum of 500 tonnes.

### **1007 Coarse Aggregates**

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other approved inert material. They shall not contain pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregates having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS:2386, Parts I to VIII.

The contractor shall submit for the approval of the Engineer, the entire information indicated in Appendix A of IS:383.

Maximum nominal size of coarse aggregate for various structural components in PCC, RCC or PSC, shall conform to Section 1700 of these Specifications.

The maximum value for flakiness index for coarse aggregate shall not exceed 35 percent.

The coarse aggregate shall satisfy the requirements of grading as given in Table 1000-1:

**table 1000-1 : grading requirements of coarse aggregate**

| is sieve size | percentage passing for graded aggregate of nominal size |          |          |
|---------------|---|----------|----------|
|               | 40 mm   | 20 mm    | 12.5 mm  |
| 63 mm         | —   | —        | —        |
| 40 mm         | 95 – 100  | 100      | —        |
| 20 mm         | 30 – 70   | 95 – 100 | 100      |
| 12.5 mm       | —   | —        | 90 – 100 |
| 10 mm         | 10 – 35   | 25 – 55  | 40 – 85  |
| 4.75 mm       | 0 – 5   | 0 – 10   | 0 – 10   |

### **1008 Fine Aggregates**

For masonry work, sand shall conform to the requirements of IS:2116. Natural sand, crushed stone sand or crushed gravel sand or a suitable combination of natural sand, crushed stone or gravel, shall be used as fine aggregates in plain, reinforced and prestressed concrete works. The fine aggregates shall be dense, durable, clean and free from veins and adherent

coating and other deleterious substances. They shall not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Mechanised sand washing machines should be used to remove impurities from sand. Fine aggregates having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS:383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5. Fine aggregate for structural concrete shall conform to the following grading requirements:

**Table 1000-2 : grading requirements of fine aggregates**

| is sieve size | percent passing for |                 |                  |
|---------------|---------------------|-----------------|------------------|
|               | grading Zone i      | grading Zone ii | grading Zone iii |
| 10 mm         | 100                 | 100             | 100              |
| 4.75 mm       | 90-100              | 90-100          | 90-100           |
| 2.36 mm       | 60-95               | 75-100          | 85-100           |
| 1.18 mm       | 30-70               | 55-90           | 75-100           |
| 600 micron    | 15-34               | 35-59           | 60-79            |
| 300 micron    | 5-20                | 8-30            | 12-40            |
| 150 micron    | 0-10                | 0-10            | 0-10             |

**Note :** When the grading falls outside the limits of any particular grading zone of sieves other than 600-micron IS Sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. However for crushed stone sand, the permissible limit on 150-micron IS Sieve is increased to 20 percent. Reference shall be made to Clause: 4.3 of IS:383.

## **1009 Steel**

### **Cast Steel**

The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS:1030. In case where subsequent welding is unavoidable in the relevant cast steel components, the letter N at the end of the grade designation of the steel casting shall be replaced by letter W. To increase the corrosion resistance properties, 0.3% to 0.5% copper may be added.

### **Steel For Prestressing**

The prestressing steel shall conform to any one of the following standards:

- a) Plain hard drawn steel wire conforming to IS:1785 (Part I) and IS:1785 (Part II)
- b) Cold drawn indented wire conforming to IS:6003

- c) High tensile steel bar conforming to IS:2090
- d) Uncoated stress relieved strands conforming to IS:6006
- e) Uncoated stress relieved low relaxation seven ply strand conforming to IS:14268

Data in respect of modulus of elasticity, relaxation loss at 1000 hours, minimum ultimate tensile strength, stress strain curve etc. shall be obtained from the manufacturer. Pre-stressing steel shall be subjected to acceptance tests prior to actual use in the works.

## Reinforcement/Untensioned Steel

### Reinforcing Bars

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, the reinforcement/untensioned steel as the case may be, shall consist of the following grades of reinforcing bars.

**Table 1000-3 : grades of reinforcing Bars**

| grade designation | Bar type conforming to governing Specifications | is characteristic | elastic Modulus |
|-------------------|---|-------------------|-----------------|
| Fe240             | IS:432 Part I Mild Steel                        | 240               | 200             |
| Fe 415            | IS:1786 High Strength Deformed Steel Bars       | 415               | 200             |
| Fe 500 or Fe 500D | IS:1786 High Strength Deformed Steel Bars       | 500               | 200             |
| Fe 550 or Fe 550D | IS:1786 High Strength Deformed Steel Bars       | 550               | 200             |
| Fe 600            | IS:1786 High Strength Deformed Steel Bars       | 600               | 200             |

**Note :** If any grade of steel given in the above table is not available steel of next higher grade may be used.

All steel shall be procured from 'Original producers' who manufacture billets directly from iron ores and roll the billets to produce steel conforming to IS:1786. No re-rolled steel shall be incorporated in the works. However, in case the original producers give certificate that they are unable to supply the steel within the required time period or that they are not producing bars of the required diameter, the Engineer may allow the procurement of steel from other suppliers, provided that the reinforcement is manufactured from billets procured from the original producers. In such cases, the manufacturer's certificate alone shall not be considered as sufficient and the steel shall be got tested by the Engineer in the NABL accredited laboratories only, as a third party check. It shall be ensured that all the test results conform to IS:1786 requirements

Only new steel shall be delivered to the site. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bars shall be discarded. Bars with cracked ends shall be discarded

For the steel procured from original producers also, the Engineer / Employer may carry out occasional checks on materials through third party as mentioned above, for confirming

the test results shown in the certificates, in case of any doubt regarding the quality of steel supplied.

### **Coating of Reinforcing Bars**

#### **Fusion Bonded Epoxy Coated Reinforcement**

Fusion bonded epoxy coated reinforcement shall conform to IS:13620 or other international standards as approved by Engineer. The location of the source of supply of the coated bars shall be such as to ensure that the bars are not transported for a distance of more than 300 Km.

Additional requirements for the use of such reinforcement bars are given below:

- a) Patch up materials shall be procured in sealed containers with certificates from the agency who has supplied the fusion bonded epoxy bars.
- b) PVC coated G.I. binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.
- c) Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.
- d) The cut ends and damaged portions shall be touched up with repair patch up material.
- e) The bars shall be cut by saw-cutting and not by flame cutting.
- f) While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.
- g) The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethylene sheets or such other approved materials.
- h) While concreting, the workmen or trolley shall not move directly on coated bars but shall move only on wooden planks placed on the bars.

#### **Hot Dipped Galvanized Bars**

Hot dipped galvanized reinforcing steel shall be provided wherever specified. The coating shall conform to IS:12594–1988.

#### **Grey Iron Castings**

Grey Iron castings to be used for bearings shall have the following minimum properties:

|      |                                   |            |
|------|-----------------------------------|------------|
| i)   | Minimum ultimate tensile strength | 370 MPa    |
| ii)  | Modulus of Elasticity             | 147000 MPa |
| iii) | Brinell Hardness                  | 230 MPa    |



|     |                      |          |
|-----|----------------------|----------|
| iv) | Shear Strength       | 370 MPa  |
| v)  | Compressive Strength | 1370 MPa |

The testing shall be as specified in IS:210.

### **Steel Forgings**

Forged steel pins shall comply with clause 3, 3A or 4 of IS:1875 and steel forgings shall comply with clause 3, 3A or 4 of IS:2004. Raw materials of the forging shall be as per IS:1875 with minimum reduction ratio of 1.8:1. Alternatively, if forging is made from ingot, the minimum reduction ratio shall be 4:1. Forging shall be normalized.

### **Structural Steel**

Unless otherwise permitted, all structural steel shall, before fabrication, comply with the requirements of the following Indian Standards:

|          |   |   |
|----------|---|---|
| IS:226   | : | Structural Steel (Standard Quality)   |
| IS:961   | : | Structural Steel (High Tensile)   |
| IS:2062  | : | Weldable Structural Steel   |
| IS:8500  | : | Weldable Structural Steel (medium and high strength qualities)                              |
| IS:1148  | : | Hot rolled rivet bars (upto 40 mm dia) for structural purposes                              |
| IS:1149  | : | High tensile rivet bars for structural purposes   |
| IS:1161  | : | Steel tubes for structural purposes   |
| IS:4923  | : | Hollow Steel sections for structural use  |
| IS:11587 | : | Structural weather resistant steel  |
| IS:808   | : | Specifications for Rolled Steel Beam, Channel and Angle Sections                            |
| IS:1239  | : | Mild Steel Tubes  |
| IS:1730  | : | Dimension for Steel Plate, sheet and strip for structural and general Engineering purposes. |
| IS:1731  | : | Dimension for Steel flats for structural and general engineering purposes                   |
| IS:1732  | : | Dimension for round and square steel bars for structural and general engineering purposes.  |
| IS:1852  | : | Rolling and cutting tolerances for hot rolled steel products                                |

The use of structural steel not covered by the above standards may be permitted with the specific approval of the Engineer. Refer to Section 1900 of these Specifications for further details.

### **Stainless Steel**

Stainless steel shall be austenitic chromium-nickel steel, possessing rust, acid and heat resistant properties conforming to IS:6603 and IS:6911. Mechanical properties/grade for such



stainless steel shall be as specified by the accepting authority, but in no case inferior to mild steel. Generally, stainless steel is available as per AISI grades. AISI 304 which is equivalent to grade 04 Cr 18 Ni 110 of IS:6911 satisfies the requirements for mechanical properties of structural steel. Other grades of stainless steel for specific purposes may be provided as per specific requirements. For application in adverse/corrosive environment, stainless steel shall conform to AISI 316L or 02G17 Ni Mo2 of IS:6911.

### **1010 Water**

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

In case of doubt regarding development of strength, the suitability of water proposed to be used for the production of concrete shall be ascertained by carrying out tests for the compressive strength of concrete and initial setting time of cement using the same water.

The sample of water taken for testing shall represent the water proposed to be used for concreting, taking into account seasonal variations, if any. The sample shall not receive any treatment before testing other than that being given to the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

Average 28 days compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS:516.

The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not be more than 30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS:4031 (Part 5).

pH value of water shall not be less than 6. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted.

As a guide, the following concentrations represent the maximum permissible values:

- a) To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. For details of test refer IS:3025(Part 22).
- b) To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal.  $H_2SO_4$ . For details of test refer IS: 3025(Part 23).
- c) The Permissible limit's for solids shall be as follows

|                  | Tested as Per  | Permissible Limit max  |
|------------------|----------------|--|
| Organic          | IS:3025(Pt.18) | 200 mg/lit   |
| Inorganic        | IS:3025(Pt.18) | 3000 mg/lit  |
| Sulphates (SO )  | IS:3025(Pt.28) | 400 mg/lit   |
| Chlorides (Cl)   | IS:3025(Pt.32) | 2000 mg/lit for concrete work not<br>containing embedded steel and<br>500 mg/lit for prestressed/reinforced<br>concrete work |
| Suspended matter | IS:3025(Pt.17) | 2000 mg/lit  |

All samples of water (including potable water) shall be tested and suitable measures taken, where necessary, to ensure conformity of the water to the requirements stated herein.

### 1011 Timber

The timber used for structural purposes shall conform to IS:883.

### 1012 Concrete Admixtures general

Admixtures may be added to the concrete before or during mixing with a view to modifying one or more of the properties of concrete in the plastic or hardened state.

#### Mineral admixtures

Any of the following mineral admixtures may be used as part replacement of Portland Cement with the approval of the Engineer.

**fly ash:** conforming to of IS:3812-3

**granulated slag:** Ground granulated slag obtained by grinding granulated slag conforming to IS:12089.

**silica fume:** Silica fume is very fine, non- crystalline SiO<sub>2</sub> , obtained as a by-product of Silicon and Ferro – Silicon alloy industries and shall conform to IS:15388

#### Chemical Admixtures

##### Information Required From The Manufacturer

Chemical admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

The contractor shall provide the following information concerning each admixture, after obtaining the same from the manufacturer:

- a) Normal dosage and detrimental effects, if any, of under dosage and over dosage.
- b) The chemical names of the main ingredients.
- c) The chloride content, if any, expressed as a percentage by weight of the admixture.
- d) Values of dry material content, ash content and relative density which can be used for Uniformity Tests.
- e) Whether it leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
- f) Confirmation regarding its compatibility with type of cement.
- g) Whether it increases the risk of corrosion of reinforcement or other embedments.
- h) Whether it affects the durability of concrete adversely.

### **Physical and Chemical Requirements**

Admixtures shall conform to the requirements of IS:9103. In addition, the following conditions shall be satisfied.

- a) "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".
- b) Except where resistance to freezing and thawing and to disruptive action of deicing salts is required, the air content of freshly mixed concrete in accordance with the pressure method given in IS:1199, shall not be more than 2 percent higher than that of the corresponding control mix and in any case not more than 3 percent of the test mix.
- c) The chloride content of the admixtures shall not exceed 0.2 percent when tested in accordance with IS:6925. In addition, the maximum permissible limit of chloride content of all the constituents as indicated in Section 1700 of these Specifications shall also not be exceeded.
- d) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

The tests that shall be performed along with permissible variations are as follows:

- i) Dry Material Content : within 3 percent and 5 percent of liquid and solid

- ii) Ash content : within 1 percent of the value stated by the manufacturer.
- iii) Relative Density (for liquid admixtures) : within 2 percent of the value stated by the manufacturer.
- e) All tests relating to concrete admixtures shall be conducted periodically at an independent laboratory and the results compared with the data given by the manufacturer.

### **1013 Reinforced and Prestressed Concrete Pipes**

Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS:458. Prestressed concrete pipes (NP4) conforming to IS: 784 can also be used depending on the requirement.

### **1014 Storage of Materials**

#### **General**

All materials shall be stored at proper places so as to prevent their deterioration, intrusion of foreign matter and ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and re-storage of the materials. All such materials, even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

#### **Bricks**

Bricks shall not be dumped at site, but shall be stacked in regular tiers as they are unloaded, to minimize breakage and defacement. Bricks selected for use in different situations shall be stacked separately. Sufficient supply of bricks as required for the works, shall be available at site at any time.

#### **Aggregates**

Aggregate stockpiles may be made on ground that is hard, well drained and devoid of vegetation.

Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25 mm or less and 3 sizes when the nominal size is 32 mm or more). In case of aggregates placed directly on the ground the material in the stock pile only up to a level of 30 cm above the ground level shall be taken out and used initially. Remaining material shall be permitted to be used in the final stages of work only after it has been fully cleaned.

#### **Cement**

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked to a height of not more than eight bags. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirement at site. The containers shall be cleaned at least once every 3 months.

Cement shall be used in the sequence in which it is delivered at site. Each consignment shall

be stored separately so that it may be readily identified and inspected. Any consignment or part of a consignment of cement which has deteriorated in any way during storage, shall not be used in the works and shall be removed from the site by the Contractor at his own cost.

The Contractor shall prepare and maintain proper records at site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Engineer at all times.

The Contractor shall submit a monthly return to the Engineer showing the quantities of cement received and issued during the month and in stock at the end of the month.

### **Reinforcement/Untensioned Steel**

The reinforcement bars, shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

### **Prestressing Materials**

All prestressing steel, sheathing, anchorages and sleeves or couplers shall be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories shall be stored under cover from rain or damp ground and protected from the ambient atmosphere if it is likely to be aggressive. Period of storage at site must be kept to the absolute minimum.

- a) **tendons** : Wires, strands and bars from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances shall tendon material be subjected to any welding operation or on site heat treatment or metallic coating such as galvanizing. Storage facilities and the procedures for transporting material into or out of the store, shall be such that the material does not become kinked or notched. Wires or strands shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 3 m dia without breaks or joints shall be obtained from manufacturer. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.
- b) **anchorage components** : The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The corrosion of the gripping and securing system shall be prevented. The use of correctly formulated oils and greases or of other corrosion preventing material,

shall be guaranteed by the producer to be non-aggressive and non-degrading.

Prestressing steel which shall be absolutely clean and without any signs of rust, shall be stored in a closed store having single door with double locking arrangements and no windows. The air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer, so as to eliminate the possibility of initial rusting of prestressing steel during storage. Instrument measuring the air humidity shall be installed inside the store. The prestressing steel shall be coated with water-soluble grease.

All prestressing steel shall be stored at least 300 mm above ground level and shall be invariably wrapped with a protective covering of tar paper or polythene or any other approved material.

The Contractor should ensure that prestressing steel is used within 3 months of its manufacture. He should chalk out his prestressing programme in such a manner as to avoid the possibility of initial corrosion before placing in position.

### **Water**

Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion of foreign matter or growth of organic matter. Use of water from shallow, muddy or marshy sources, shall not be permitted. The intake pipe shall be suitably enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

### **1015 Tests And Standard Of Acceptance**

All materials, even though stored in an approved manner shall be subjected to an acceptance test in accordance with the relevant IS specification prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at site or in the laboratory approved by the Engineer before use. Any cement with lower quality than that shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

### **Testing and Approval of Material**

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant specifications. The testing of all the materials shall be carried out by the Engineer for which the shall make all the necessary arrangements and bear the entire cost.

Test which cannot be carried out in the field laboratory have to be got done at the Contractor's cost at any recognized laboratory/testing establishments approved by the Engineer.

### **Sampling of Materials**

Samples provided to the Engineer for inspection are to be in labelled boxes suitable for

storage.

Samples required for testing and approval must be supplied well in advance by at least 48 hours or before the minimum period required for carrying out the relevant tests. Delay to works arising from the late submission of samples, will not be acceptable as a reason for delay in completion of the works.

If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

### **1015.3 Rejection of Materials not Conforming to the Specifications.**

Any stack or batch of material(s) of which sample(s) does (do) not conform to the prescribed tests and quality shall be rejected by the Engineer and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any rectifications.

### **1015.4 Testing And Approval Of Plant And Equipment**

All plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works, shall be in accordance with manufacturer's specifications and shall be got approved by the Engineer before use

## **1501 DESCRIPTION**

Formwork shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish, as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

## **1502 MATERIALS**

All materials shall comply with the requirements of IRC:87. Materials and components used for formwork shall be examined for damage or excessive deterioration before use/re-use and shall be used only if found suitable after necessary repairs. In case of timber formwork, the inspection shall not only cover physical damages but also signs of attacks by decay, rot or insect attack or the development of splits.

Forms shall be constructed with metal or timber. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or steel or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4 mm. Other materials conforming to the requirements of IRC:87 may also be used if approved by the Engineer.

## **1503 DESIGN OF FORMWORK**

**1503.1** The design, erection and removal of formwork shall conform to IRC:87

"Guidelines for Formwork, Falsework and Temporary Structures" and these specifications. The forms shall be such as to ensure that they can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of formwork for inspection.

**1503.2** The Contractor shall furnish the design and drawing of complete formwork

(i.e. the forms as well as their supports) for approval of the Engineer before any erection is taken up. If proprietary system of formwork is used, the Contractor shall furnish detailed information as per Appendix 1500/I, to the Engineer for approval.

Notwithstanding any approval or review of drawing and design by the Engineer, the Contractor shall be entirely responsible for the adequacy and safety of formwork.

**1503.3** In the case of prestressed concrete superstructure, careful consideration shall be given to redistribution of loads on props due to prestressing.

## **1504 WORKMANSHIP**

**1504.1** The formwork shall be robust and strong and the joints shall be leak-proof.

Bellies shall not be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Staging shall be provided with an appropriately designed base plate resting on firm strata.

**1504.2** The number of joints in the formwork shall be kept to a minimum by using large sized panels. The design shall provide for proper "soldiers" to facilitate alignment. All joints shall be leak proof and must be properly sealed. Use of PVC joint sealing tapes, foam rubber or PVC 1-section, is essential to prevent leakage of grout.

**1504.3** As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of nails shall be used and these shall be of the double-headed type. Alternatively, if the nails are of the normal type, they shall be left partially projecting without being driven to their full length, so that they can be withdrawn easily.

**1504.4** Use of ties shall be restricted, as far as practicable. Wherever ties are used they shall be used with HDPE sheathing so that they can easily be removed. No parts prone to corrosion shall be left projecting or near the surface. The sheathing shall be grouted with cement mortar of the same strength as that of the structure.

**1504.5** Unless otherwise specified, or directed, chamfers or fillets of size 25 mm x 25 mm shall be provided at all angles of the formwork to avoid sharp corners. The chamfers, beveled edges and mouldings shall be made in the formwork itself. Opening for fixtures and other fittings shall be provided in the shuttering as directed by the Engineer.

**1504.6** Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings to permit inspection and cleaning out before placing of concrete.

**1504.7** The formwork shall be constructed with pre-camber to the soffit to allow for deflection of the formwork. This shall be in addition to the pre-camber for the permanent structure as shown on the drawings.

**1504.8** Where centering trusses or launching trusses are adopted for casting of



superstructure, the joints of the centering trusses, whether welded, riveted or bolted shall be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion. Launching truss, casting truss of span more than 40 m and travelling forms, shall be load tested before they are put to use.

**1504.9** The formwork shall be so made as to produce a finished concrete true to shape, line and levels and dimensions as shown on the drawings, subject to the tolerances specified in respective Sections of these specifications, or as directed by the Engineer.

**1504.10** Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plane surface. Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of concrete.

**1504.11** Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete.

**1504.12** The formwork shall ensure the correct final shape of the structure, with the calculated amount of positive or negative camber. The deformation of falsework, scaffolding or propping and the instantaneous or deferred deformation due to various causes arising in prestressed structures, shall be properly accounted for.

**1504.13** Suitable camber shall be provided to horizontal members of structure, specially in long spans, to counteract the effects of deflection. The formwork shall be so fixed as to provide for such camber.

**1504.14** The formwork shall be coated with an approved release agent that will effectively prevent sticking and will not stain the concrete surface. Lubricating oils (machine oils) shall be prohibited for use as coating.

## **1505 LINING OF FORMWORK**

The formwork shall be lined with material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and shall be so fixed to its backing as not to impart any blemishes. It shall be of the same type and obtained from only one source throughout for the construction of any one structure. The contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts shall be carefully detailed and their use shall be subject to the approval of the Engineer.

## **1506 PRECAUTIONS**

The following precautions shall be observed:

i) It shall be ensured that any cut-outs or openings provided in any structural member to facilitate erection of formwork, are closed with the same grade of concrete as that of the structure, after formwork is removed.

- ii) Provision for safe access to the formwork shall be, made at all levels as required.
- iii) Close watch shall be maintained to check for settlement of formwork during concreting and any settlement shall be promptly rectified.
- iv) Natural ground shall be checked for bearing capacity and likely settlement before erection of the staging.
- v) It shall be ensured that water used for curing or rain water does not stagnate near the base plate of the staging.
- vi) For shutters used for deep and narrow member, temporary openings in the sides shall be provided to facilitate pouring and compaction of concrete.

#### **1507 PREPARATION OF FORMWORK BEFORE CONCRETING**

The inside surfaces of forms shall, except in the case of permanent formwork or where otherwise agreed to by the Engineer, be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the formwork. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in contact with any reinforcement or prestressing tendons and . anchorages. Different release agents shall not be used in formwork for exposed concrete.

Before re-use of forms, the following actions shall be taken :

- i. The contact surfaces of the forms shall be cleaned carefully and dried before applying a release agent.
- ii. It should be ensured that the release agent is appropriate to the surface to be coated. The same type and make of release agent shall be used throughout on similar formwork materials and different types should not be mixed.
- iii. The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess wiped out.
- iv. It shall be ensured that the reinforcement or the surface of the hardened concrete shall not come in contact with the release agent.

All forms shall be thoroughly cleaned immediately before concreting.

The Contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and approve the formwork. However, such inspection shall not relieve the contractor of his responsibility for safety of formwork, men, machinery, materials and finish or tolerances of concrete.

#### **1508 REMOVAL OF FORMWORK**

The scheme for removal of formwork (i.e. de-shuttering and de-centering) shall be planned in advance and furnished to the Engineer for scrutiny and approval. No formwork or any part thereof shall be removed without prior approval of the Engineer.

The formwork shall be so removed as not to cause any damage to concrete. Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually to avoid any shock or vibration.

Form work shall not be released unless the concrete has achieved strength of at least twice

the stress the concrete may be subjected at the time of the removal of formwork. When no test is conducted for determination of strength of concrete and where the time of removal of formwork is not specified, the same shall be as under :

|    |   |  |
|----|---|--|
| a) | Walls, piers, abutments, columns and vertical faces of structural members | 12 to 48 hours as may be decided by the Engineer |
| b) | Soffits of Slabs (with props left under)                                  | 3 days   |
| c) | Props left under slabs  | 14 days  |
| d) | Soffits of Girders (with props left under)                                | 7 days   |
| e) | Props (left under girders)  | 21 days  |

The above time schedule is applicable when ordinary Portland Cement is used without any admixtures at an ambient temperature exceeding 10°C.

For concrete made with Portland pozzolona cement, Portland slag cement or mineral admixtures, additional cube samples shall be taken for verifying the strength of concrete to decide the time of deshuttering.

Where there are re-entrant angles in the concrete sections, the formwork should be removed at these sections as soon as possible after the concrete has set, in order to avoid cracking due to shrinkage of concrete.

Additional precautions as given in Clause 8.17 of IRC: 87, shall also be followed.

#### **1509 RE-USE OF FORMWORK**

When the formwork is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination shall always be carried out before their use again. Before re-use all components shall be cleaned of deposits of soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning.

All bent steel props shall be straightened before re-use. The maximum permissible deviation from straightness is 1/600 of the length. The maximum permissible axial loads in used props shall be suitably reduced depending upon their condition. The condition of the timber components, plywood and steel shuttering plates shall be examined closely for distortion and defects before re-use.

#### **1510 SPECIALISED FORMWORK**

Specialised formwork such as slipform, floating caisson and travelling form, wherever used shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions supplied to the Engineer. In case proprietary equipment is used, the supplier shall furnish drawings, details, installation instructions etc, in the form of manuals along with the formwork.

For slipform, the rate of climb of the formwork shall be designed for each individual case taking into account various parameters including the grade of concrete, concrete strength, concrete temperature, ambient temperature and concrete admixtures.

For floating caisson, the details of fabrication, floating to site and placing in position shall be as given in Clause 1203.5 of these Specifications.

In order to verify the time and sequence of striking/removal of specialised formwork, routine field tests for the consistency and strength development of concrete are mandatory.

For specialised formwork, the form lining material may be either plywood or steel sheet of appropriate thickness.

### **1511 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.

### **1512 MEASUREMENTS FOR PAYMENT**

Unless stated otherwise, the rate for concrete in plain concrete or reinforced concrete or prestressed concrete, shall be deemed to include all formwork required in accordance with this Section, which shall not be measured separately.

Where it is specifically stipulated in the Contract that the formwork shall be paid for separately, measurement of formwork shall be taken in square metres of the surface area of concrete which is in contact with formwork.

### **1513 RATE**

The unit rate of plain concrete or reinforced concrete or prestressed concrete as defined in respective Sections of these Specifications, shall be deemed to cover the costs of all formwork and staging, including cost of all materials, labour, tools and plant required for design, construction and removal of formwork and supervision as described in this Section including properly supporting the members until the concrete is cured, set and hardened as required.

Where the contract unit rate for formwork is specially provided as a separate item in the contract, it shall include the cost of all materials, labour, tools and plant required for design, construction and removal of formwork and supervision as described in this Section including properly supporting the members until the concrete is cured, set and hardened as required.

### **1701 DESCRIPTION**

The work shall consist of producing, transporting, placing and compacting of structural concrete including fixing formwork and temporary works etc. and incidental construction in accordance with these Specifications and in conformity with the lines, grades and dimensions, as shown on the drawings or as directed by the Engineer.

### **1702 MATERIALS**

All materials shall conform to Section 1000 of MORTH SPECIFICATION 5th Revision.

### **1703 GRADES OF CONCRETE**

1703.1 The grades of concrete shall be designated by the characteristic strength as given in Table 1700-1, where the characteristic strength is defined as the strength of concrete below which not more than 5 percent of the test results are expected to fall.

Table 1700-1: Grades of Concrete

| Type of Concrete/Grade designation |                   |                           | Characteristic strength in MPa |
|------------------------------------|-------------------|---------------------------|--------------------------------|
| nominal Mix Concrete               | standard Concrete | High Performance Concrete |                                |
| M15                                | M15               |                           | 15                             |
| M20                                | M20               |                           | 20                             |
|                                    | M25               |                           | 25                             |
|                                    | M30               | M30                       | 30                             |
|                                    | M40               | M35                       | 35                             |
|                                    | M45               | M40                       | 40                             |
|                                    | M50               | M45                       | 45                             |
|                                    |                   | M50                       | 50                             |
|                                    |                   | M55                       | 55                             |
|                                    |                   | M60                       | 60                             |
|                                    |                   | M65                       | 65                             |
|                                    |                   | M70                       | 70                             |
|                                    |                   | M75                       | 75                             |
|                                    |                   | M80                       | 80                             |
|                                    |                   | M85                       | 85                             |
|                                    |                   | M90                       | 90                             |

1. Normal Mix Concrete is made on the basis of nominal mix proportioned by weight of its main ingredients - cement, coarse and fine aggregates and water.
2. Standard concrete is made on the basis of design mix proportioned by weight of its ingredients, which in addition to cement, aggregates and water, may contain chemical admixtures to achieve certain target values of various properties in fresh condition, achievement of which is monitored and controlled during production by suitable tests. Generally concrete of grades up to M50 are included in this type.
3. High Performance Concrete is similar to standard concrete but contains additional one or more mineral admixtures providing binding characteristics and partly acting as inert filler material which increases its strength, reduces its porosity and modifies its other properties in fresh as well as hardened condition. Concrete of grades upto M90 are included in this type.
4. For concrete of grades higher than M90, the design parameters may be obtained from specialized literature and experimental results.

The minimum grades of concrete and corresponding minimum cement content and maximum water/cement ratios for different exposure conditions shall be as indicated in Table 1700-2.

For concrete subjected to sulphate attack the minimum grades of concrete, minimum cement content and maximum water/cement ratios and types of cement for different concentration of sulphate content shall be as indicated in Table 1700-3.

Table 1700-2: Requirement of Concrete for Different Exposure Condition using 20 mm Aggregate

| exposure Condition | Maximum Water Cement Ratio | Minimum Cement Content, kg/m <sup>3</sup> | Minimum Grade of Concrete |
|--------------------|----------------------------|---|---------------------------|
| Moderate           | 0.45                       | 340                                       | M25                       |
| Severe             | 0.45                       | 360                                       | M30                       |
| Very Severe        | 0.40                       | 380                                       | M40                       |

Note:

1. All three provisions given in the above table for a particular exposure condition, shall be satisfied.
2. The term cement for maximum w/c ratio and minimum cement content shown in Table includes all cementitious materials mentioned in Clause 1715.2. The maximum limit of flyash and ground granulated blast furnace slag in the blended cement shall be as specified in 18:1489 (Part 1) and 18:455 respectively.
3. For plain cement concrete, with or without surface reinforcement, the minimum grade of concrete can be lowered by 5 MPa and maximum water/cement ratio exceeded by 0.05.

Cement content shown in the above table shall be increased by 40 kg/m<sup>3</sup> for use of 12.50 mm nominal size aggregates and decreased by 30 kg/m<sup>3</sup> for use of 40 mm nominal size aggregates.

Table 1700-3: Requirement of Concrete Exposed to Sulphate Attack

| Class | Concentration of sulphates as so |                                    |                      | type of Ceme nt (note ii) | Minimu m Cement Content , kg/m <sup>3</sup> | Maximu m Water / Cement Ratio | Minimu m Grade of Concret e |
|-------|----------------------------------|------------------------------------|----------------------|---------------------------|---|-------------------------------|-----------------------------|
|       | in soils                         |                                    | in Ground Water, g/l |                           |   |                               |                             |
|       | total so , %                     | so in 2:1 Water: soil extract, g/l |                      |                           |   |                               |                             |
| 1)    | Traces                           | < 1.0                              | < 0.3                | -OPC, PPC or PSC          | 280   | 0.5                           | M25                         |
| 2)    | 2.0 to 0.5                       | 1.0 to 1.9                         | 0.3 to 1.2           | -OPC, PPC or PSC -SRPC    | 330   | 0.5                           | M25                         |
| 3)    | 0.5 to 1.0                       | 1.9 to 3.1                         | 1.2 to 2.5           | -SRPC, -PPC or PSC        | 330<br>350                                  | 0.5<br>0.45                   | M25<br>M30                  |
| 4)    | 1.0 to 2.0                       | 3.1 to 5.0                         | 2.5 to 5.0           | -SRPC                     | 370   | 0.45                          | M35                         |

|    |      |      |      |  |     |     |     |
|----|------|------|------|--|-----|-----|-----|
| 5) | >2.0 | >5.0 | >5.0 | -SRPC<br>with<br>protecti<br>ve<br>coating | 400 | 0.4 | M40 |
|----|------|------|------|--|-----|-----|-----|

Note: If the requirements of maximum water/cement ratio, minimum grade of concrete and minimum cement content from other durability considerations as given in Table 1700-2 are more stringent than those given in this table, then the former will govern.

OPC: Ordinary Portland Cement, PPC: Portland Pozzolona Cement. PSC: Portland Slag Cement, SRPC: Sulphate Resisting Portland cement.

The minimum cement content shall be as low as possible but not less than the quantities specified in Table 1700-2 and 1700-3.

The maximum cement content excluding any mineral admixtures (Portland cement component alone) shall not exceed 450 kg/cu.m.

Concrete used in any component or structure shall be specified by designation along with prescribed method of design of mix i.e. 'DesignMix' or 'NominalMix'. For all items of concrete, only design mix shall be used, except where nominal mix concrete is permitted as per drawing or by the Engineer. Nominal mix may be permitted only for minor bridges and culverts or other incidental construction, where strength requirements are up to M 20 only. Nominal mix may also be permitted for non-structural concrete or for screed below open foundations.

If the Contractor so proposes, the Engineer may permit the use of concrete of higher grade than that specified on the drawing, provided the higher grade concrete meets the specifications applicable. The additional cost of such higher grade concrete shall be borne by the Contractor.

## **1704 PROPORTIONING OF CONCRETE**

Prior to the start of construction, the Contractor shall design the mix in case of design mix concrete or propose nominal mix in case of nominal mix concrete, and submit to the Engineer for approval, the proportions of materials, including admixtures to be used. Water-reducing admixtures (including plasticisers or super-plasticisers) may be used at the Contractor's option, subject to the approval of the Engineer.

### **1704.1 Requirements of Consistency**

The mix shall have the consistency which will allow proper placement and compaction in the required position. Every attempt shall be made to obtain uniform consistency. Slump test shall be used to measure consistency of the concrete.

The optimum consistency for various types of structures shall be as indicated in Table 1700-4, or as directed by the Engineer. The slump of concrete shall be checked as per IS:516.

Table 1700-4: Requirements of Consistency

| type | slump (mm) (at the time of Placing of Concrete) |
|------|---|
|------|---|

|    |   |           |
|----|---|-----------|
| 1) | a) Structure with exposed inclined surface requiring low slump concrete to allow proper compaction  | 25        |
|    | b) Plain cement concrete  | 25        |
| 2) | RCC structure with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining  | 40 – 50   |
| 3) | RCC structure with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts, well curb, well cap, walls with thickness greater than 300 mm | 50 – 75   |
| 4) | RCC and PSC structure with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm                                   | 75 – 125  |
| 5) | Underwater concreting through tremie e.g. bottom plug, cast in-situ piling  | 150 – 200 |

Notwithstanding the optimum consistency indicated against Sl. No. 1 to 3, the situation should be properly assessed to arrive at the desired workability with the adjustment of admixture in each case, where the concrete is to be transported through transit mixer and placed using concrete pump. Under these circumstances, the optimum consistency during placement for the items of work of Sl. No. 1 to 3, can be considered ranging from 75 mm to 150 mm. This is, however, subject to satisfying the other essential criteria of strength, durability etc. and approval of the Engineer.

### Requirements for Design Mixes

#### Target Mean Strength

The target mean strength of specimen shall exceed the specified characteristic compressive strength by at least the current margin.

1. The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.
2. Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Table 1700-5 :

**Table 1700-5: Current Margin for Initial Design Mix**

| Concrete Grade | Current Margin (MPa) | target Mean strength (MPa) |
|----------------|----------------------|----------------------------|
| M 15           | 10                   | 25                         |
| M 20           | 10                   | 30                         |
| M 25           | 11                   | 36                         |
| M 30           | 12                   | 42                         |
| M 35           | 12                   | 47                         |



|      |    |     |
|------|----|-----|
| M 40 | 12 | 52  |
| M 45 | 13 | 58  |
| M 50 | 13 | 63  |
| M 55 | 14 | 69  |
| M60  | 14 | 74  |
| M 65 | 15 | 80  |
| M 70 | 15 | 85  |
| M 75 | 15 | 90  |
| M 80 | 15 | 95  |
| M85  | 16 | 101 |
| M90  | 16 | 106 |

The initial current margin given in Table 1700-5 shall be used till sufficient data is available to determine the current margin as per Sub-Clause 1704.2.1 (i).

### **1704.2.2 Trial Mixes**

The Contractor shall give notice to the Engineer to enable him to be present at the time of carrying out trial mixes and preliminary testing of the cubes. Prior to commencement of trial mix design, all materials forming constituents of proposed design mix should have been tested and approval obtained in writing from the Engineer. Based on test results of material draft mix design calculation for all grades of concrete to be used in the works, shall be prepared after taking into account the provisions in the Contract Technical Specifications Guidelines of IS:10262, IS:SP:23 and IRC:112 and submitted to the Engineer for approval.' Prior to commencement of concreting, trial mix design shall be performed for all grades of concrete and trial mix which has been found successful, shall be submitted by the Contractor and approval obtained. During concreting with the approved trial mix design, if source of any constituents is changed, the mix design shall be revised and tested for satisfying the strength requirements. -

The initial trial mixes shall be carried out in a laboratory approved by the Engineer. However, Engineer may permit the initial trial mixes to be prepared at the site laboratory of the Contractor, if a full fledged concrete laboratory has been established well before the start of construction, to his entire satisfaction. Sampling and testing procedures shall be in accordance with these Specifications.

When the site laboratory is utilized for preparing initial mix design, the concrete production plant and means of transport employed to make the trial mixes shall be similar to those proposed to be used in the works.

For each trial mix, a set of six cubes shall be made from each of three consecutive batches for purposes of testing. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these Specifications. The mean strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

### 1704.2.3 Control of Strength of Design Mixes

#### Adjustment to Mix Proportions

Adjustment to mix proportions arrived at in the trial mixes, shall be made subject to the Engineer's approval, in order to minimize the variability of strength and to maintain the target mean strength. Such adjustments shall not be taken to imply any change in the current margin.

#### Change of Current Margin

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with clause 1704.2.1. The recalculated value shall be adopted as directed by the Engineer, and it shall become the current margin for concrete produced thereafter.

#### Additional Trial Mixes

In case any changes are observed in the properties of fresh concrete and/or strength of hardened concrete on the basis of early age tests, additional mixes and tests shall be carried out during production, so as to control and bring the quality of concrete within acceptable limits. In case of any change in the source or properties of materials, the design of mix shall be established afresh.

### 1704.3 Requirements of Nominal Mix Concrete

Requirements for nominal mix concrete unless otherwise specified shall be as given in Table 1700-6.

**Table 1700-6: Requirements for Nominal Mix Concrete**

| Concrete Grade | total Quantity of dry aggregate by Mass per 50 kg of Cement to be taken as the sum of individual Masses of Fine and Coarse aggregates (kg) | Proportion of Fine to Coarse aggregate (by Mass)                     | Maximum Quantity of Water for 50 kg of Cement (litres) |     |
|----------------|--|--|--|-----|
|                |  |  | PCC  | RCC |
| M 15           | 350  | Generally 1:2, subject to upper limit 1:1.5 and lower limit of 1:2.5 | 25   |     |
| M 20           | 250  |  | 25   | 22  |

#### Additional Requirements

Concrete shall meet any other requirements as specified on the drawing or as directed by the Engineer. The overall limits of deleterious substances in concrete shall be as follows:

- Total acid soluble chloride content in the concrete mix expressed as chloride ions shall not exceed the following values by mass of cement.

|  |              |
|--|--------------|
| Prestressed concrete   | 0.10 percent |
| Reinforced concrete (in severe, very severe or extreme exposure condition) | 0.20 percent |
| Reinforced concrete in moderate exposure                                   |              |

condition

0.30 percent

- b) The total water soluble sulphate content of the concrete mix expressed as SO<sub>3</sub>, shall not exceed 4 percent by mass of cement in the mix.

For concrete made with Portland pozzolona cement, Portland blast furnace slag cement or mineral admixtures, the setting time and rate of gain of strength are different from those for concrete made with OPC alone. Such modified properties shall be taken into account While deciding the de-shuttering time, curing period, early age loading and time of prestressing. Additional cube samples may be required to be taken for verifying the concrete properties.

#### **1704.5 Suitability of Proposed Mix Proportions**

The Contractor shall submit the following information for the Engineer's approval :

- a) Nature and source of each material
- b) Quantities of each material per cubic metre of fully compacted concrete
- c) Either of the following :
  - i. Appropriate existing data as evidence of satisfactory previous performance for the target mean strength, current margin, consistency and water/cement ratio and any other additional requirement (s) as specified.
  - ii. full details of tests on trial mixes.
- d) Statement giving the proposed mix proportions for nominal mix concrete

Any change in the source of material or in the mix proportions shall be subject to the Engineer's prior approval.

#### **1704.6 Checking of Mix Proportions and Water/Cement Ratio**

In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement per bag as given by the manufacturer is accepted, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed from bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

The specified water/cement ratio shall always be kept constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible, the frequency for a given job being determined by the Engineer according to the weather conditions. The amount of water to be added shall then be adjusted to compensate for variations in the moisture content. For the determination of moisture content in the aggregates 18:2386 (Part III) shall be referred. Suitable adjustments shall also be made in the weight of aggregates to allow for their variation in weight due to variation in their moisture content.

#### **1704.7 Grading of Aggregates for Pumped Concrete**

Materials for pumped concrete shall be batched consistently and uniformly. Maximum size of aggregate shall not exceed one-third of the internal diameter of the pipe.

The grading of aggregates shall be continuous and shall have sufficient ultra fine materials (material finer than 0.25 mm). Proportion of fine aggregates passing through 0.25 mm shall be

between 15 and 30 percent and that passing through 0.125 mm sieve shall not be less than 5 percent of the total volume of aggregate. Admixtures to increase workability can be added. When pumping long distances and in hot weather, set-retarding admixtures can be used. Fluid mixes can be pumped satisfactorily after adding plasticisers and super plasticisers. Suitability of concrete shall be verified by trial mixes and by performing pumping test.

## **1705 ADMIXTURES**

### **1705.1 Chemical Admixtures**

Chemical admixtures such as superplasticisers, or air entraining, water reducing, accelerating and retarding agents for concrete, may be used with the approval of the Engineer.

As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of their products only after obtaining complete information of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the work. Admixtures/additives conforming to IS:9103 may be used subject to approval of the Engineer. However, admixtures/additives generating hydrogen or nitrogen and containing chlorides, nitrates, sulphides, sulphates or any other material likely to adversely affect the steel or concrete, shall not be permitted. i

The general requirements for admixtures are given in Clause 1007 of these Specifications.

Compatibility of the admixtures with the cement and any other pozzolona or hydraulic addition shall be ensured by for avoiding the following problems

- i. Requirement of large dosage of super plasticiser for achieving the desired workability,
- ii. Excessive retardation of setting,
- iii. Excessive entrainment of large air bubbles,
- iv. Unusually rapid stiffening of concrete,
- v. Rapid loss of slump
- vi. Excessive segregation and bleeding.

### **1705.2 Mineral Admixtures**

For use of mineral admixtures, refer Clauses 1714.1 and 1715.2.

## **1706 SIZE OF COARSE AGGREGATES**

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be as given in Table 1700-7.

Table 1700-7: Maximum Nominal Size of Coarse Aggregates

| <b>Components</b>  | <b>Maximum nominal size of Coarse aggregate (mm)</b> |
|--|--|
| i) RCC well curb   | 20   |
| ii) RCC/PCC well steining                                | 40   |
| iii) Well cap or Pile Cap Solid type piers and abutments | 40   |

|  |                              |
|--|------------------------------|
| iv) RCC work in girder, slabs wearing coat, kerb, approach slab, hollow piers and abutments, pier/abutment caps, piles | 20                           |
| v) PSC Work  | 20                           |
| vi) Any other item   | As specified by the Engineer |

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values:

- a) 10 mm less than the minimum lateral clear distance between individual reinforcements
- b) 10 mm less than the minimum clear cover to the reinforcement
- c) One quarter of minimum thickness of member

The proportions of the various individual sizes of aggregates shall be so adjusted that the grading produces the densest mix and the grading curve corresponds to the maximum nominal

## 1707 EQUIPMENT

Unless specified otherwise, equipment for production, transportation and compaction of - concrete shall be as under:

### a) Production of Concrete :

For overall bridge length of less than 200 m - batch type concrete mixer, diesel or electric operated, with a minimum size of 200 litres automatic water measuring system and integral weigher (hydraulic/pneumatic type).

For overall bridge length of 200 m or more - concrete batching and mixing plant fully automatic, with minimum capacity of 15 cum per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be checked over the range in use, when set up at each site and thereafter, periodically as directed by the Engineer. Size adopted for the concrete mix.

The accuracy of the measuring devices shall fall within the following limits :

|  |   |
|--|---|
| Measurement of Cement                  | ± 3 percent of the quantity of cement in each batch |
| Measurement of Water                   | ± 3 percent of the quantity of water in each batch  |
| Measurement of Aggregate<br>each batch | ± 3 percent of the quantity of aggregate in         |
| Measurement of Admixture<br>each batch | ± 3 percent of the quantity of admixture in         |

### b) Transportation of Concrete:

- i. Concrete dumpers minimum 2 tonnes capacity
- ii. Powered hoists minimum 0.5 tonne capacity
- iii. Chutes
- iv. Buckets handled by cranes

- v. Transit truck mixer
- vi. Concrete pump
- vii. Concrete distributor booms
- viii. Belt conveyor
- ix. Cranes with skips
- x. Tremies

c) For Compaction of Concrete:

- |                       |  |
|-----------------------|--|
| i. Internal vibrators | size 25 mm to 70 mm                        |
| ii. Form vibrators    | minimum 500 watts                          |
| iii. Screed vibrators | full width of carriageway (upto two lanes) |

## **1708 BATCHING, MIXING, TRANSPORTING, PLACING AND COMPACTION**

### **1708.1 General**

Prior to start of concreting, the Contractor shall submit for approval of the Engineer, his programme along with list of equipment proposed to be used by him for batching, mixing, transporting and placing concrete.

### **1708.2 Batching of Concrete In batching concrete:**

The quantity of cement, aggregate and mineral admixtures, if used, shall be determined by mass.

Chemical admixtures, if solid, shall be determined by mass. Liquid admixtures may be measured in volume or mass, and Water shall be weighed or measured by volume in a calibrated tank.

The concrete shall be sourced from on-site or off-site batching and mixing plants, or from approved Ready Mixed Concrete plants, preferably having quality certification.

Except where supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock piles. The materials should be stock piled several hours, preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible to ensure that the specified grading is maintained.

The water/cement ratio shall always be maintained constant at its correct value. To this end, determination of moisture content in both fine and coarse aggregates shall be made as frequently as possible, depending on weather conditions. The amount of added water shall be adjusted to compensate for any observed variations in the moisture content. To allow for the variation in mass of aggregate due to variation in moisture content, suitable adjustment in the mass of aggregate, shall also be made. Accurate control shall be kept on the quantity of mixing water, which when specified, shall not be changed without approval.

### **1708.3 Mixing Concrete**

#### **1708.3.1 Mixing at Site**

All concrete shall be machine mixed. In order to ensure uniformity and good quality of concrete the ingredients shall be mixed in a power driven batch mixer with hopper and suitable weigh batching arrangement or in a central mix plant. Hand mixing shall not be permitted. The mixer or the plant shall be at an approved location considering the properties of the mixes and the transportation arrangements available with the Contractor. The mixer or the plant shall be approved by the Engineer.

Mixing shall be continued till materials are uniformly distributed, a uniform colour of the entire mass is obtained and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement. In no case shall mixing be done for less than 2 minutes. It shall be ensured that the mixers are not loaded above their rated capacities and are operated at a speed recommended by the manufacturer. When mineral admixtures are added at the mixing stage, their thorough and uniform blending with cement shall be ensured, if necessary by longer mixing time. The addition of water after the completion of the initial mixing operation, shall not be permitted.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch and also before changing from one type of cement to another.

#### 1708.3.2 Ready Mix Concrete

Use of ready mix concrete proportioned and mixed off the project site and delivered to site in a freshly mixed and unhardened state conforming to IS:4926, shall be allowed with the approval of the Engineer.

### **1708.4 Transporting Concrete**

Mixed concrete shall be transported from the place of mixing to the place of final deposit as rapidly as possible by methods which will prevent the segregation or loss of the ingredients. The method of transporting or placing of concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position so that no contamination, segregation or loss of its constituents materials take place.

Concrete may be transported by transit mixers or properly designed buckets or by pumping. Transit mixers or other hauling equipment when used should be equipped with the means of discharge of concrete without segregation. During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to be reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

In case concrete is to be transported by pumping, the fresh concrete should have adequate fluidity and cohesiveness to be pumpable. Proper concrete mix proportioning and initial trials should ensure this. The conduit shall be primed by pumping a batch of mortar through the line to lubricate it. Once the pumping is started, it shall not be interrupted, as concrete standing idle in the line is liable to cause plug. The operator shall ensure that some concrete is always

there in the pump'sreceiving hopper during operation. The lines shall always be maintained clean and free of dents.

Pipelines from the pump to the placing area shall be laid with minimum bends. For large quantity placements, standby pumps shall be available. Suitable air release valves, shutoff valves etc. shall be provided as per site requirements. The pumping of priming mix i.e. rich mix of creamy consistency, to lubricate the concrete pump and pipelines, shall precede the pumping of concrete. Continuous pumping shall be done to the extent possible. After concreting, the pipelines and accessories shall be cleaned immediately. The pipes for pumping shall not be made of material which has adverse effect on concrete. Aluminium alloy pipelines shall not be used.

### **1708.5 Placing of Concrete**

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained. If concreting is not started within 24 hours of the approval being given, the approval shall have to be obtained again from the Engineer. Concreting shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes, unless a proper construction joint is formed.

The concrete shall be deposited as nearly as practicable in its original position to avoid re-handling. Methods of placing should be such as to preclude segregation. Care should be taken to avoid displacement of reinforcement or movement of formwork. To achieve this, concrete should be lowered vertically in the form and horizontal movement of concrete inside the forms should, as far as practicable, be minimised.

The concrete shall be placed and compacted before its initial setting so that it is amenable to compaction by vibration. The workability of concrete at the time of placement shall be adequate for the compaction equipment to be used. If there is considerable time gap between mixing and placing of concrete, as in the case of ready mixed concrete plants or off-site batching and mixing plants, concrete mix shall be designed to have appropriately higher workability at the time of discharge from the mixer, in order to compensate the loss of workability during transit. This is generally achieved by suitable chemical admixtures. Keeping these considerations in view, the general requirement for ready mixed concrete plants or off-site batching and mixing plants, is that concrete shall be discharged from the truck mixer within two hours of the time of loading. A longer period may be permitted if suitable retarding admixtures are used.

In wall forms, drop chutes attached to hoppers at the top should preferably be used to lower concrete to the bottom of the form. As a general guidance, the permissible free fall of concrete may not exceed 1.5 metres and under no circumstances shall it be more than 2 metres. When free fall of larger height is involved, self compacting concrete having adequate fluidity, cohesiveness and viscosity and which uniformly and completely fills every corner of the formwork by its own weight without segregation, shall be used.



Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not more than 300 mm in all other cases.

Concrete when deposited shall have temperature of not less than 5°C and preferably not more than 30°C and in no case more than 40°C. In case of site mixing, fresh concrete shall be placed and compacted in its final position within 30 minutes of its discharge from the mixer. When the concrete is carried in properly designed agitator operating continuously, the concrete shall be placed and compacted within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. It may be necessary to add retarding admixtures to concrete, if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

#### **1708.6 Compaction of Concrete**

Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over-vibration shall be avoided to minimize the risk of forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrations shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided.

When internal vibrators are used, they shall be inserted vertically to the full depth of the layer being placed and ordinarily shall penetrate the layer below for a few centimetres. The vibrator should be kept in place until air bubbles cease escaping from the surface and then withdrawn slowly to ensure that no hole is left in the concrete, care being taken to see that it remains in continued operation while being withdrawn. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdown.

Mechanical vibrators used shall comply with 18:2502, 18:2506, 18:2514 and 18:4656.

#### **1709 CONSTRUCTION JOINTS**

Construction joints shall be avoided as far as possible. In no case shall the locations of such joints be changed or increased from those shown on the drawings except with the express approval of the Engineer.

Joints should be positioned where they are readily accessible for preparation and concreting. Construction joints should be positioned to minimize the effects of the discontinuity of the durability, structural integrity and appearance of the structure. As far as possible, joints should be provided in non-aggressive zones, but if joints in aggressive zones cannot be avoided, they should be sealed. Joints should be located away from the regions of maximum stress caused by loading; particularly where shear and bond stresses are high.

In beams and slabs joints should not be near the supports. Construction joints between slabs and ribs in composite beams, shall be avoided. For box girders, there shall be no construction joint between the soffit and webs.

Joints should be either vertical or horizontal. For a vertical construction joint, the lifts of concrete shall finish level or at right angles to the axis of the member. Concreting shall be continued right up to the joint.

Before resuming work at a construction joint when concrete has not yet fully hardened, all laitance shall be removed thoroughly. The surface shall be roughened, taking care to avoid dislodgement of coarse aggregates. Concrete shall be brushed with a stiff brush soon after casting, while the concrete has only slightly stiffened. If the concrete has partially hardened, it may be treated by wire brushing or with a high pressure water jet, followed by drying with an air jet, immediately before the new concrete is placed. Fully hardened concrete shall be treated with mechanical hand tools or grit blasting, taking care not to split or crack aggregate particles. The practice of first placing a layer of mortar or grout when concreting joints, shall be avoided. The old surface shall be soaked with water, without leaving puddles, immediately before starting concreting. The new concrete shall be thoroughly compacted against it.

Where there is likely to be a delay before placing the next concrete lift, protruding reinforcement shall be protected. In all cases, where construction joints are made, the joint surface shall not be contaminated with release agents, dust, or sprayed curing membrane and reinforcement shall be firmly fixed in position at the correct cover.

The sequence of concreting, striking of forms and positioning of construction joints for every individual structure, shall be decided well in advance of the commencement of work.

## **1710 CONCRETING UNDER WATER**

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used, shall be got approved from the Engineer before any work is started.

Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall not be less than 16°C, nor more than 30°C.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 m per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter. To minimise the formation of laitance, care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only. The number and spacing of the tremies should be worked out to ensure proper concreting. However, it is necessary to have a minimum number of 2 tremies for any concreting operation, so that even if one of the tremies goes out of commission during concreting, the other one can be used to complete the work. The tremie concreting when started should continue without interruption for the full height of the member being concreted. The capacity of the concrete production and placement equipment should be sufficient to enable the underwater concreting to be

completed uninterrupted within the stipulated time. The top section of the tremie shall have a hopper large enough to hold one full batch of the mix or the entire contents of the transporting bucket, as the case may be. The tremie pipe shall not be less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe.-

Preferably, flanged steel Pipe of adequate strength shall be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise the tremie slowly in order to allow a uniform flow of concrete. At all times after placing of concrete is started and until all the required quantity has been placed, the lower end of the tremie pipe shall be kept below the surface of the plastic concrete and shall not be taken out of concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. It is advisable to use retarders or suitable super plasticizers to retard the setting time of concrete, which shall be established before the commencement of work.

## **1711 CONCRETING IN EXTREME WEATHER**

### **1711.1 Concreting in Cold Weather**

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5°C and that the temperature shall be maintained above 4°C until the concrete has hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock-Co piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregate or water shall not exceed 65°C. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. Concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement. To counter slower setting of concrete, accelerators can be used with the approval of the Engineer. However, accelerators containing chloride shall not be used.

### **1711.2 Concreting in Hot Weather**

When depositing concrete in hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 30°C while placing. This shall be achieved by using chilled mixing water, using crushed ice as a part of mixing water, shading stock piles of aggregates from direct rays of the sun, sprinkling the stock piles of coarse aggregate with water to keep them moist, limiting temperature of cement below 30°C at the time of use, starting curing before concrete dries out and restricting time of concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered as part of the

water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted. The Contractor will be required to state is methodology for the Engineer's approval when temperatures of concrete are likely to exceed 30°C during the work.

## **1712 PROTECTION AND CURING**

### **1712.1 General**

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately , after compaction of the concrete.

The concrete shall be protected from:

- Premature drying out particularly by solar radiation and wind

- High internal thermal gradients

- Leaching out by rain and flowing water

- Rapid cooling during the first few days after placing

- Low temperature or frost

Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

Vibration caused by traffic including construction traffic.

Concrete shall be protected, without allowing ingress of external water, by means of wet (not dripping) gunny bags, hessian etc. Once the concrete has attained some degree of hardening (approximate 12 hrs after mixing), moist curing shall commence and be continued through the requisite period. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

### **1712.2 Water Curing**

Water for curing shall be as specified in Section 1000 of these specifications.

Sea water shall not be used for curing. Sea water shall not come into contact with concrete members before they have attained adequate strength.

The concrete should be kept constantly wet by ponding or covering or use of sprinklers/ perforated pipes for a minimum period of 14 days after concreting, except in the case of concrete with rapid hardening cement, where it can be reduced to 5 days. Water should be applied on surfaces after the final set. Curing through watering shall not be done on green concrete. On formed surfaces, curing shall start immediately after the forms are stripped. The concrete shall be kept constantly wet with a layer of sacking, canvas, hessian or similar absorbent material.

### **1712.3 Steam Curing**

Where steam curing is adopted, it shall be ensured that it is done in suitable enclosure to contain the live steam in order to minimize moisture and heat losses. The initial application of

the steam shall be after about four hours of placement of concrete to allow the initial set of the concrete to take place.

Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete. Steam curing is applied in enclosures or tunnels through which concrete members are transported on a conveying system. Alternatively, portable enclosures or plastic covers are placed over precast members and steam is supplied to the enclosures. The rate of increase or decrease of temperature should not be more than 10°C to 20°C per hour and the maximum temperature shall be about 70°C. The maximum temperature shall be maintained until the concrete has attained the desired strength required at the end of steam curing period and shall be decided by prior trials. When steam curing is discontinued, the air temperature shall not drop at a rate exceeding 10°C per hour, until a temperature of about 10°C above the ambient temperature outside has been reached. Steam curing of concrete shall be followed by water curing for at least 7 days. The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

#### **1712.4 Curing Compound**

Membrane forming curing compounds consisting of waxes, resins, chlorinated rubbers etc. may be permitted by the Engineer in special circumstances. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist cured and no curing compound shall be permitted in locations where concrete surfaces are required to be bonded together.

Liquid membrane forming compounds shall conform to ASTM C 309 and the curing efficiency shall be as per ASTM C 156.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

The membrane formed shall be stripped off after 14 days, when curing is complete. Impermeable membranes, such as sheet materials for curing concrete conforming to ASTM C 171 or polyethylene sheeting covering closely the concrete surface, may also be used to provide effective barrier against Evaporation.

#### **1713 FINISHING**

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water and carefully pointed and rendered true with mortar. The mortar shall be of cement and fine aggregate

mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as possible. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of twenty four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good. The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance of the member, shall be rejected. Surface defects of a minor nature may be accepted. On acceptance of such work, the same shall be rectified as directed by the Engineer.

## **1714 CONCRETE WITH BLENDED CEMENTS OR MINERAL ADMIXTURES**

### **1714.1 Production of Concrete**

In order to improve the durability of the concrete, use of blended cement or blending of mineral admixtures, is permitted. The maximum limit of flyash and ground granulated blast furnace slag in concrete, shall be as specified in Clause 1715.2. Blending at site shall be permitted only through a specific facility with complete automated process control to achieve the specified design quality or through RMC plants with similar facility.

### **1714.2 Modified Properties**

For concrete made with Portland Pozzolona Cement, Portland Blast furnace slag cement or mineral admixtures, the setting time and rate of gain of strength are different from those of concrete made with OPC alone. Cognizance of such modified properties shall be taken in deciding de-shuttering time, initial time of prestressing, curing period and for early age loading.

### **1714.3 Compatibility of Chemical Admixtures**

Compatibility of chemical admixtures and super plasticizers with Portland Pozzolona cement Portland blast furnace slag cement and mineral admixtures shall be ensured by trials outlined in Clause 1705.

### **1714.4 Additional Tests**

In addition to the strength tests prescribed in other Sections of these Specifications, the following additional tests are required to be carried out from considerations of durability.

#### **Rapid Chloride Ion Permissibility Test**

Rapid Chloride Ion permeability test on as per ASTM C 1202 at 56 days for extreme, very severe and severe conditions of exposure. The permissible value of Chloride-Ion permeability for extreme condition 800 Coulombs very severe condition 1200 coulombs and severe exposure condition 1500 coulombs.

#### **Water Permeability Test**

Water permeability test as per DIN: 1048 Part 5-1991 shall be carried out as described in Clause 1717.2.5.5.

## **1715 HIGH PERFORMANCE CONCRETE**

### **1715.1 General**

High Performance Concrete shall be used where special performance requirements of high strength, high early strength, high workability, low permeability and high durability for severe service environments, are required. Production and use of such concrete in the field shall be carried out with high degree of uniformity between batches and very stringent quality control.

### **1715.2 Materials**

Cement, mineral admixtures, chemical admixtures, aggregates and water shall conform to Section 1000 of these Specifications and this Section.

Fly-ash when used, shall neither be less than 20 percent nor shall be greater than 35 percent of the total by mass of ordinary Portland cement and fly-ash and shall conform to grade-1 of IS:3812.

Ground granulated blast furnace (GGBS) slag when used, shall neither be less than 50 percent nor greater than 70 percent of the total mass of ordinary Portland cement and GGBS and shall conform to 18:12089.

Silica fume conforming to 18:15388 shall be used.

The cement content of concrete inclusive of any mineral admixtures shall not be less than 380 kg/m<sup>3</sup>. The cement content excluding any mineral admixtures (Portland cement content alone) shall not exceed 450 kg/m<sup>3</sup> • The water/cement (cement plus all cementitious materials) ratio should generally not exceed 0.33 but in no case shall be more than 0.40.

### **1715.3 Compatibility of Admixtures**

Compatibility of the superplasticiser and admixtures with the cement and any other Pozzolanic or hydraulic dilutes shall be ensured by trials as outlined under Clause 1705.

### **1715.4 Characteristic Strength and Target Mean Strength**

Characteristic strength and the initial target mean strength of concrete, shall be as given in Table 1700-8.

The target mean strength shall be calculated as per Clause 1704.2 after obtaining data on standard deviation from sufficient samples.

Table 1700-8: Characteristic Compressive Strength and Target Mean Strength

| <b>Grade designation</b> | <b>Specified Compressive strength at 28 days (MPa)</b> | <b>target Mean strength (MPa)</b> |
|--------------------------|--|-----------------------------------|
| M 40                     | 40   | 52                                |
| M 45                     | 45   | 58                                |
| M 50                     | 50   | 63                                |

|      |    |     |
|------|----|-----|
| M 55 | 55 | 69  |
| M 60 | 60 | 74  |
| M 65 | 65 | 80  |
| M 70 | 70 | 85  |
| M 75 | 75 | 90  |
| M 80 | 80 | 95  |
| M85  | 85 | 101 |
| M90  | 90 | 106 |

#### **1715.5 Workability and Other Requirements**

Workability, concrete mix design, field trial mixes, chloride and sulphate contents shall be as laid down in other Sections of these Specifications.

#### **1715.6 Mixing of Concrete**

The concreting plant and means of transportation employed to make trial mixes and to transport them to representative distances shall be similar to the corresponding plant and transport to be used in the works. The optimum sequence of mixing of ingredients shall be established by trials. Mixing time may be longer than in normal grade concrete mixes.

The temperature of concrete at the time of placement shall not exceed 25°C. The temperature of concrete at the mixing stage should be lower, to allow for rise in temperature during transport. When considerable distance of transport is involved, particular attention should be paid to ensure retention of slump as targeted for placement.

#### **1715.7 Prototype Testing**

Mock-up trials or prototype testing may be carried out to ensure that the concrete can be satisfactorily placed and compacted, taking into account the location of placement and provision of reinforcement, and required adjustments made in concrete mix design and/or detailing of reinforcement.

#### **1715.8 Curing of Concrete**

High performance concrete containing silica fume is more cohesive than normal mixes hence, there is a little or no bleeding and no bleed water to rise to the surface to offset water loss due to evaporation. Plastic shrinkage cracking is possible, if curing is not proper. Initial curing should commence soon after initial setting of concrete. Concrete should be covered with moist covers, opaque colour plastic sheets or suitable curing compound. Final moist curing should commence after final setting of concrete and continue for at least 14 days.

#### **1715.9 Additional Tests for Concrete**

Apart from the strength tests prescribed in other Sections of these Specifications, the additional tests as specified under Clause 1714.3 shall also be carried out.

### **1716 TOLERANCES**

Tolerances for dimensions/shape of various components shall be as indicated in these Specifications or shown on the drawings or as directed by the Engineer.



## **1717 TESTS AND STANDARDS OF ACCEPTANCE**

1717.1 Concrete shall conform to the surface finish and tolerance as prescribed in these Specifications for respective components.

**1717.2** Random sampling and lot by lot acceptance inspection shall be made for the 28 days cube strength of concrete.

**1717.3** Concrete under acceptance, shall be notionally divided into lots for the purpose of sampling before commencement of work. The basis of delimitation of lots shall be as follows:

No individual lot shall be more than 30 cu.m in volume

Different grades of mixes of concrete shall be divided into separate lots.

Concrete of a lot shall be used in the same identifiable component of the bridge.

### **1717.4 Sampling and Testing**

Concrete for preparing 3 test cubes shall be taken from a batch of concrete at point of delivery for construction, according to procedure laid down in IS:1199.

A random sampling procedure shall be adopted which ensures that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes.

150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28 day test strength result for each cube shall form an item of the sample. Tests at other age shall also be performed, if specified.

Where automated batching plant/Ready Mixed Concrete Plant is located away from the place of use and the time gap between production and placement is more than the initial setting time or where any ingredients are added subsequent to mixing, separate sets of samples shall be collected and tested at batching plant and at location of placement. The results shall be compared and used to make suitable adjustment at batching plants so that properties of concrete at placement are as per the requirements.

### **1717.5 Test Specimen and Sample Strength**

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than  $\pm 15$  percent of the average. If variation is more, the test results of the sample are invalid.

### **1717.6 Frequency**

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 1700-9.

**Table 1700-9: Minimum Frequency of Sampling**

| Quantity of Concrete in Work, m <sup>3</sup> | no. of samples   |
|--|--|
| 1 – 5  | 1  |
| 6 – 15                                       | 2  |
| 16 – 30                                      | 3  |
| 31 – 50                                      | 4  |
| 51 and above                                 | 4 plus one additional sample for each additional 50 m <sup>3</sup> or part thereof |

At least one sample shall be taken from each shift of work.

## **1717.7 Acceptance criteria**

### **1717.7.1 Compressive Strength**

#### **Cubes**

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

The mean strength determined from any group of four consecutive non-overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.

Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

#### **Cores**

When the concrete does not satisfy both the conditions given in (1) above, representative cores shall be extracted from the hardened concrete for compression test in accordance with the method described in IS: 1199 and tested to establish whether the concrete satisfies the requirement of compressive strength.

Evaluation of compressive strength by taking cores may also be done in case of doubt regarding the grade of concrete used either due to poor workmanship or based on results of cube strength tests.

The locations from which core samples are to be taken and their number shall be decided so as to be representative of the whole of the concrete under consideration. However, in no case shall fewer than three cores be tested. Cores shall be prepared and tested as described in IS:516. Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has strength less than 75 percent of the specified strength.

### **1717.7.2 Chloride and Sulphate Content**

The total chloride and sulphuric anhydride (SO<sub>3</sub>) content of all the constituents of concrete as a percentage of mass of cement in the mix, shall not exceed the values given in this Section.

### **1717.7.3 Density of Fresh Concrete**

Where minimum density of fresh concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

### **1717.7.4 Density of Hardened Concrete**

Where minimum density of hardened concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

### **1717.7.5 Permeability Test**

Water permeability test as per DIN:1048 Part 5-1991 shall be carried out as described below:

A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared.

After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that specimen can be subjected to a water pressure of up to 7 bars. A typical machine is shown in Appendix-1700/1.

The concrete specimen shall be subjected to a water pressure of 0.5 N/mm<sup>2</sup> from the top for a period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and the specimen rejected as failed.

After 3 days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.

When the split faces show signs of drying (after 5 to 10 minutes) the maximum depth of penetration in the direction of height shall be measured with the scale and extent of water penetration established.

The mean of maximum depth of penetration obtained from three specimens thus tested, shall be taken as the test result and it shall not exceed 25 mm.

**1717.7.6** If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance, shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable even after investigation, the Contractor shall remove the rejected concrete forthwith.

**1717.7.7** When durability of concrete is desired the rapid chloride ion permeability test as stated under Clause 1714.3.1 shall also be performed in addition to above tests.

## **1718 MEASUREMENTS FOR PAYMENT**

Structural concrete shall be measured in cubic metres. In reinforced or prestressed concrete, the volume occupied by reinforcement or prestressing cables and sheathing shall not be

deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

### **1719 RATE**

The contract unit rate for structural concrete shall cover costs of all materials, labour, tools, plant and equipment required for mixing, transporting and placing in position, vibrating and compacting, finishing and curing as per this Section or as directed by the Engineer, including all incidental expenses, sampling and testing, quality assurance and supervision. Unless mentioned separately as an item in the contract, the contract unit rate for concrete shall also include the cost of providing, fixing and removing formwork required for concrete work as per Section 1500 of these Specifications.

If the concrete is found to be acceptable by the Engineer as sub-standard work, the Contractor shall be subjected to reduction in his contract unit rate. For deficiency in compressive strength of concrete when accepted by the Engineer, the reduction in rate shall be applied as under:

Percentage reduction in rate=  $(\text{Design Strength}-\text{Observed Strength})/(\text{Design Strength}) \times 100$

### **2101 DESCRIPTION**

The work shall cover furnishing and providing plain or reinforced concrete foundation placed in open excavation, in accordance with the drawings and these Specifications or as directed by the Engineer.

### **2102 MATERIALS**

Materials shall conform to Section 1000 of these Specifications.

### **2103 GENERAL**

A method statement indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of construction of open foundation :

1) Sources of materials

Design, erection and removal of formwork

Production, transportation, laying and curing of concrete

Personnel employed for execution and supervision

Tests and sampling procedures

Equipment details

Quality Management System to be adopted including Quality Manual

Any other relevant information

Details of necessary arrangements for execution under water wherever necessary, shall be included in the method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the foundations are located correctly and in accordance with the drawings.

Formwork, steel reinforcement and structural concrete for open foundations shall conform to Sections 1500, 1600 and 1700 respectively of these Specifications.

## **2104 WORKMANSHIP**

### **2104.1 Preparation of Foundations**

Excavation for laying the foundation shall be carried out in accordance with Section 300 of these Specifications. The last 300 mm of excavation shall be done just before laying of lean concrete below foundation. Excavation shall be made only to the exact depth as shown on the drawing. In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M10 concrete in case of foundation resting on soil and with concrete of the same grade as that of the foundation, in case of foundation resting on rock. This shall be done at the cost of the Contractor and shall be considered as incidental to the work.

Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements, wherever required, to the satisfaction of the Engineer.

Where light blasting is required for excavation in rock or other hard strata, the same shall be carried out in accordance with Clause 302 of these Specifications. Where blasting is likely to endanger adjacent foundations or other structures, controlled blasting with all necessary precautions shall be resorted to

### **2104.2 Setting Out**

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis.

### **2104.3 Construction**

Excavation for open foundations shall be carried out in accordance with Section 300 of these Specifications. For guidance regarding safety precautions to be taken, IS:3764 may be referred.

For foundation resting on soil, a layer of M10 concrete of minimum thickness 100 mm shall be provided above the natural ground to provide an even surface to support the foundation concrete. Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. If any part of the surface has become muddy due to over-wetting, the same shall be removed. If required, the M10 concrete may be laid to a thickness of more than 100 mm, as per the direction of the Engineer. No construction joint shall be provided in the lean concrete. For foundations resting on rock, the rock surface shall be cleaned of any loose material and then levelled with a layer of concrete of the same grade as that of the foundation, so as to provide an even surface.

No point of the surface of the lean concrete, in the case of foundation on soil or the surface of hard rock, in the case of foundation on hard rock, shall be higher than the founding level shown on the drawing or as ordered by the Engineer. Levels of the surface shall be taken at

intervals of not more than 3 metres centre-to-centre in each direction, subject to a minimum of nine levels on the surface.

No formwork is necessary for the lean concrete layer. Side formwork shall be used for foundation concrete work. When concrete is laid in slope without top formwork, the slump of the concrete shall be carefully maintained to ensure that compaction is possible without slippage of freshly placed concrete down the slope. In certain cases it may be necessary to build the top formwork progressively as the concreting proceeds up the slope. Reinforcement shall be laid as shown on the drawing.

Before laying foundation concrete, the lean concrete or hard rock

surface shall be cleaned of all loose material and lightly moistened. Foundation concrete of required dimensions and shape shall be laid continuously up to the location of construction joint shown on the drawing or as directed by the Engineer.

The concrete surface shall be finished smooth with R trowel. The location of construction joint and its treatment shall be done as per requirements of Section 1700 of these Specifications. Formwork shall not be removed earlier than 24 hours after placing of concrete. Where formwork has been provided for top surface, the same shall be removed as soon as concrete has hardened. Curing of concrete shall be carried out by wetting of formwork before removal. After its removal, curing shall be done by laying not less than 100 mm thickness of loose moistened sand free from clods or gravel, over the concrete. The sand shall be kept continuously moist for a period of 7 days. Before backfilling is commenced, the loose sand shall be removed and disposed of as directed by the Engineer.

vii) Normally, open foundations shall be laid dry. Where dewatering is necessary for laying of concrete, it shall be carried out adopting any one of the following methods or any other method, approved by the Engineer:

A pit or trench of suitable size, deeper than the founding level as necessary, is dug beyond the foundation excavation so that the water flows into it and the excavated surface at founding level is fully drained.

**Water table is depressed by well point system or other methods.**

Steel/concrete caissons or sheet piling are tised for creating an enclosure for the foundations, which can subsequently be dewatered.

No pumping of water shall be permitted from the time of placing of concrete up to 24 hours after placement.

viii) In situations where foundations cannot be laid dry or where percolation is too heavy to keep foundation strata dry, concrete may be laid under water only by tremie. In case of flowing water or artesian spring, the flow shall be stopped or reduced to the feasible extent at the time of placing the concrete.

ix) Where blasting is required, it shall be carried out in accordance with Section 300 of these Specifications, observing all precautions indicated therein. 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.

x) All spaces excavated and not occupied by the foundations or other

permanent works shall be refilled with earth up to surface of surrounding ground with sufficient allowance for settlement. All backfill shall be thoroughly compacted and in general, its top surface shall be neatly graded. Backfilling shall be in accordance with Section 300 of these Specifications. In case of excavation in rock, the annular space around the footing shall

be filled with M15 concrete up to the level of top of rock. Filling with M15 concrete shall also be carried out for excavations having depth up to 1.5 m in ordinary rock or 0.6 m in hard rock. In case, the excavations are even deeper so as to require further filling up to the level of top of rock, the same shall be done by boulders grouted with cement.

Protective works, where provided shall be completed before the onset of floods so as to avoid the risk of the foundation getting undermined

### **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.

#### **2106 TOLERANCES**

1. Variation in dimensions : +50 mm, -10 mm
2. Misplacement from specified position in plan : 15 mm
3. Surface unevenness measured with 3 m straight edge : 5 mm
4. Variation of levels at the top  $\pm 25$  mm

#### **2107 MEASUREMENT FOR PAYMENT**

Excavation in foundation shall be measured in cubic metres in accordance with Section 300 of these Specifications, based on the quantity ordered or as shown on the drawing.

Lean concrete shall be measured in cubic metres in accordance with Section 1700 of these Specifications, based on the quantity ordered or as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with Section 1700 of these Specifications, based on the quantity ordered or as shown on the drawing. Reinforcement steel shall be measured in tonnes in accordance with Section 1600 of these Specifications, based on the quantity ordered or as shown on the drawing.

#### **2108 RATE .**

The contract unit rates for excavation in foundation, lean concrete, including dewatering and blasting where required, concrete in foundation and reinforcement steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section and as shown on the drawings.

The measurement and payment will be on Cu.m. of actual work executed.

#### **2202 MATERIALS**

Materials shall conform to **section 1000** of these Specifications.

### **2203 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 substructure:

- i) Sources of materials,
- ii) Design, erection and removal of formwork,
- iii) Production, transportation, laying and curing of concrete,
- iv) Personnel employed for execution and supervision,
- v) Tests and sampling procedures,
- vi) Equipment details,
- vii) Quality Management System to be adopted including Quality Manual
- viii) Safety measures
- ix) Any other relevant information.

Arrangements for execution under water wherever necessary, shall be included in the method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the substructure is constructed in accordance with the drawings.

Brick masonry, stone masonry, formwork, steel reinforcement and concrete for piers, abutments, pier caps, abutment caps, dirt walls, return walls and wing walls shall conform to Sections 1300, 1400, 1500, 1600 and 1700 respectively of these Specifications.

### **2204 PIERS AND ABUTMENTS**

For concrete piers, horizontal construction joints shall be avoided as far as possible, by pouring the entire required concrete in one operation. Where construction joints are unavoidable, they shall be treated in accordance with Section 1700 of these Specifications or in accordance with special provisions as directed by the Engineer. No vertical construction joint shall be permitted.

Construction joints shall not be permitted in splash zones.

The work shall be strictly in accordance with the drawings or as directed by the Engineer.

In case of tall piers and abutments, use of slipform shall be preferred. The design, erection and raising of slipform shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be subjected to additional specifications as necessary. All specifications and arrangements for use of slipform and placing of concrete therein shall be subjected to the approval of the Engineer.



The top surface of foundation/well cap/pile cap over which new concrete is to be laid, shall be scraped 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 and hollow concrete piers, weep holes as shown on the drawings or as directed by the Engineer, shall be provided in conformity with Clause 2706 of these Specifications.

The surface finish shall be smooth, except on the earth face of abutments which shall be rough finished.

In case of abutments likely to experience considerable movement on account of earth pressure from backfill 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. Casting of superstructure resting on the abutment shall be taken up only thereafter.

## **2205 PIER CAP AND ABUTMENT CAP**

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. The surface of cap shall be finished smooth and shall have a slope for draining off 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 or as indicated on the drawings.

## **2206 DIRT WALL, RETURN WALL AND WING WALL**

In case of cantilever return walls, no construction joint shall be permitted. The dirt wall and cantilever return walls shall be cast in one operation.

For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as that prescribed for construction of abutment. No horizontal construction joint shall be provided. Vertical construction joint may be provided, if shown on the drawing or as directed by the Engineer.

Vertical expansion gap of 20 mm shall be provided in return wall/wing wall at every 10 metre intervals or as directed by the Engineer. The 20 mm gaps shall be filled with suitable type of asphaltic/bituminous board, so as to prevent embankment material from coming out. The cost of such board shall be borne by the Contractor and shall be incidental to the work. For masonry/concrete return walls and wing walls, weep holes shall be provided as prescribed for abutments or as shown on the drawings.

The finish of the surface on the earth side shall be rough while that of the front face shall be smooth.

Coping for wing wall/return wall in brick masonry/stone masonry shall conform to section 1300 of

these Specifications.

## **2207 TESTS AND STANDARDS OF ACCEPTANCE**

The materials shall be tested in accordance with these Specifications and shall meet the prescribed requirements.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

## **2208 TOLERANCES IN CONCRETE ELEMENTS**

- a) Variation in cross-sectional dimensions : +10 mm
- b) Misplacement from specified position in plan : 10 mm
- c) Variation of levels at the top :  $\pm 10$  mm
- d) Variations of reduced levels of bearing areas :  $\pm 5$  mm
- e) Variations from plumb over full height :  $\pm 10$  mm
- f) Surface unevenness measured with 3 m straight edge

## **2209**

- All surfaces except bearing areas : 5 mm
- Bearing areas : 3 mm

## **MEASUREMENTS FOR PAYMENT**

Masonry in substructure shall be measured in cubic metres in accordance with Section 1300 or Section 1400 of these Specifications, based on the quantities ordered or as shown on the drawings.

Concrete in substructure shall be measured in cubic metres in accordance with Section 1700 of these Specifications, based on the quantity ordered or as shown on the drawings. No deduction shall be made for weep holes.

Steel in concrete of substructures shall be measured in tonnes, in accordance with Section 1600 of these Specifications, based on the quantity ordered or as shown on the drawings.

Weep holes shall be measured as per Section 2700 of these Specifications, based on the numbers provided or as shown on the drawings.

## **2210 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 these Specifications and shown on the drawings.

The measurement and payment will be on Cum. of actual work executed

## **2302 MATERIALS**

Materials shall conform to Section 1000 of these Specifications.

## **2303 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 the construction of superstructure.

- i) Sources of Materials
- ii) Design, erection and removal of formwork
- iii) Production, transportation, laying and curing of concrete
- iv) Prestressing system, if applicable
- v) Personnel employed for execution and supervision
- vi) Tests and sampling procedure
- vii) Equipment details
- viii) Quality Management System to be adopted including Quality Manual
- ix) Safety measures
- x) Any other relevant information

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the completed superstructure is in full accordance with the drawings and as approved by the Engineer.

The formwork, steel reinforcement, structural concrete and prestressing for concrete superstructure shall conform to Section 1500, Section 1600, Section 1700 and Section 1800 respectively, of these Specifications.

Specifications with regard to some of the common types of concrete superstructure construction shall be as given in subsequent Clauses of this Section.

## **2304 REINFORCED CONCRETE CONSTRUCTION**

### **solid slabs**

Where adjacent span of slab has already been cast, the expansion joint and filler board shall be placed abutting the already cast span, which shall form the shutter on that side of the new span to be cast. The reinforcement for the road kerb and railings embedded in the slab shall be tied in position before casting of slab. The entire slab shall be cast in one go. Where the slab is continuous over two spans or more, the entire span of the first slab and the length of the slab in the next adjacent span up to the point of contraflexure, shall be cast in one go, the same sequence of concreting being repeated for additional spans as required. No other construction joint shall be allowed except with the express permission of the Engineer. In very wide slabs, however, longitudinal construction joints may be permitted with the approval of the Engineer. Construction joints, if provided, shall be made in the prescribed manner as per Clause 1710 of these Specifications.

The portions of solid slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of solid slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

Where wearing coat is required to be provided after the slab has been cast, the surface of the slab shall be finished rough, but true to lines and levels as shown on the drawings, before the concrete has hardened.

The top of the slab shall be covered with clean moist sand as soon as the surface has hardened. Curing shall be carried out as per Section 1700 of these Specifications.

If bearings are provided for the solid slab, the same shall be placed in position in accordance with the drawings, before casting of slab.

### **RCC T-BEAM AND SLAB**

Provision of construction joint shall conform to the drawings or as per directions of the Engineer. No construction joint shall be provided between the bottom bulb and the web. If not indicated on the drawing, construction joint may be provided at the junction of the web and the fillet between the web and the deck slab, with the approval of the Engineer.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

## **2305 PRESTRESSED CONCRETE CONSTRUCTION**

### **PSC GIRDER AND COMPOSITE RCC SLAB**

PSC girder may be precast or cast in-situ as mentioned on the drawing or as directed by the Engineer. Girders may be post tensioned or pre-tensioned. Where precast construction is required to be adopted, selection of casting yard and details of methodology and equipment for shifting and launching of girders, shall be included in the method statement.

In case of cast in-situ construction, the sequence of construction including side shifting of girders, if required, and placing on bearings shall be in accordance with the drawings.

The PSC girder constituting the top flange, web and bottom flange shall be concreted in a single operation without any construction joint.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened.

Care shall be taken for correct alignment and setting of bearings as indicated on the drawings.

### **BOX GIRDER**

Box girders may be simply supported or continuous. Simply supported box girders shall have minimum construction joints as approved by the Engineer. In the case of continuous box girders, the sequence of construction and location of construction joints shall be strictly in accordance with the drawings.

The box section shall be constructed with only one construction joint located in the web below the fillet between the deck slab and the web.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

### **SEGMENTAL CONSTRUCTION**

Where segments are cast in-situ using form travellers, continuity of untensioned reinforcement from one segment to the next must be ensured by providing full lap length as necessary.

It shall be ensured that the load of equipment as well as construction live load as taken in the design, are not exceeded during construction.

Pre-cambering of the superstructure during construction shall be done in such a manner that the finally constructed structure under permanent load attains the final profile intended in the drawings.

### **GRADES OF CONCRETE**

Minimum grades of concrete, minimum cement content, maximum water-cement ratio and other durability requirements shall be as indicated in Tables 1700-2 and 1700-3 of these Specifications.

### **PRECASTING**

All sides, bottom inside and header forms shall be of steel. Forms shall be of sufficient thickness, with adequate external bracing and shall be stiffened and adequately anchored to withstand the forces due to placement and vibration of concrete. Compaction of concrete may be achieved through needle vibrators or form vibrators along with needle vibrators.

For casting of precast segments, any of the two commonly used techniques of precasting viz. Long Line method or Short Bench method may be used. After the first segment of each unit is cast, succeeding segments shall be match cast against the previous ones and shall be given a unique identification mark so that it is placed at the intended locations in the superstructure. A bond breaking material such as flax, soap, talc, wax or any other approved material shall be used between previously cast segment and newly cast segments, as well as the end headers, where required.

Segments shall not be moved from the casting yard until stipulated strength requirements have been met. They shall be supported in a manner that will minimize warping. Under all circumstances, the concrete shall have attained a minimum compressive strength of 20 MPa at the time of removal of forms. At the time of lifting and assembly of precast segments, the concrete shall have attained sufficient strength to withstand the handling stresses. Curing of segments may be achieved through water curing or steam curing followed by water curing. Approved curing compound may also be used.

In case of spliced girder system, match casting is not necessary because the gap between the girder segments is filled with concrete or epoxy material at the location of splices. The faces which are required to receive the cast-in-situ stitch concrete, shall be adequately roughened and prepared as construction joint before pouring the stitch concrete. In case of epoxy jointed spliced girder system (with no gap between the girder segments), match casting shall be resorted to and all provisions of epoxy jointed segmental structure shall apply.

A full scale mock-up of the lifting and holding equipment (including assembly truss, cantilevering formwork etc.) shall be performed to demonstrate their adequacy and efficacy prior to start of erection/assembly of the segments.

### **TOLERANCES IN PRECASTING**

Finished segment tolerances should not exceed the following:

|  |   |              |
|--|---|--------------|
| Length of match-cast segment (not cumulative)  | : | $\pm 5$ mm   |
| Overall span length between bearings   | : | $\pm 10$ mm  |
| Web thickness, depths of top and bottom flanges,<br>width of top and bottom flanges, overall depth of<br>segment, thickness of diaphragm | : | $\pm 5$ mm   |
| Grade of edge and and soffit   | : | $\pm 1$ mm/m |
| Tendon hole location   | : | $\pm 3$ mm   |
| Position of shear keys   | : | $\pm 5$ mm   |

#### **2305.3.4          SHEAR KEYS**

Shear keys covering as much area of the cross-section as possible, shall be provided at match cast joints of precast segments. Shear keys in the webs shall be smaller in size and more in number than those in top flange and bottom flange, which may have larger sizes and lesser numbers. Shear keys shall be dimensioned in the form of trapezium and shall be located away from tendon holes. In case of spliced girder superstructure, where match casting is not used, large amplitude shear keys may be used.

#### **2305.3.5    EPOXY JOINTING OF SEGMENTS**

For epoxy jointed superstructure, mating surfaces of both adjoining segments shall be effectively prepared by wire brushing, water jetting or any other approved means to ensure that bond breaking material is completely removed. Epoxy of about 1 mm thickness shall be applied (usually by hand) on each of the mating surfaces. The epoxy should not have crossed 70 percent of its shelf life at the time of application. The segments shall then be brought in contact and an axial temporary compression of at least 0.3 MPa shall be applied by approved means for a minimum of 24 hours. The erection system shall be so planned by the Contractor that the time elapsed between mixing of components of epoxy and application of temporary axial surface, does not exceed 60 minutes. No epoxy from a batch for which the time since combining the components, has exceeded 20 minutes, shall be used.

### **SEQUENCE OF OPERATION**

The broad sequence of operations shall generally comprise placing of all segments which are to be assembled and prestressed in one stage touching each other and then visually examining the matching of mating surfaces. Subsequently, each segment shall be separated from adjoining segment by a distance just sufficient to enable application of the epoxy. The temporary axial compression shall then be imparted and maintained for a minimum of 24 hours.

Thereafter, intended permanent prestress shall be imparted prior to demobilizing the temporary axial prestress.

### **epoxy**

Depending on the ambient temperature range, the following types of epoxies may be

|                             |   |               |
|-----------------------------|---|---------------|
| used: 5° to 20° Celsius     | : | Fast reacting |
| 15° to 30° Celsius          | : | Medium fast   |
| reacting 25° to 40° Celsius | : | Slow reacting |

Resin, which is one component of the epoxy, must be stirred by a mixer in its container for about 10 seconds or until homogeneity is achieved. Thereafter, the hardener which is the second component, must be added and mixing continued. For a mix of 5 kg batch, a mixing rotor attached to 350 W, 400 rpm electric hand drilling machine may be used. The speed of revolution should not exceed 400 rpm in order to avoid entrapment of air and excessive frictional heat leading to shorter pot life. The mixing time should not exceed 3 minutes. For fast reacting and medium fast reacting formulations, the temperature should not be allowed to rise above 40°C while for slow reacting formulations, it should not rise above 60°C. The mixing paddles should scrape the bottom and sides of the container so as to ensure complete mixing of the two components. The mixing should be carried out as close as possible to the site where the epoxy is to be used, so as to avoid loss of time and wastage of pot life in transport.

Epoxy shall be tested for its conformance to the FIP-1978 "Proposal for Standard Tests and Verification of Epoxy Bonding Agents for Segmental Construction". Some of the important properties of epoxy (minimum values) are as follows:

|                      |   |   |
|----------------------|---|---|
| Pot life             | : | 20 minutes at upper temperature limit   |
| Open time            | : | 60 minutes at upper temperature limit   |
| Compressive strength | : | 60 MPa at 24 hrs and 75 MPa at 168 hrs on 50 x 50 x 50 mm cube (at lower temperature limit)   |
| Tensile bonding      | : | After 24 hrs at 100% strength, humidity, should have concrete failure, no joint failure with M40 concrete (at lower temperature limit)      |
| Shear strength       | : | 12 MPa (at lower temperature limit)   |
| Curing rate          | : | compressive strength on 50 x 50 x 50 mm cube shall be 20 MPa at 12 hrs, 40 MPa at 24 hrs and 75 MPa at 168 hrs (at lower temperature limit) |

### **Cast In-Situ Concrete Pour**



In every unit of superstructure, consisting of precast segments, there shall be suitable numbers (at least one) cast in-situ concrete pour/stitch so as to ensure longitudinal alignment of the segment.

#### **spliced Girder system**

Spliced girder system in which smaller segments, usually pre-tensioned at precasting yard, are assembled together using cast in-situ concrete or epoxy and post tensioned, may be used to obtain large girder spans. For this purpose, the girder segments are temporarily supported over centering/steel tower or assembled at ground level and then post tensioned after jointing. In case of superstructures curved in plan, straight girder segments are placed along the chord line of the curvature to obtain the required geometry. In such cases, it is necessary to provide a cast in-situ cross diaphragm at each such kink in plan coinciding with the splice. The splicing can be done either before casting the deck or along with the deck. In the former case, post tensioning is imparted to the girder section alone whereas in the latter case, the post tensioning is imparted to the composite section.

A preferred location of splice will be the points of minimum stress such as one-third span points. At each cast in-situ splice location, adequately designed untensioned reinforcement shall be provided by lapping, welding or use of mechanical couplers subject to the limitation of the relevant codes. However, in case of epoxy jointed splice, such reinforcement is not provided.

#### **PRESTRESSING DUCTS**

In the case of dry jointed segments, the prestressing ducts shall necessarily be of HDPE. In the case of epoxy jointed segments, either metallic or HDPE ducts may be used. The ducts shall be corrugated and shall have size and thickness as per the provisions of Clause 1802.2.2 of these Specifications. Adequate precaution shall be taken to ensure that epoxy material does not leak into the joints of the ducts.

#### **2305.3.9 PRESTRESSING COUPLERS**

In case prestressing couplers are used, in general, not more than 50 percent of the prestressing cables passing through a section shall be coupled at that section. Longitudinally the couplers shall be staggered by at least a distance equal to segment length or twice the overall depth of girder, whichever is more. Usual practice is to couple half the cables in one span and the other half in the next span and so on. Two immediately adjacent cables shall not be provided with couplers at one section.

#### **2305.4 PRECAST PRE-TENSIONED GIRDERS**

Precast pre-tensioned girders can be used for superstructure of bridges in association with cast in-situ/precast deck slabs and diaphragms. They can also be made continuous either through untensioned reinforcement at the intermediate support or through post tensioning. All construction requirements of precast pre-tensioned girders shall be in accordance with the provisions of Section 1800 of these Specifications.

#### **2306 CAST IN-PLACE VOIDED SLABS**

Voided slabs can be either in reinforced concrete or in prestressed concrete.

Voids can be either circular or rectangular in shape. Void formers may be manufactured



from steel sheets, fibre reinforced cement, expanded polystyrene, HDPE, etc. They are generally corrugated to attain sufficient rigidity in order to prevent distortion or collapse during concreting. They should also be leak tight.

Void formers shall be suitably tied down in order to prevent flotation during concreting. Care shall be taken during placement of concrete to ensure that the concrete flows fully into the space beneath the void formers.

## **2307 TOLERANCES**

### **PRECAST CONCRETE SUPERSTRUCTURE**

- a) Variations in thickness of top and bottom slab for box girders, top and bottom flange for T-girders and slabs :  $\pm 5$  mm to
- b) Variations in web thickness : -5 mm to +10 mm
- c) Variations in overall depth or width :  $\pm 5$  mm
- d) Variation in length overall and length between bearings : shall not exceed  $\pm 10$  mm between bearings or  $\pm 0.1$  percent of the span length, whichever is less
- e) Permissible surface unevenness in deck slab when measured with a 3 m straight edge or template : 5mm

### **CAST IN-SITU SUPERSTRUCTURE**

- a) Variations in thickness of top and bottom slab for box girders, top and bottom flange for T-girders and slabs : -5 mm to +10 mm
- b) Variations in web thickness : -5 mm to +10 mm
- c) Variations in overall depth or width :  $\pm 5$  mm
- d) Variation in length overall and length between bearings : shall not exceed  $\pm 10$  mm or  $\pm 0.1$  percent of the span length, whichever is less
- e) Permissible surface unevenness in deck slab when measured with a 3 m straight edge or template : 5 mm

## **2308 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.

## **2309 MEASUREMENT FOR PAYMENT**

Concrete in superstructure shall be measured in accordance with Section 1700, based on the quantity ordered or as shown on the drawings.

Steel reinforcement (untensioned) in superstructure shall be measured in accordance with Section 1600, based on the quantity ordered or as shown on the drawings.

High tensile steel (prestressing) in superstructure shall be measured in accordance with Section 1800, based on the quantity ordered or as shown on the drawings.

### **2310 RATE**

The contract unit rates for concrete, steel reinforcement (untensioned) and high tensile steel (prestressing) shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing superstructure as mentioned in this Section and as shown on the drawings.

The measurement and payment will be on **Cu.m.** of actual work executed

#### **Item No. 11**

**Providing and fixing mild steel dowel bars of minimum 32mm dia. for anchoring by drilling holes in foundation strata including necessary bending, hooking of dowel bars and grouting the holes complete as per detailed drawing and as directed.**

**MORTH V<sup>th</sup> REVISION Cl. No. 602.6.5, Pg. no. 275**

#### **602.6.5 Dowel Bars**

Dowel bars shall be mild steel rounds in accordance with Clause 602.2.8 with details/dimensions as indicated in the drawings 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. Any protrusions shall be removed by grinding the ends of the dowel bars. 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.

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 centered 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 here-in-under, the compliance of which shall be checked as per Clause 602.11.7.

- i) For bars supported on cradles prior to the laying of the slab:
  - a) All bars in a joint shall be within  $\pm 2$  mm per 300 mm length of bar
  - b) 2/3rd of the number of bars shall be within  $\pm 3$  mm per 500 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.
- ii) For all bars inserted after laying of the slab except those inserted by a Dowel Bar Inserter the tolerance for alignment may be twice as indicated in (i) above.

The transverse joints at curves shall be radial in the direction of the radius.

Dowel bars, supported on cradles in assemblies, when subject to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and in both directions horizontally) shall conform to be within the limits given in Clause 602.6.5.2.

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:-

- i) 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 load shall be not more than 3 mm.
- ii) The fixings for joint assembly 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.
- iii) 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.

Dowel bars in the contraction joints, construction joints and expansion joints shall be covered by a thin plastic sheath. The thickness of the sheath shall not exceed 0.5 mm and shall be tightly fitted on the bar for at least two-thirds of the length from one end for dowel bars in contraction/construction joints and half the length plus 50 mm for expansion joints. The sheathed bar shall comply with the following pull-out tests:

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 mm x 150 mm x 600 mm, made of the same mix proportions to be used in the pavement, but 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 bond stress to achieve this movement shall not be greater than 0.14 MPa.

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 expansion space (about 25 mm) 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 into the annular space between the sheathing and dowel bar shall be taped around its mouth.

### **Measurement and Rate**

The measurement and payment will be on **RMT.** of actual work executed.

#### **Item No. 17**

**Providing and placing in position CRS (Corrosion Resistance Steel) FE 550D bar reinforcement for All Structural Component including cutting bending hooking and tying complete as per detailed drawing.**

**MORTH V<sup>th</sup> REVISION Cl. No. 1600, Pg. no. 527**

#### **1601 DESCRIPTION**

This work shall consist of furnishing and placing coated or uncoated mild steel or high strength deformed reinforcement bars of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer.

#### **1602 GENERAL**

Steel for reinforcement shall meet the requirements of **Section 1000** of these Specifications. Reinforcements may be either mild steel or high strength deformed bars. They may be uncoated or coated with epoxy.

#### **1603 PROTECTION OF REINFORCEMENT**

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or by thoroughly cleaning it using any suitable method such as sand blasting, mechanical wire brushing etc., as directed by the Engineer. Reinforcements shall be stored above the ground in a clean and dry condition, on blocks, racks or platforms and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete, shall be protected within one week after initial placing of concrete, with a brush coat of neat

cement mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

In case of fusion bonded epoxy coated reinforcement or hot dipped galvanized bars used, reference shall be made Clause 1010.3.2 of Section 1000 of these specifications.

#### **1604 BENDING OF REINFORCEMENT**

Bar bending schedule shall be furnished by the Contractor and got approved by the Engineer before start of work.

Reinforcing steel shall conform to the dimensions and shapes given in the approved Bar Bending Schedules.

Bars shall be bent cold to the specified shape and dimensions or as directed by the Engineer using a proper bar bender, operated by hand or power to obtain the correct shape and radii of bends.

Bars shall not be bent or straightened in a manner that will damage the parent material or the coating.

Bars bent during transport or handling shall be straightened before being used on work. They shall not be heated to facilitate straightening.

#### **1605 PLACING OF REINFORCEMENT**

- a) The reinforcement cage should generally be fabricated in the yard at ground level and then shifted and placed in position. The reinforcement shall be placed strictly in accordance with the drawings and shall be assembled in position only when the structure is otherwise ready for placing of concrete. Prolonged time gap between assembling of reinforcement and casting of concrete, which may result in rust formation on the surface of the bars, shall not be permitted.
- b) Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS:280 to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1 mm.
- c) Bars shall be kept in position usually by the following methods:

- i) In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover, shall be placed between the bars and formwork, subject to satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided they have the same strength and specification as those of the member.
- ii) In case of dowels for columns and walls, the vertical reinforcement shall be kept in position by means of timber templates with slots cut in them accurately, or with cover blocks tied to the reinforcement. Timber templates shall be removed after the concreting has progressed upto a level just below their location.

Layers of reinforcements shall be separated by spacer bars at approximately one metre intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be allowed to sag between supports.
- iii) Necessary stays, blocks, metal chairs, spacers, metal hangers, supporting wires etc. or other subsidiary reinforcement shall be provided to fix the reinforcement firmly in its correct position.
- iv) Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc., as devices for positioning reinforcement shall not be permitted.
- d) Bars coated with epoxy shall be placed on supports that do not damage the coating. Supports shall be installed in a manner such that planes of weakness are not created in hardened concrete. The coated reinforcing steel shall be held in place by use of plastic or plastic coated binding wires especially manufactured for the purpose. Refer Section 1000 of these Specifications for other requirements.
- e) Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concreting is commenced.

## **1606 BAR SPLICES**

### **Lapping**

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing, shall be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other, and shall be kept apart by 25 mm or 1.25 times the maximum size of coarse aggregate, whichever is greater. If this is not feasible, overlapping bars shall be bound with annealed steel binding wire not less than 1 mm diameter and twisted tight in such a manner as to maintain minimum clear cover

to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points along the span where stresses are low.

## **Welding**

Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or greater than that of the bars connected.

While welding may be permitted for mild steel reinforcing bars conforming to IS:432, welding of deformed bars conforming to IS:1786 shall in general be prohibited. Welding may be permitted in case of bars of other than Fe 240 grade including special welding grade of Fe 415 grade bars conforming to IS:1786, for which necessary chemical analysis has been secured and the carbon equivalent (CE) calculated from the chemical composition using the formula:

$$CE = c + \frac{Mn}{6} + \frac{Cr+Mg+V}{5} + \frac{Ni+Cu}{15}$$

is 0.4 or less.

The method of welding shall conform to IS:2751 and IS:9417, any supplemental specifications and Clause 1904.8 of these Specifications to the satisfaction of the Engineer. Welding may be carried out by metal arc welding process. Oxy-acetelene welding shall not be permissible. Any other process may be used subject to the approval of the Engineer and necessary additional requirements to ensure satisfactory joint performance. Precautions on overheating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.

All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm) which may be lap welded. Single-V or Double-V butt joints may generally be used. For vertical bars single bevel or double bevel joints may be used.

Welded joints shall be located well away from bends and shall be not less than twice the bar diameter away from a bend.

Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, process, consumables, operators and welding procedure, are adequate to produce and maintain uniform quality at par with that attainable in shop welding, to the satisfaction of the Engineer.

Joint welding procedures which are to be employed shall invariably be established by a procedure specification. All welders and welding operators to be employed shall be qualified by tests prescribed in IS:2751. Inspection of welds shall conform to IS:822 and destructive or non-destructive testing may be undertaken when deemed necessary. Joints with weld defects detected by visual inspection or dimensional check inspection, shall not be accepted.

Suitable means shall be provided for holding the bars securely in position during welding.

It must be ensured that no voids are left in welding. When welding is done in two or three stages, the surface shall be cleaned properly after each stage. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Only competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars.

M.S. electrodes used for welding shall conform to IS:814.

Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum permissible stresses and welds so staggered that at any one section, not more than 20 percent of the bars are welded.

Specimens of welded pieces of reinforcement taken from the site, shall be tested. The number and frequency of tests shall be as directed by the Engineer.

## **Mechanical Couplers and Anchorages**

### **Mechanical Couplers**

Bars may be joined with approved patented mechanical devices as indicated on the drawing or as approved by the Engineer e.g. by special grade steel sleeves swaged on to bars in end to end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 percent of the characteristic strength of the reinforcement bar.

### **Anchorage**

Bars may be anchored with approved patented mechanical anchorages as indicated on the drawing or as approved by the Engineer. The anchorages shall be connected to the reinforcing bar by the use of taper thread system. The anchorage shall be capable of developing the characteristic strength of reinforcement without damage to concrete and shall have sufficient diameter and width to develop adequate shear cone strength. The connection shall develop 125% of the characteristic strength of reinforcement bar.

## **1607 TESTING AND ACCEPTANCE**

The material shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, will be got carried out by the Contractor at his own cost.

The supply, fabrication and placing of reinforcement shall be in accordance with these Specifications and shall be as checked and accepted by the Engineer.

Manufacturer's test certificate regarding compliance with Indian Standards for each lot of steel, shall be obtained and submitted to the Engineer. If required by the Engineer, the Contractor shall carry out confirmatory tests in the presence of a person authorized by



the Engineer. Cost of these tests shall be borne by the Contractor. The sampling and testing procedure shall be as laid down in IS:1786. If any test piece selected from a lot fails, no re-testing shall be done and the lot shall be rejected.

#### **1608 MEASUREMENT FOR PAYMENT**

Reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in **tonnes** on the basis of IS:1732. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing, shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

#### **1609 RATE**

The contract unit rate for coated/uncoated reinforcement shall cover the cost of material, royalty, fabricating, transporting, storing, bending, placing, binding and fixing in position as shown on the drawings and as per these Specifications and as directed by the Engineer, including all labour, equipment, supplies, incidentals, sampling, testing and supervision.

The unit rate for coated reinforcement shall be deemed to also include cost of all material, labour, tools and plant, royalty, transportation and expertise required to carry out the coating work as well as sampling, testing and supervision required for the work.

The measurement and payment will be on **Tonne** of actual work executed

**Item No. 18****Providing and fixing in position fully moulded restrained elastometric Bearings as per detailed drawing**

**MORTH V<sup>th</sup> REVISION: Cl. No. 2000 Pg. no. 623**

**2001 Description**

This work shall consist of furnishing and fixing bearings in position in accordance with the details shown on the drawings, to the requirements of these Specifications or as directed by the Engineer.

**2002 General**

- i) Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be in accordance with the details shown on the drawings.
- ii) The bearings may either be supplied directly to the Engineer by the manufacturer to be installed by the Contractor or supplied and installed by the Contractor as part of the contract. In the former case, the manufacturer shall be associated with the installation of the bearings to the full satisfaction of the Engineer, whereas in the latter case, the Contractor shall be solely responsible for the satisfactory supply and installation of the bearing. In the detailed description of the specification, a general reference shall be made to the Contractor or manufacturer and the interpretation shall be as per terms of contract.
- iii) The Contractor shall exercise the utmost care in setting and fixing all bearings in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.
- iv) Bearings shall be handled with care and stored under cover.
- v) When bearing assemblies or plates are shown on the drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12 mm) and shall be finished by grinding.
- vi) It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm thickness) may be provided for this purpose.
- vii) It shall be ensured that the bottoms of girders to be seated on the bearings are plane at the locations of the bearings and that the bearings are not displaced while placing the girders.
- viii) M.S bearings sliding on M.S. plates shall not be permitted. For sliding

plate bearings, stainless steel surface sliding on stainless steel plate with mild steel matrix shall be used. The other option shall be to provide PTFE surface sliding on stainless steel.

- ix) Segmental rollers are not permitted; only full cylindrical rollers shall be used. Adequate width of base plate shall be provided to cater for anticipated movements of the supporting structure.
- x) For seismic Zones IV and V, roller and rocker bearing components shall have guides to prevent them from being displaced during earthquakes.
- xi) For bridges with skew angle less than 20°, the bearings shall be placed at right angles to the longitudinal axis of the bridge. For bridges with skew angle greater than 20°, very wide bridges and curved bridges, the location of bearings shall be ensured as shown on the drawings.
- xii) Easy access to the bearing shall be made available for purposes of inspection and maintenance. Provision shall also be made for jacking up of the superstructure so as to allow repair/replacement of bearings.
- xiii) For types of bearings not covered in this Section, required specifications shall be as laid down in the contract.

## **2003 Steel Bearings**

### **Materials**

#### **Mild steel**

Mild steel to be used for components of bearings shall comply with IS:2062, Steel for General Structural Purposes.

For all components and plates exceeding 50 mm in thickness requiring welding, the carbon content shall be ascertained and suitable welding procedure like pre-heating, use of low hydrogen electrodes etc, shall be adopted after approval by the Engineer.

#### **Forged steel**

Forged steel to be used in components of bearings shall be in accordance with

**Clause 1009.5** of these Specifications.

All slabs shall be normalised after forging. If welding is involved and if the slabs are more than 20 mm thick, pre-heating of the slab up to 200°C shall be done.

Railway axles (R 19) are also acceptable as forged steel for rollers.

#### **High tensile steel**

High tensile steel shall comply with IS:961.

## **Cast steel**

Cast steel shall be in accordance with Clause 1009.1 of these Specifications.

For the purpose of checking the soundness, castings shall be ultrasonically examined following procedures as per IS:7666, with acceptance standard as per IS:9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS:1030.

Quality level of castings shall be Level 3 as per IS:9565.

## **stainless steel**

Stainless steel shall be in accordance with Clause 1009.7 of these Specifications.

## **Welds**

Welding of steel conforming to IS:2062 shall be as per IS:1024 using electrodes as per IS:814.

## **Grease**

The grease for bearings shall conform to the requirements of IS:503 (Grade 4).

## **Construction operations**

- a) All work of steel bearings shall conform strictly to the drawings and shall be in accordance with the provisions of this Section. Care shall be taken to ensure that all parts of an assembly fit accurately together. The workmanship shall satisfy all relevant provisions laid down in Section 1900 of these Specifications.
- b) Knuckle pins, rolling surfaces of the rollers and bearing surface of the bearing plates shall be machined and all bolt holes shall be drilled. The whole bearing shall be fitted and finished as required for good quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material, any surface which is to be in permanent contact with the grout or the yielding material, may be left unmachined.  
  
In prestressed concrete construction involving launching of girders, slipping or jumping of rollers due to vibration or jolts, shall be avoided and adequate measures shall be taken to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings at the launching end and place the beam on the rocker slightly in advance of placing on the roller.
- c) During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings and between top plate, base plate and saddle plate in case of roller-cum-rocker bearings or by any other suitable arrangement which prevents the relative displacement of the components.
- d) In precast prestressed girders, where recesses are left on the underside

of girders to receive the anchor bolts, grout holes extending to the sides or top of the beam shall be provided. The grout hole shall be filled with cement sand grout of mix 1:1 or with grout made of non-shrink high strength mortar. Alternatively, the precast girder may be fitted with a template screwed or bolted into sleeves already cast in the concrete, which can be removed and replaced by the top plate of the bearing at the time of erection of superstructure.

## **Workmanship**

- a) Fabrication shall be carried out by an organization sufficiently experienced and qualified to undertake precision engineering of this type as approved by the Engineer.
- b) Workmanship shall be of good quality such as to achieve neat finish and good appearance.
- c) Castings shall be true to the forms and dimensions shown on the drawings and shall be free from pouring faults, sponginess, cracks, blow holes and other defects, affecting their appearance or strength. Warped or distorted castings shall not be accepted. Exposed surfaces shall be smooth and dense.
- d) All castings shall be cleaned by sand or shot blasting to remove sand or scale and to present a clean uniform surface.
- e) All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes or similar blemishes shall be rejected if the imperfections are located in bearing surfaces or cannot be remedied to the satisfaction of the Engineer.
- f) Imperfections which are not located in bearing surfaces shall be cleaned out, filled with weld metal of the appropriate composition and ground flush.
- g) All surfaces of major components like top plates, saddle plates, base plates and rollers of the bearings shall be machined all over for correct alignment, interchangeability and proper fitting.

## **Tolerances**

Tolerances for individual components or of the assembled bearings shall be as shown on the drawings and subject to the approval of the Engineer.

Unless otherwise specified, the following tolerances shall be maintained.

### **i) Rollers and Curved surfaces**

Tolerances on diameter of rollers and all convex surfaces shall conform to K7 of IS:919.

Tolerances on diameter of all concave surfaces shall conform to D8 of IS:919.

ii) **Height of Bearings**

Tolerances on height of any component shall not exceed +0.5 mm. No minus tolerance shall be allowed. The edges of all ribs shall be parallel throughout their length.

iii) **Plates**

Tolerance on length and width of the plates shall not exceed +1.0 mm; tolerance on the thickness of the plate shall not exceed +0.5 mm. No minus tolerance shall be allowed. All rocking, rolling and sliding surfaces shall have a machine smooth finish to 20 micron maximum mean deviation as per IS:3073.

iv) **Castings**

No minus tolerance shall be allowed in the thickness of any part of the castings. The edges of all ribs shall be parallel throughout their length.

## **installation**

### **General**

- a) Bearings shall be placed in the position as shown on the drawings with all bearing surfaces in full contact and to the tolerances as specified.
- b) Roller and rocker bearings shall be placed so that their axes of rotations are horizontal and normal to the direction of movement of the members they support. Upper and lower bearing plates shall be set horizontal in both directions.
- c) During installation, the bearings shall be pre-set with respect to the bearing axis to account for the movement due to the following :
  - i) Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.
  - ii) Shrinkage, creep and elastic shortening of prestressed girders.
- a) For bridges in gradient, the bearing plates shall be placed in a horizontal plane.

### **Placing**

- a) On supporting structures, pockets shall be provided to receive anchor bolts; one side of the pocket shall project beyond the bearing plate. The pocket shall be filled with mortar and the concrete bearing area also

shall be finished level by a thin and stiff mortar pad (of thickness not exceeding 12 mm) just before placing of bearing assemblies or bottom plate on the concrete seat. The mortar shall be of mix 1:1 or of the non-shrink prepacked type.

- b) In case of precast girders a recess of 6 mm shall be provided on the underside with a level finish for housing the bearing plate. A thin and stiff mortar pad with thickness not exceeding 3 mm, shall be provided over the top plate before lowering the precast beam in position in order to ensure full and even pressure on the plate surface.
- c) It shall be ensured that while placing the girders, the bearings are in their exact positions as indicated on the approved drawing and not displaced therefrom.
- d) All concrete surfaces to be in contact with the mortar shall be thoroughly cleaned and wetted for a period not less than 24 hours before placing mortar. Operations are to be carried out when the surface temperatures of the exposed bearings are the minimum practicable.
- e) No mortar that is more than 30 minutes old after completion of mixing, shall be used.
- f) After placing and finishing the mortar, the bearing shall be checked for position and shims or other temporary supports removed and the mortar made good. If the bearing has moved, it shall be lifted, the mortar removed and the whole procedure repeated.
- g) Exposed faces of the mortar shall be cured under damp hessian for 7 days.
- h) Placing of the bearing and mortar shall only be carried out in the presence of the Engineer.

### **Checking, Cleaning and lubrication**

- a) Before installation, each bearing shall be uncrated, dis-assembled and checked. Any damaged parts shall be made good for approval.
- b) All bearings with sliding surfaces shall be cleaned and lightly lubricated with an approved lubricant immediately before installation.

### **Testing**

- i) The manufacturer has to produce test certificate from original producers of raw materials used in the manufacture of the bearings. Irrespective of the producers test certificates, the manufacturer will carry out the detailed tests on raw materials (both physical and chemical) for different types of raw materials used in the manufacture of the

bearings as per relevant codes for such raw materials. For this purpose they will identify stock materials with certain batch number and draw samples from such stock materials and mark them with the same batch numbers. For each batch, 3 sets of samples will be drawn separately for tests of physical and chemical properties on samples. The manufacturer will carry out tests on chemical and physical properties on one set of samples and keep the remaining 2 sets of samples duly identified with the batch number for verification by the Engineer and/or his authorized representatives for confirmatory tests with respect to the results obtained by the manufacturer. Such tests can be carried out on a few samples selected at random at the discretion of the Engineer and/or his representatives. The following IS Codes may be referred for carrying out such tests (both physical and chemical):

IS:1030 for casting

IS:2062 for mild steel components IS:2004

for forging

Other special materials shall be as per relevant IS/BS/AISI Codes.

- ii) All machined cast steel components shall be tested by ultrasonic testing to level III of IS:9565. Critical surface shall also be checked by Dye Penetration Test (DPT) and/or magnetic particle test for detecting presence of surface defects.
- iii) All forged steel components after machining will be subjected to ultrasonic testing. Guidelines given in Appendix 3 of IRC:83 (Part 1) may be referred. To ensure the reduction ratio, macro-etching test will be conducted on the integral test piece (per heat/batch) attached to anyone of the forgings.
- iv) All bearings shall be tested to 1.25 times the design load. Recovery should be 100 percent. Contact surfaces shall be examined by sufficient illumination and ultrasonic/DPT tests for detecting any defects/cracks.
- v) All welding shall be checked by Dye Penetration Test. If specifically required by Engineer, the X-ray test may also be done.
- vi) Engineer may carry out the destructive testing of any component/ components of bearings supplied in order to check their conformity with the test results submitted.
- vii) For large lots, (consisting of 12 sets or more), the bearings manufacturer shall, unless otherwise agreed by him and the Engineer, furnish a complete report on the process of quality control. The Engineer may appoint an authorized inspection agency for inspection on his behalf, which shall also submit reports to the Engineer regarding various tests performed on the bearing and certify the acceptance of the bearings.

The quality control report shall cover the following:



- a) A detailed system of quality control including stage by stage inspection, starting from raw materials up to the finished bearing.
  - b) Test certificates of all raw materials. If manufacturer's test certificates are not available for the raw materials, the bearings manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and furnish the test results.
  - c) A list of consumption of raw material for a period of at least preceding one year.
  - d) Test certificates of bearings manufactured during preceding one year at the manufacturer's works.
- viii) The Engineer shall reserve the right to witness inspection at manufacturer's works at any time. For this, the bearing manufacturer shall have in-house testing facilities as required.
  - ix) In case the lot size of similar bearings exceeds 12 sets as per the direction of the Engineer, one extra bearing for each set of 24 bearings or part thereof, shall be manufactured and the cost of such extra bearing shall be borne by the user.
  - x) The Engineer shall select the extra bearing(s) at random and shall perform various tests including destructive testing on it at his discretion, either at the manufacturer's works or at any other approved test laboratory, notwithstanding the test reports submitted.
  - xi) In case there is any major deficiency/discrepancy regarding material, the Engineer shall declare the whole lot of bearings as unacceptable.
  - xii) In case minor defects in fabrication, relating to welding or machining, are found in the test bearing before destructive testing and if the test bearing is found to be acceptable after destructive testing, the minor defects in the test bearings shall not be a bar to the acceptance of the entire lot.
  - xiii) The opinion of the Engineer in cases xi) and xii) above shall be final and binding on the manufacturer.

### **Inspection, Maintenance and Replacement**

- i) Suitable easy access to the bearing shall be provided for inspection and maintenance.
- ii) Provision shall be made for jacking up of the superstructure so as to allow for adjustment/repair/replacement of the rollers of the bearings.
- iii) Each bridge bearing assembly and the adjacent members in

contact with it, shall be inspected at least once a year to ascertain their actual condition. Suitable remedial measures shall be taken immediately if defects are noticed including replacement in the event of irreparable damage.

- iv) The bearings shall also be examined carefully after unusual occurrences such as passage of heavy traffic/oversized loads, earthquakes and battering by floating debris in high floods.

## **2004 Special Bearings**

### **Spherical Bearing**

Spherical bearings which will permit uniaxial translatory movement along longitudinal axis of the bridge and rotation on all axes, shall consist of the following parts :

- a) **Bottom Plate**

A bottom plate of circular/square shape is provided with a circular concave surface integrally cast with it. The bottom plate is connected to the substructure by means of tight fitted anchor bolts, which are embedded in concrete. The material of bottom plate shall be cast steel.

Pure unfilled quality dimpled PTFE of specified thickness shall be provided on top of concave surface of bottom plate in order to allow smooth rotation.

- b) **saddle Plate**

A saddle plate of square/circular/rectangular shape and circular convex surface at bottom shall be placed in the concave surface of bottom plate. The radius of the convex bottom of the saddle plate shall be slightly less than that of the concave top surface of the bottom plate, so as to ensure sufficient contact over a small area. Rotation along all axes shall be permitted on the contact surface of the saddle plate and the bottom plate. Pure unfilled quality dimpled PTFE sheet shall be recessed to specified depth of recess over the top of saddle plate. Suitable elastomeric seal shall be provided on the saddle plate to prevent ingress of dirt and moisture. The material of saddle plate shall be cast steel.

- c) **top Plate**

The top plate shall have stainless steel plate welded to its bottom which shall slide over PTFE. The top plate shall be connected to the superstructure by tight fitted anchor bolts. Translatory movements along longitudinal axis of bridge shall be accommodated at the PTFE/ Stainless steel sliding surface. The material of top plate shall be cast

steel.

d) **Guide Plate**

Guide plates shall be welded to saddle plate so as to permit only longitudinal movement. The material of guide plates shall be cast steel.

**Pin Bearing**

A pin bearing shall consist of a metal pin provided within a metal cylinder to bear and transmit horizontal force along any direction in the horizontal plane and accommodate rotational movement about any axis. Pin bearings shall not bear or transmit any vertical load.

The sliding spherical and pin bearing shall conform to BS:5400, Parts 9.1 and 9.2 and all relevant clauses of these Specifications. The term bearing shall include the entire assembly covering all the accessories required for operation, erection and dismantling for replacement. All bearings shall be of replaceable type. The design of bearings shall be in accordance with the specifications mentioned/international specifications. The manufacturer shall get the design approved from Engineer and should be associated with installation of bearings.

**Materials**

- i) The material of pin bearing including rocker plates shall be high tensile steel conforming to IS:961.
- ii) All materials shall be original, unused or non-recycled conforming to relevant specifications.
- iii) Cast steel, mild steel and stainless steel shall conform to Clause 2003.1.
- iv) Copolymer polytetrafluoroethylene (PTFE) unfilled quality shall have required properties as per BS:5400 and thickness as specified.
- v) Anchor bolts shall be as per relevant IS specifications.

**Seating of Pin Bearing**

- i) Backing plate with studs welded on the face opposite to the seating face shall be delivered by the manufacturer.
- ii) This backing plate shall be accurately positioned on the reinforcement grid of the pedestal and levelled.
- iii) Studs shall be tack welded/tied to the reinforcement to keep the backing plate in proper location during casting.
- iv) Depth of embedment of the backing plate in the concrete shall be

as per relevant drawing.

- v) The round base of the pot (bottom) of the pin bearing assembly shall be connected to the backing plates by anchor screws after concreting of pier cap/pedestal.
- vi) In order to ensure successful transfer of large horizontal forces to be resisted by the Pin bearing, great care shall be taken in detailing the reinforcement in the substructure and the superstructure adjacent to the studs in the backing plate.

### **Acceptance test on spherical Bearings**

- i) All bearings shall be checked for overall dimensions.
- ii) All bearings shall be load tested to 1.25 times design vertical load.
- iii) A pair of bearings selected at random shall be tested to determine coefficient of friction which shall be less than 0.05.
- iv) Two bearings selected at random shall be tested for permissible rotation.

### **Acceptance test on Pin Bearings**

- i) All bearings shall be checked for overall dimensions
- ii) All bearings shall be load tested (if required, for design horizontal load only)

## **2005 Elastomeric Bearings**

Elastomeric bearings shall cater for translation and/or rotation of the superstructure by elastic deformation.

### **Materials**

- i) Chloroprene Rubber(CR) only shall be used.
- ii) Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life viz. Neoprene WRT, Neoprene W, Bayprene 110, Bayprene 210, Skyprene B-5, Skyprene B-30, Denka S-40V and Denka M-40, shall be used.
- iii) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

- iv) The polychloroprene content of the compound shall not be lower than 60 per cent. The ash content shall not exceed 5 per cent of its weight. Polychloroprene content shall be determined in accordance with ASTM- D297 and ash content as per IS:3400-Part XXII.
- v) Use of synthetic rubber-like materials such as Ethyl Propylene Dimonomer (EPDM), Isobutane Isoprene Copolymer (IIR) and Chloro-Isoprene Copolymer (CIIR) shall not be permitted.

### Properties of elastomer

The elastomer shall conform to the properties specified in Table 2000-1.

**Table 2000-1 : Properties of elastomer**

| Property  | unit | Value of the Characteristic Specified |        |        | test Method<br>IS Specification<br>Reference |
|---|------|---------------------------------------|--------|--------|--|
| 1. Physical properties  |      |                                       |        |        |  |
| 1.1 Hardness  | IRHD | 50 ± 5                                | 60 ± 5 | 70 ± 5 | IS:3400 (Part II)                            |
| 1.2 Minimum tensile strength  |      |                                       |        |        |  |
| - Moulded test piece  | MPa  | 17                                    | 17     | 17     | IS:3400 (Part I)                             |
| - Test piece from bearing   |      | 14                                    | 14     | 14     |  |
| 1.3 Minimum elongation at break   |      |                                       |        |        |  |
| - Moulded test piece  | %    | 450                                   | 400    | 300    | IS:3400<br>(Part II)                         |
| - Test piece from bearing   | %    | 400                                   | 350    | 250    |  |
| 2. Maximum compression set (%)<br>(24 h, 100 ± 1 °C)                              | %    | < 35                                  |        |        | IS:3400 (Part X)                             |
| 3. Accelerated aging<br>(72 h, 100 ± 1 °C)<br>(Maximum change from un-aged value) |      |                                       |        |        | IS:3400 (Part IV)                            |
| 3.1 Maximum change in hardness  | IRHD | ± 5                                   |        |        |  |
| 3.2 Maximum change in tensile strength  | %    | ± 15                                  |        |        |  |
| 3.3 Maximum change in elongation  | %    | ± 30                                  |        |        |  |

Shear modulus (G) is the apparent “conventional shear modulus” of the elastomer bearing determined by testing. At nominal temperature of  $23\text{ }^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , the value of G shall comply with the values given in **table 2000-2**.

**Table 2000-2 : shear Modulus at nominal temperature**

| Hardness (iRHd) | G (MPa) | tolerances of G (MPa) |
|-----------------|---------|-----------------------|
| (1)             | (2)     | (3)                   |
| $50 \pm 5$      | 0.7     | $\pm 0.15$            |
| $60 \pm 5$      | 0.9     | $\pm 0.18$            |
| $70 \pm 5$      | 1.15    | $\pm 0.20$            |

The adhesion strength of elastomer to steel plates determined according to IS:3400 (Part XIV) method A, shall not be less than 7 Kn/m.

For elastomeric bearings (CR) used in adverse climatic conditions, the ozone resistance of elastomer shall be proved satisfactory when assessed by test according to IS:3400 (Part XX). The testing shall be carried out for a duration of 96 hours at a temperature of  $40 \pm 1^{\circ}\text{C}$ , strain of 30 per cent and ozone concentration of 100 pphm by volume.

If any cracking is detected by visual observation at the end of the test, the material shall be considered unsatisfactory. No specific tests for assessment of low temperature resistance are deemed necessary.

**Note :** For use of elastomer in extreme cold climates, the Engineer may specify special grade of low temperature resistant elastomer in conformity with operating ambient temperature conditions. The specifications for such special grade elastomer including the tests for low temperature resistance, shall be mutually agreed by the Engineer and the producer/ supplier and are outside the purview of these Specifications.

Laminates of mild steel conforming to IS:2062/IS:1079 or equivalent international grade, shall only be permitted. The yield stress of the material shall not be less than 250 MPa. Use of any other material like fibre glass or similar fabric as laminates, shall not be permitted.

The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for carrying out the following tests on elastomer in accordance with the relevant provisions of ASTM D-297.

- |    |                            |   |  |
|----|----------------------------|---|--|
| a) | Identification of polymers | : | to confirm the usage of chloroprene (Appendix X-2) |
| b) | Ash content                | : | to determine the percentage (sub-section 34)       |

- |    |                  |   |                  |
|----|------------------|---|------------------|
| c) | Specific gravity | : | (sub-section 15) |
| d) | Polymer content  | : | (sub-section 10) |

The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative. In case of any dispute regarding interpretation of results, the Engineer may carry out test as per ASTM S-3452-78 (chromatography test) at the manufacturer's cost in a recognized test house. The elastomer specimen to conduct the test shall be obtained from the bearing selected at random for destructive test. The remaining part of the test bearing shall be preserved by the Engineer for any test to be done later, if required.

### **Manufacturing and Workmanship**

- i) Plain pad and strip bearing shall be moulded in one piece, or comprise single pieces cut from previously moulded strips or slabs. Cutting shall produce a smooth surface without injurious heating of the elastomer.
- ii) Bearing with steel laminates shall be moulded as a single unit in a mould and vulcanised under heat and pressure. Moulding of elements in separate units and subsequent bonding as well as cutting from large sized cast, shall not be permitted.
- iii) The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.
- iv) Steel plates for laminates shall be sand/grit blasted, clean of all mill scales and shall be free from all contaminants prior to bonding by vulcanization. Rusted plates with pitting shall not be used. The plates shall be rounded so as to be free of sharp edges.
- v) Bonding shall be carried out during vulcanisation using suitable bonding agent for bonding of elastomer to steel such that the bond peel strength is at least 7 N/mm width when tested in accordance with IS:3400 Part XIV method A.
- vi) Spacers used in mould to ensure cover and location of laminates shall be of minimum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.
- vii) Care shall be taken to ensure uniform vulcanizing conditions and homogeneity of elastomer through the surface and body of bearings.
- viii) The vulcanizing equipment/press shall be such that between the platens of the press, the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanization of the bearing.
- ix) The moulding dies utilized for manufacturing the bearings shall be so

set inside the platen of the press that the pressure developed during vulcanization of the product is evenly distributed and the thickness maintained at all places are within acceptable tolerance limits taking into consideration the expansion/shrinkage allowance of vulcanizate (the product of vulcanization).

- x) The raw compound which is introduced inside the metal dies for vulcanization shall be accurately weighed each time and shall be of sufficient quantity to ensure proper flow of material to every part of the die so that a homogeneous and compact bearing is produced without any sign of sponginess or deficiency of material at any place.
- xi) Before the rubber mix of any batch is used for producing vulcanized bearings, test pieces in the form of standard slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.
- xii) Bearings of similar size to be used in a particular bridge project shall be produced by identical process and in one lot as far as practicable. Phased production may be resorted to only when the total number of bearings is large.

### Manufacturing tolerances

The bearings shall be fabricated/manufactured with the tolerances specified in Table 2000-3. Tolerances of thickness of individual layer of elastomer, dimension of laminates, and flatness of laminates are primarily meant for quality control during production. In order to measure thickness of individual layer of elastomer, dimension of laminates and flatness of laminates of a finished bearing, it is essential to cut the bearing, which may be done if agreed upon between the manufacturer and the buyer.

**Table 2000-3: tolerances**

|    | items  | tolerances   |
|----|--|--------------|
| 1) | <b>overall linear plan dimensions</b>  | -3 mm, +6 mm |
| 2) | <b>total mean bearing thickness</b><br>(The mean thickness is the arithmetic average of the thickness measured at five points on the major surface as indicated for various shaped bearings:<br>Rectangular : corners and centre<br>Circular : corners of inscribed square and centre) | -2.5%, +5%   |
| 3) | <b>Parallelism</b>   |              |
| a) | Of top surface of bearing with respect to the bottom surface as datum  | 1 in 200     |
| b) | Of one side surface with respect to the other as datum   | 1 in 100     |



|    |  |   |
|----|--|---|
| 4) | <b>thickness of individual layer of elastomer</b>  |   |
| a) | Inner layer of elastomer   | $\pm 12\%$ (max of 2 mm )   |
| b) | Outer layer of elastomer   | $+20\%$ (max of 1 mm )  |
| c) | Side cover   | -0 mm, +3 mm  |
| 5) | <b>dimension of laminates</b>  |   |
| a) | Plan dimensions of laminates   | -3 mm, + 0  |
| b) | Thickness of laminate  | $\pm 10\%$  |
| c) | Parallelism of laminate with respect to bearing base as datum (with respect to diameter for plates circular in plan and shorter side for plates rectangular in plan) | 1 in 100  |
| 6) | Flatness   |   |
|    | Flatness shall be assessed by placing a straightedge along the diagonal or diameter. The gap between the straightedge  |   |
|    | Load bearing surface of the bearing  | 0.3% of diameter or diagonal or 2% of mean bearing thickness which ever is higher |
|    | Steel laminate   | 1% of diameter or diagonal (max of 1.5 mm)  |

### Acceptance Specifications

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and Engineer.

A testing programme shall be submitted by the manufacturer to the Engineer and his approval obtained before commencement of acceptance testing.

Any acceptance testing delayed 180 days beyond the date of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the Inspector with the aid of the manufacturer's personnel having adequate expertise and experience in rubber testing, working under the supervision of the Inspector and to his complete satisfaction.

Inspection and acceptance shall be carried out lot by lot.

## **Acceptancelot**

A lot under acceptance shall comprise all bearings, including the pair of extra test bearings where applicable, of equal or near equal size produced under identical conditions of manufacture, to be supplied for a particular project.

The size and composition of acceptance lot shall be got approved by the Engineer.

For the purpose of grading levels of acceptance testing, a lot size of 24 or larger number of bearings shall be defined as a 'large lot', while a lot size of less than 24 number of bearings shall be defined as a 'small lot'.

When the number of bearings of equal or near equal size for a single bridge project is large and phased production and acceptance is permitted, the number of bearings supplied in any single phase of supply shall comprise a lot under acceptance. When such phased supply is made, each such lot shall be considered as a large lot for the purpose of acceptance testing.

## **Levels of acceptance testing**

The following two Levels of acceptance testing shall be adopted, depending on lot size :

Acceptance testing Level 1 is a higher level of inspection and testing and shall be applicable to large lots only, unless otherwise specified. This shall involve manufacture of two extra bearings for each lot to be used as test bearings and eventually consumed in destructive testing.

Acceptance testing Level 2 shall be applicable to small lots only, for which one extra bearing shall be manufactured and shall not involve destructive testing of finished bearing. Out of the lot, one bearing shall be selected at random for carrying out material tests. This bearing shall be excluded from the lot accepted.

Acceptance testing Level 1 may be specified for small lots also at the sole discretion of the Engineer taking into account the special importance of a bridge project. The cost of extra bearings, in such cases shall be borne by the user, while the cost of all other materials, equipment and testing shall be borne by manufacturer.

## **Testing**

Acceptance testing shall comprise general inspection, test on specially moulded test pieces and test on complete bearings or sections for measurement of various quality characteristics detailed below :

### **Acceptance testing level 1**

#### **General inspection**

- i) All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape, hardness or any other discernible superficial defects.

- ii) All bearings of the lot shall be checked for tolerances for overall dimensions, mean bearing thickness, parallelism of bearing surfaces and flatness of load bearing surfaces as specified in Table 2000-3.
- iii) The test shall be carried out on all bearings as part of the standard production process. The temperature of the room in which the bearings are tested shall not vary more than 10 °C. The main objective of this test is to eliminate poorly made bearings by visual inspection in a quick and efficient way. All bearings of the lot shall be subjected to an axial load to correspond to the design load at serviceability limit state while visual examination is made to check for discernible defects like:

Misalignment of reinforcing plates

Poor bond at laminate/steel interface

Variation in elastomer layer thickness

Any surface defects developed during testing

- iv) During acceptance testing, complete test data shall be furnished by the manufacturer and one bearing per lot shall be selected at random and the same test shall be repeated. The bearings shall then be visually inspected for defects and the stiffness shall also be measured.
- v) During the test, the deflection between 30 percent and 100 percent of the maximum load for the application shall be recorded and used to check the consistency of the stiffness value. Variation in stiffness of any individual bearing from the mean of the measured values for all such bearings of the lot, shall not be larger than 20 percent of the mean value.
- vi) In case of any visual defect or unacceptable stiffness during acceptance testing, all bearings of the lot shall be subjected to the same test again and only the bearing that passes the test in all respects, shall be accepted.

### **Tests on specially Moulded test Pieces**

- i) Test pieces shall be moulded by the manufacturer with identical compound and under identical vulcanising conditions as used in the manufacture of the bearings of the acceptance lot. The process shall be open to inspection by the Inspector/Engineer.
- ii) Test pieces offered for inspection shall be identified by suitable markings and duly certified by the manufacturer.
- iii) The quality characteristics to be tested are listed below. The specification reference in parenthesis shall define the corresponding specification for test piece, test method and criterion for acceptance.

Composition (see Note 1 below)

Hardness (Table 2000-1, 1.1)

Tensile strength (Table 2000-1, 1.2)

Elongation at Break (Table 2000-1, 1.3)

Compression Set (Table 2000-1, 2)

Accelerated Ageing (Table 2000-1, 3)

Adhesion Strength (Clause 2005.1.4)

Ozone Resistance (see Note 2 below)

**Note 1** The properties enumerated in **Clause 2005.1** and specific gravity of elastomer of test pieces from test bearing, shall be compared with those for corresponding specially moulded test pieces furnished by the manufacturer. The following variations shall be deemed maximum acceptable:

Specific Gravity + 0.02.

Ash Content  $\pm 0.5$  per cent (e.g., if the ash content of elastomer from test bearing is 4%, the ash content of the specially moulded test piece shall be within 3.5% to 4.5% or vice versa)

Hardness (Table 2000-1, 1.1)

Tensile strength (Table 2000-1, 1.2)

Elongation at Break (Table 2000-1, 1.3)

Compression Set (Table 2000-1, 2)

Accelerated Ageing (Table 2000-1, 3)

Adhesion Strength (Clause 2005.1)

**Note 2** Ozone resistance test can be waived by the Engineer for bearings of CR when satisfactory results of ozone resistance tests on similar grade of elastomer may be available from process control records or development test data furnished by the manufacturer.

Where such process control data are not available or the frequency of testing not deemed adequate, ozone resistance test shall be mandatory for acceptance of bearings of CR.

However, such tests may not be insisted upon for bearings not located in adverse conditions of exposure and where the test on accelerated ageing could be considered as adequate.

Process and acceptance control tests for ozone resistance by an independent testing agency shall be acceptable.

#### **tests on Complete Bearings or samples**

- i) Two bearings shall be selected at random from the lot as test bearings. The tests to be conducted are:

a) Test for determination of shear modulus (on a pair of bearings)  
And

b) Test for determination of compression stiffness (on one bearing out of the selected pair).

The test specifications and acceptance criteria shall conform to those given in Appendix-3 of IRC:83 Part II. The tested bearings shall be part of the lot accepted.

ii) The test for determination of shear bond strength shall be conducted on two identical bearings selected at random from the lot as test bearings or on two identical specially moulded sample bearings of plan dimension 200 mm x 300 mm and overall thickness 41 mm (3 elastomer layers of thickness 8 mm each, 4 reinforcing plates of thickness 3 mm each, face cover 2.5 mm, and side cover 4 mm) as agreed upon between the manufacturer and buyer:

The test specifications and acceptance criteria shall conform to those given in Appendix-3 of IRC:83 Part II. This is a destructive test and the test bearings shall not be used in the structure.

## **Acceptance testing level 2**

**General inspection** : This shall conform to the provisions in Clause 2005.4.3.1 in all respects.

**Test on specially moulded test pieces** : This shall conform to the provisions in Clause 2005.4.3.1 in all respects.

**Test on complete bearings** : Test for determination of shear modulus shall be conducted using two bearings of the lot selected at random and conforming to relevant provisions of Clause 2005.4.3.1. These bearings shall, however, be part of the lot accepted. The remaining tests stipulated in aforesaid clause shall be carried out on two bearings selected at random which shall be excluded from the lot accepted.

## **Special acceptance inspection**

Special acceptance inspection shall comprise the following :

- i) Acceptance testing by a NABL accredited independent external agency with separate or supplemental test facilities provided by it for polymer identification and confirmation about percentage of polymer content and ash content by TGA method.
- ii) Acceptance testing on test pieces prepared from the surface or body of the test bearings instead of specially moulded test pieces.
- iii) Acceptance testing on cut sample from finished bearing in order to measure thickness of individual layer of elastomer, dimension of laminates and flatness of laminates.
- iv) Acceptance test at ULS condition. Bearings tested at ULS condition cannot be used in the structure as its performance at SLS condition

cannot be guaranteed after such test.

- v) Acceptance tests not covered by these specifications but according to the specifications laid down by the Engineer.

Special acceptance inspection may be specified under the following conditions :

- a) Special contract agreement between the manufacturer and the buyer. Cost of additional bearings to be consumed for special acceptance inspection, shall be borne by buyer.
- b) Evidence of unsatisfactory process or acceptance control

### **Inspection Certificate**

A lot under inspection shall be accepted by the Inspector and so certified, when no defect is found with respect to any of the quality characteristics tested on samples drawn from the lot, according to specifications laid down to Clause 2005.4.3 covering general inspection tests on specially moulded test pieces and on complete bearings.

In case any bearing is found defective, the lot shall be rejected by the Inspector and so certified.

In case any bearing is found to be defective with respect to any quality characteristic, discerned by general inspection tests specified in Clauses 2005.4.3.1 and 2005.4.3.2, tests on specially moulded test pieces and complete bearings as applicable according to those Clauses, shall nevertheless be completed. If the said lot, rejected by general inspection, satisfies the acceptance criteria in respect of these other tests, the lot and individual bearings found defective shall be clearly identified in the inspection certificate.

Immediately on completion of inspection by the Inspector authorized by the Engineer, the manufacturer shall obtain an inspection certificate which shall include the details of a lot or lots accepted/rejected by him and records of all test measurements.

### **Quality Control Certificate**

The manufacturer shall certify for each lot of bearings under acceptance that :

- a) an adequate system of continuous quality control was operated in his plant.
- b) the entire process remained in control during the production of the lot of bearings under acceptance, as verified from the quality control records/charts which shall be open to inspection of Engineer/Inspector on demand.

A certified copy of results of process control testing done on samples of elastomer used in the production of the lot shall be appended and shall include the following information :

Composition of compound – raw elastomer and ash content, the grade of raw elastomer used (including name, source, age on shelf), test results of hardness, tensile strength, elongation at break, compression set, accelerated ageing, etc.

A higher level certification of the process quality control shall be called for at the sole discretion of the Engineer in special cases e.g. where adequate inspection of bearings similar to those comprising the lot under inspection produced in the same plant, is not available with the Engineer or where there is any evidence of process or acceptance control being deemed unsatisfactory. The higher level certification shall comprise submittal of a complete quality control report covering tests as given in Appendix 3 of IRC:83 (Part II), supplementing the quality control certificate.

### **Acceptance**

The manufacturer shall furnish the following to Engineer for obtaining acceptance:

- 1) Quality control certificate as laid down in Clause 2005.4.6.
- 2) Inspection certificate as laid down in Clause 2005.4.5.

The manufacturer shall furnish any supplementary information on the system of quality control and/or process and acceptance control testing as may be deemed necessary by the Engineer.

In case of any evidence of process or acceptance control testing being deemed unsatisfactory by him, Engineer at his sole discretion may call for a special acceptance testing of the lot according to specifications laid down by him, without any prejudice to his right to reject the lot. The entire cost of such supplementary inspection shall be borne by the manufacturer.

The Engineer shall be the sole authority for acceptance of a lot on scrutiny of the certificates along with any supplementary evidence as mentioned in this Clause, to his complete satisfaction therewith.

In case of rejection of a lot, the Engineer shall reserve the right to call for special acceptance inspection for the succeeding lots offered for inspection, according to the specifications laid down by him. The entire cost of such tightened inspection shall be borne by the manufacturer.

### **2005.5 Certification and Marking**

Bearings shall be transported to bridge site after final acceptance by Engineer and along with an authenticated copy of the certificate to that effect.

Each bearing shall be uniquely and individually numbered on its external faces for

identification. The identification number shall be unique and such as to enable other bearings manufactured at the same time, to be traced through the production control records, should the need arise. The manufacturer's name and unique identification number of the bearing should be vulcanized on the top or bottom of the bearing.

An information card giving the following details for the bearings, duly certified by the manufacturer, shall also be appended :

Name of manufacturer

Date of manufacture

Elastomer grade used

Bearing dimensions

Production batch no.

Acceptance lot no.

Date of testing

Name and specific location of bridge

Explanation of markings used on the bearing

All bearings shall have suitable index markings identifying the information. The markings shall be made in indelible ink or flexible paint and if practicable, should be visible after installation. The top of the bearing and direction of installation shall be indicated.

### **Storage and Handling**

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover and packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather of the bearings during transport and handling prior to and during installation.

### **Installation**

- i) Bearings shall be installed in the structure as specified or approved by the Engineer to ensure that right bearing is being installed at the right location.
- ii) Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 percent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance  $\pm 3$  mm).
- iii) Concrete surfaces shall be free from local irregularities (maximum



tolerance  $\pm 1$  mm in height).

- iv) Departures from common planarity of twin or multiple bearings shall be within such tolerance as may be specified or approved by the engineer.
- v) Design shall be got checked for the actual inclination in seating if larger inaccuracies than those specified are permitted.
- vi) For cast in-situ concrete superstructure, where bearings are installed prior to concreting, the forms around the bearings shall be capable of easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar/grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.
- vii) Fixing of bearing to precast concrete or steel superstructure elements, shall be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent possibility of behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearings against displacement for the purpose of design.
- ix) Lifting of a cast in-situ post-tensioned bridge deck for relieving time dependent deformation shortly after installation of bearings, should be avoided. In case such lifting is unavoidable, the lifting arrangement, proper seating of the girder on the bearing, etc. shall be rigidly controlled to avoid any risk of misalignment.
- x) Bulging of the rubber layer between the reinforcing steel laminates on free exposed perimeter under load, which is a normal phenomenon, shall be examined carefully for detecting any evidence of crack or bond failure.
- xi) In case seating of bearings on a non-horizontal plane is required, it shall be carried out in accordance with acceptable practice and particular specifications as may be laid out and directed by the Engineer.
- xii) As a measure of ample precaution against accidental displacement, the bearings shall be placed in a recess as shown in Fig. 9 of IRC:83 (Part II).
- xiii) After installation, bearings and their surrounding areas shall be left clean.

## **Maintenance**

- i) The maintenance of bearings shall be carried out according to a planned schedule.
- ii) The structure should be designed and detailed in such a way that the bearings are easily accessible after installation for inspection and maintenance. Arrangements for insertion of jacks to lift the bridge deck shall be made in detailing of structure.
- iii) The exposed bearing surface shall be maintained clean and free from contamination with grease, oil or other deleterious matter.
- iv) Annual routine maintenance inspection or special maintenance inspection of all bearings shall be made to check the following aspects and results reported:
  - The top and bottom load bearing surfaces shall be in full contact with the plinth (bottom supporting surface) and the soffit (top supporting surface). If there is imperfect contact between the bearing surfaces and the soffit and plinth, the angle between the soffit and plinth shall be checked against the design specifications.
  - The magnitude of the shear deflection of each bearing shall be checked to ensure that it is within the design specifications.
  - A visual inspection shall be made of all the accessible edges. A note shall be made of the size and position of any cracks, splits or uneven bulges.
  - The plinth and soffit shall be examined for signs of displacement from original position of bearing which may be indicated by black marks left on the plinth and soffit.
  - Where applicable, the sliding surfaces shall be examined for cleanliness and for any movements beyond the design range.
  - Where applicable, protective coating and/or dust protection shall be examined for signs of deterioration.
- v) Damaged bearings shall be replaced immediately. To avoid differences in stiffness, all adjacent bearings on the same line of support shall also be replaced.

### **Measurements For Payment**

The elastomeric Bearing quantity of this item shall be measured in **Cu.cm** of finished dimensions.

### **2006 Pot Bearings**

#### **General**

Pot bearings shall consist of a metal piston supported by a disc of unreinforced elastomer

confined within a metal cylinder to take care of rotation. Horizontal movement, if required, shall be provided by sliding surfaces of PTFE pads sliding against stainless steel mating surfaces, with a system of sealing rings. Pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

## Materials

Structural steel, mild steel, high tensile steel and steel for forging shall conform to the requirements of Section 1009 of these Specifications.

Cast steel shall comply with Grade 280-520W or 340-570W of IS:1030.

Stainless steel shall conform to AISI 316 L or O Cr  $2\frac{1}{2}$  Ni  $12\frac{1}{2}$  M  $2$  of IS:6911.

## Ptfe

The raw material for PTFE used in bearings shall be pure polytetrafluoroethylene, free sintered without regenerated materials or fillers. The mechanical and physical properties of unfilled PTFE shall comply with Grade A of BS:3784 or equivalent. PTFE shall be either in the form of solid rectangular modules or large sheets with dimples formed by hot pressing or moulding. Sheet with dimples formed by machining or drilling from a solid PTFE sheet, shall not be permitted. The surface of PTFE sheets/modules which are to be in contact with metal backing plates, shall be provided with suitable chemical treatment for proper bonding. Adhesives used for bonding PTFE to backing plates, shall produce a bond with minimum peel strength of 4 N/mm width when tested in accordance with BS:5350 (Part C9).

## Elastomer

The elastomer to be used for the components of bearings shall comply with provisions of Table 2000-1 of this Section.

The confined elastomer inside the pot shall have the properties as given in Table 2000-4:

**Table 2000-4 : Properties of Confined Elastomer**

| s.no. | Property                 | unit | Test Method-Specification Reference | limiting Value |
|-------|--------------------------|------|-------------------------------------|----------------|
| 1)    | Hardness                 | IRHD | IS:3400 (Part II)                   | 50 ± 5         |
| 2)    | Min. tensile strength    | MPa  | IS:3400 (Part I)                    | 15.5           |
| 3)    | Min. elongation at break |      | As per Table 1 of IRC:83 (Part II)  |                |
| 4)    | Max. compression set     |      | -do-                                |                |
| 5)    | Accelerated aging        |      | -do-                                |                |

## Composite Material

For guide of Pot bearings, composite material may be used for achieving lower coefficient of friction and higher strength. Such composite material shall consist of either (a) a bronze backing strip and a sintered inter-locking porous matrix impregnated and overlaid with a

PTFE/lead mixture or (b) a mixture of PTFE, glass fibre and graphite embedded in a bronze mesh which is bonded to a galvanized steel backing strip.

### **Seals**

- i) Internal seals shall be either of the following:
  - a) Brass sealing ring made of metallic brass conforming to IS:410.
  - b) Poly Oxy Methylene (POM) sealing chain of proven type consisting of individual interlocking elements made of moulded polyoxymethylene having properties as specified in Table 2 of IRC:83 (Part III).
- ii) External seals and wiper seals shall be made of elastomer conforming to provisions of Clause 2006.2.5.

### **Fasteners**

Bolts, screws, nuts and lock nuts, shall generally conform to IS:1363, IS:1364, IS:1365, IS:2269, IS:3138, IS:6761 and IS:6639 as appropriate with mechanical properties conforming to IS:1367. Threads shall generally conform to IS:4218. Washers shall conform to IS:2016 and IS:6610 as appropriate.

### **Manufacture**

- i) The main components of a bearing shall be cast/forged as a single monolithic body. If they are made from mild steel, they shall be machined to the desired shape from a single piece of mild steel free of laminations. No welding is permitted for manufacture of the main components of a bearing.
- ii) The mating surface of the piston and cylinder of Pot bearings and that of the pin and cylinder of Pin bearings, shall be metallurgically hardened. The surface hardness shall not be less than 300 BHN.
- iii) The guides shall always be monolithic with the parent component.
- iv) For cast steel bearings, surfaces which will be in contact with concrete as well as non-working external surfaces of components may be kept in as-cast condition.
- v) For sliding components, stainless steel sheet shall be attached to the backing plate by continuous fillet welding along the edges, in such a fashion as to ensure flatness of the stainless steel sheet throughout its service life and avoid entrapment of air and prevent ingress of moisture at the interfaces. The backing plate shall extend beyond the edges of the stainless steel sheet to accommodate the weld which should not protrude above the top of the stainless steel sheet.
- vi) Suitable glue shall be used while confining the PTFE in the recesses. For large PTFE sheets sub-divided into parts, each individual part shall be confined into separate recess.

- vii) For internal seal, split rings 2 mm thick and 20 mm wide made of metallic brass shall be provided in layers with staggered split positions. For elastomeric pressure pad of up to 480 mm diameter, a minimum of 2 layers of rings shall be provided, while for that above 480 mm diameter, a minimum of 3 layers of rings shall be provided.
- viii) For internal seal of POM, the sealing chain made of individual interlocking elements shall be moulded as an integral part of the elastomeric pressure pad during the vulcanization process.
- ix) Pre-setting of sliding element if required shall be done in the manufacturer's workshop before dispatch.
- x) The bearing assembly shall be provided with temporary clamps to avoid separation of parts during transportation and installation.
- xi) All welding shall be as per IS:816 and IS:9595, with electrodes as per IS:814. Preheating and post-weld stress relieving shall be done if required.
- xii) Movement indicators shall be provided to facilitate routine inspection during service period.
- xiii) All non-working surfaces as well as the surfaces to be in contact with the structure shall be suitably prepared by sand/shot blasting to SA 2½ quality as per IS:9954.
- xiv) All non-working surfaces shall be given suitable protective coating either by painting or by zinc spraying. The total dry film thickness of protective coating shall not be less than 160 µm.
- xv) Painted protective coating shall comprise of two coats of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per manufacturer's specification.
- xvi) Bearing components to be embedded in concrete or surfaces of any component to be in contact with concrete structure, shall be given a coat of epoxy primer or any other suitable coating before dispatch, to prevent corrosion during transportation and storage at site. The protective coating shall be such that it will not affect the bond between the bearing component and the concrete.
- xvii) Silicon grease shall be applied at the PTFE – stainless steel interface of Pot bearings.
- xviii) The confined elastomeric pressure pad shall be lubricated with a suitable lubricant, which will not affect the material of the pad.

### **Manufacturing tolerances**

The overall dimensions of any assembled bearing or component thereof shall not exceed the tolerance limits as given in Table 2000-5:

**Table 2000-5 : Manufacturing tolerances**

| s.no. | item   | tolerances   |
|-------|--|--|
| 1)    | Plan dimension of assembled bearing  | -0 mm to +5 mm or 0.5 percent of plan dimension whichever is higher            |
| 2)    | Overall height of assembled bearing  | -0 mm to +3 mm or 1 percent of overall height whichever is higher              |
| 3)    | Parallelism of top surface of assembled bearing w.r.t. the bottom surface as datum | 1 in 200   |
| 4)    | Height of confined elastomeric pressure pad  | -0 per cent to + 0.5 percent   |
| 5)    | Thickness of any machined steel component  | -0 mm to +1 mm   |
| 6)    | Overall dimensions of any unmachined cast steel component                          | Class 2 of IS:4897   |
| 7)    | Stainless steel sliding surface<br>(a) Flatness<br>(b) Surface finish              | 0.0004L, where L= length in direction of movement<br>Ra≤0.25 µm as per IS:3073 |

The tolerance on flatness of PTFE shall be 0.2 mm where the diameter or diagonal is less than 800 mm and 0.025 per cent of the diameter or diagonal where this dimension is greater than or equal to 800 mm. On PTFE surfaces made up of more than one piece of PTFE the above conditions shall apply to the diameter or diagonal dimension of the inscribing circle or rectangle around the PTFE. The tolerance of centre-to-centre distance of dimples, depth of dimples and diameter of dimples for dimpled PTFE sheet shall be  $\pm 0.5$  mm,  $\pm 0.5$  mm and  $\pm 1.0$  mm respectively.

The dimensional tolerances of confined PTFE shall be as given in Table 2000-6. The gap between the edge of the PTFE sheet and the edge of the recess in which it is confined, shall not anywhere exceed 0.5 mm or 0.1 per cent of the corresponding plan dimensions of the PTFE sheet, in the direction measured, whichever is greater, but in no case shall exceed 1 mm. The profile tolerance on the specified projection of PTFE above its confining recess shall be as given in Table 2000-6.

**Table 2000-6: Dimensional Tolerance of Confined PTFE and Profile Tolerance of its Projection**

| Maximum dimension of PTFE (diameter or diagonal) (mm) | tolerance on Plan dimension (mm) | tolerance on thickness (mm) | tolerance on Specified Projection above Recess (mm) |
|---|----------------------------------|-----------------------------|---|
| <600  | $\pm 1.0$                        | -0 to +0.5                  | -0 to +0.5  |
| >600, $\leq 1200$                                     | $\pm 1.5$                        | -0 to +0.6                  | -0 to +0.6  |
| >1200, $\leq 1500$                                    | $\pm 2.0$                        | -0 to +0.7                  | -0 to +0.8  |

### **Tolerance of Fit**

Tolerance of fit between different components of bearings shall be as follows:

- i) For Pot bearings the tolerance of fit between the piston and cylinder shall be +0.75 mm to +1.25 mm.
- ii) For Pot bearings the tolerance of fit between the confined elastomeric pressure pad and cylinder shall not exceed 0.5 percent of the diameter of the pad or 1 mm, whichever is higher.
- iii) For Pin bearings the tolerance of fit between the pin and cylinder shall be + 1.5 mm to +2 mm. Manufacturing tolerances of the contact surfaces of pin and cylinder shall be as per h11 and H11 of IS:919 respectively.
- iv) The tolerance of fit between guide(s) and adjacent-component shall be  
+2 mm to +4 mm.

### **inspection and testing**

- i) Inspection and testing shall consist of the following actions:
  - a) Inspection and testing of raw materials
  - b) Process inspection
  - c) Inspection and testing of finished bearings

The manufacturer shall have all test facilities required for process and acceptance control tests, installed at his plant to the complete satisfaction of the Inspector appointed by the Engineer. The test facilities and their operation shall be open for inspection by the Inspector at any time.

- iii) A testing programme shall be drawn up and submitted by the manufacturer to the Inspector and his approval obtained before commencement of testing. All tests on raw materials and finished bearings shall be carried out at the manufacturer's workshop as per procedures laid out in this Section. All the test reports duly certified by the Inspector shall be furnished by the manufacturer at the time of dispatch of the bearing from the workshop.
- iv) Routine test covering all the three items mentioned in i) above shall be carried out by the manufacturer for the bearings of each lot under acceptance. In addition, type test covering items b) and c) of i) above shall be carried out on bearings of each type and load capacity, selected at random by the Inspector, one for each lot. The size of each lot for similar type of bearings shall be 25 nos. or part thereof. Each type of bearing shall be treated as a separate lot. The Inspector may also carry out random tests on raw materials on samples drawn by the manufacturer, in which case the identification and marking of the sample will be done in the presence of the Inspector.



- v) A detailed quality control report of routine tests shall be furnished by the manufacturer to the Inspector, for each lot of bearings offered for inspection.

#### **tests on Raw Materials**

Tests on raw materials as per relevant material standards, shall be carried out by the manufacturer in accordance with stipulations in Appendix 2 of IRC:83 (Part III).

#### **Process inspection/tests**

- i) Test on welding shall consist of DP test and visual inspection as per IS:822.
- ii) The hardness of all major steel components shall be tested to determine the Brinnel Hardness Number (BHN), which shall be not less than 120 BHN for mild steel and 150 BHN for cast steel and forged steel.
- iii) All major metallic components shall be ultrasonically tested as per Level 3 of IS:9565.
- iv) The surface hardness of the mating interface shall be checked in accordance with the requirement specified in Clause 2006.3 ii).
- v) Corrosion protection shall be checked in accordance with the requirement specified in Clause 2006.3 xiv).
- vi) In case any of the acceptance control tests are deemed to be unsatisfactory by the Inspector, complete bearing or particular component(s) of the entire lot may be rejected, depending on the cause of rejection i.e. if the test of any material is unsatisfactory, the component involving that material shall be rejected for the entire lot; but if a finished bearing fails in load test, the complete bearing shall be rejected and all the bearings of that type and load capacity, shall be load tested before acceptance. If the result of process inspection is unsatisfactory, proper rectification measures shall have to be adopted by the manufacturer and the acceptance tests shall be repeated.

#### **inspection/test of Finished Bearings**

- i) All bearings of the lot shall be visually inspected for any defects in surface finish, shape or any other discernible superficial defects.
- ii) All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 2006.3.1.
- iii) At least one or a pair of bearings of each type and different vertical load capacity, selected at random, shall be load tested. For Pot and PTFE bearings, the test load shall be 1.25 times the design vertical load while that for Pin and Metallic Guide Bearings, it shall be 1.25 times the specified design horizontal load. Additionally, for testing of Pot and PTFE bearings under a combination of loads acting in different axes, the test loads shall be 1.1 times the respective design loads. The test load shall be applied in stages and held for 30 minutes. For Pot bearings, the vertical deflection under sustained test load shall not



increase by more than 4% of the thickness of the confined elastomeric pressure pad. The load shall then be removed and the bearing dismantled for visual examination.

- iv) Visual examination of the test bearing shall be carried out both during and after the test. Any visual defects, such as physical damage, cold flow of PTFE resulting in reduction of height by more than 0.5 mm, damage of internal seal and/or extrusion of the confined elastomeric pressure pad for Pot bearing, defects/cracks at metal to metal contact surfaces, shall lead to rejection of the bearing.
- v) For bearings with sliding components, friction test shall be performed on properly lubricated PTFE-stainless steel sliding surface at constant vertical load equal to the design vertical load as well as the permanent vertical load. Horizontal load shall be applied till sliding occurs. Coefficient of friction ( $\mu$ ) shall be determined on the basis of applied vertical and horizontal loads and shall not exceed two-thirds of the value specified in Table 2000-7, depending on the actual average pressure on PTFE due to the applied vertical load.

**Table 2000-7 : Coefficient of Friction for Stainless Steel Sliding on Properly Lubricated PTFE**

| <b>Average Pressure on Confined PTFE<br/>(MPa)</b> | <b>Maximum Coefficient of Friction</b> |
|--|--|
| 5  | 0.08                                   |
| 10   | 0.06                                   |
| 20   | 0.04                                   |
| $\geq 30$  | 0.03                                   |

- vi) Rotation test shall be performed on Pot bearing with properly lubricated elastomeric pressure pad for design rotation under a constant vertical load equal to the permanent vertical load.

### **Certification and Marking**

- i) Bearings should be transported to bridge site after final acceptance by the Inspector/inspection agency appointed by the concerned authority, along with an authenticated copy of the certificate of acceptance. An information card listing the required bearing characteristics, duly certified by the manufacturer should also be appended with the certificate.
- ii) All bearings shall have suitable index markings in indelible ink or flexible paint, which if practicable, shall be visible even after installation, giving the following information:
  - Name of manufacturer
  - Month and year of manufacture

- Bearing designation
- Type of bearing
- Load and movement capacity
- Centre line markings to facilitate installation
- Direction of major and minor movement, if any
- Preset, if any

## **installation**

### **General**

- i) Bearings shall be so located as to avoid the accumulation of dirt and debris on or around them. Detailing of the structure shall be such that water is prevented from reaching the bearings.
- ii) In order to avoid contamination of moving surfaces, bearings should not normally be dismantled after leaving the manufacturer's workshop. However, if for any reason, a bearing is required to be dismantled, it shall be done only under expert supervision for which the manufacturer's help may be sought.
- iii) Transfer of load from the superstructure to the bearings should not be allowed until the bedding material has developed sufficient strength. Temporary clamping devices should be removed at the appropriate time before the bearings are required to accommodate movement. The holes exposed on removal of temporary transit clamps should be filled with selected material. Where re-use of these fixing holes may be required, the material used for filling the holes should be capable of being easily removed without damaging the threads.
- iv) Suitable temporary supporting arrangements under bearing base plates should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. Such temporary supports, if provided, should be removed once the bedding material has reached its required strength. Any voids left as a consequence of their removal should be made good using the same bedding material. Steel folding wedges and rubber pads are suitable for use as temporary supports under bearing plates.

### **Bedding**

- i) The bedding material shall be selected keeping in view a number of factors such as the type and size of bearing, construction sequence, load on the bearing, required setting time, friction requirements, access around bearings, design and condition of surface in the bearing area and thickness, strength and shrinkage of bedding material.

- ii) Commonly used bedding materials are cementitious or chemical resin mortar and grout. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.
- iii) The bedding material, whether above or below the bearing, should extend over the whole area of the bearing in order to ensure even loading. After installation, there shall be no voids or hard spots. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.
- iv) The bedding material shall be capable of transmitting the applied load to the structure without being damaged. Surfaces to receive bedding mortar shall be suitably prepared so as to be compatible with the mortar chosen.

### **Fixing of Bearings**

- i) Bearings should be anchored in order to counter vibration and accidental impact. Anchorage should be accurately set into recesses cast into the structure using templates. The remaining space in the recesses should be filled with material capable of withstanding the loads.
- ii) Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Voids beneath the bearings should be completely filled with bedding material using the appropriate method.
- iii) Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location.
- iv) If the structure is of steel, the bearings may be bolted directly onto it. Care shall be taken to ensure that there is no mismatch between the bolt holes of the structure and those of the bearing.
- v) Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.

### **Bearings supporting in-situ Concrete deck**

- i) Where bearings are installed prior to casting of an in-situ concrete deck, formwork around bearings should be properly sealed to prevent grout leakage. It is essential that the bearings and particularly the working surfaces are protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of green concrete. Any mortar contaminating the bearings should be completely removed before it sets.

- ii) For bearings supporting precast concrete or steel beams, a thin layer of synthetic resin mortar should be used between bearings and the beams. Bearings shall be bolted to anchor plates or sleeves embedded in precast concrete elements or to machined sole plates on steel elements.

### **Installation tolerances**

Bearings shall be located so that their centre lines are within  $\pm 3$  mm of their correct position. The level of a bearing or the mean levels of more than 1 bearing at any support, shall be within a tolerance of  $\pm 0.0001$  times the sum of the adjacent spans of a continuous girder, but not exceeding  $\pm 5$  mm. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction, even under superstructure in gradient.

### **Maintenance**

- i) Bearings shall be designed and manufactured to make them maintenance free so as to withstand undesirable effects caused by extreme atmosphere or aggressive environmental conditions/unforeseen events.
- ii) Suitable easy access to the bearings shall be provided for inspection and maintenance. Provision shall also be available for jacking up the superstructure so as to allow repair/replacement of bearings.
- iii) The area surrounding the bearings shall be kept clean and dry to avoid damage to the bearings. The bearings shall also be periodically cleaned to remove deposits of salts, debris, dust or other foreign material.
- iv) Periodic inspection and nominal maintenance of bearings shall be carried out in order to ensure their better performance and longer life. The bearings are required to be inspected at intervals of one year for the first five years after installation and at intervals of two years thereafter.
- v) The bearings shall also be examined carefully after unusual occurrences such as passage of heavy traffic/oversized loads, earthquakes and battering by floating debris in high floods.

### **2007 Inspection And Testing**

Where any patented items are used, the manufacturer's certificate for the same with test proofs shall be submitted along with the design and got approved by the Engineer before their use in work.

### **2008 Test 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.

## **2009 Measurements For Payment**

Bearings shall be measured in numbers, according to their capacities and particular specifications given on the drawings.

The quantity of this item shall be measured in **Cu.cm** of finished dimensions.

## **2010 Rate**

The contract unit rate of each type of bearing shall include the cost of manufacturing, supplying and fixing the bearings in position complete as specified on the drawings or as directed by the Engineer.

The rate shall also include the cost of samples and their testing as required under the specifications or as directed by the Engineer.

In case of steel bearings the rate shall include the cost of all nuts, bolts and all tests prescribed in the specifications and shown on the drawings.

### **Item No. 19**

**Providing and filling sand behind abutments and between returns in layers as directed**

### **Item No. 47**

**Earthwork for embankment including breaking clods, dressing with all lead and lift (excluding watering and consolidation)(E) From Borrow area within 3.0 Km. lead (For Subgrade)**

**MORTH V<sup>th</sup> REVISION Cl. No. 305, Pg. no. 63**

## **305 Embankment Construction**

### **305.1 General**

#### **305.1.1 Description**

These Specifications shall apply to the construction of embankments including sub-grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. All embankments sub-grades, earthen shoulders and miscellaneous backfills shall be constructed 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.

### **305.2 Materials And General Requirements**

#### **305.2.1 Physical Requirements**

The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as 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.

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

- g) Materials from swamps, marshes and bogs;
- h) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS:1498;
- i) Materials susceptible to spontaneous combustion;
- j) Materials in a frozen condition;
- k) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; And
- l) Materials with salts resulting in leaching in the embankment.

305.2.1.2 Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 percent when tested as per IS:2720 – Part 40) shall not be used as a fill material. Where an expansive clay having "free swelling index" value less than 50 percent is used as a fill material, subgrade and top 500 mm portion of the embankment just below sub-grade shall be non-expansive in nature.

305.2.1.3 Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as  $SO_4$ ) per litre when tested in accordance with BS:1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementitious material.

Materials with a total sulphate content (expressed as  $SO_4$ ) exceeding 0.5 percent by mass, when tested in accordance with BS:1377, Part 3 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

305.2.1.4 The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the sub-grade. 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 in such cases, however, shall not be more than two-thirds of the compacted layer thickness.

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

**Table 300-1 : Density Requirements Of Embankment And Sub-Grade Materials**

| sl. no. | type of work  | Maximum laboratory dry unit weight when tested as per is:2720 (part 8) |
|---------|---|--|
| 1)      | Embankments up to 3 m height, not subjected to extensive flooding                                   | Not less than 15.2 kN/cu.m   |
| 2)      | Embankments exceeding 3 m height or embankments of any height subject to long periods of inundation | Not less than 16 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 material to be used in subgrade shall be non-expansive and shall satisfy design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer shall be followed.

305.2.1.6 The material to be used in subgrade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fails to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer or by the IRC Accreditation Committee shall be followed.

305.2.1.7 The material to be used in high embankment construction shall satisfy the specified requirements of strength parameters.

### 305.2.2 General Requirements

305.2.2.1 The materials for embankment shall be obtained from approved sources with preference given to acceptable materials becoming available from nearby roadway 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.

#### 305.2.2.2 Borrow Materials

The arrangement for the source of supply of the material for embankment and sub-grade and compliance with the guidelines, and 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 the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width of a minimum of 10 m.

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.

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 stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

#### 305.2.2.3 Fly-Ash

Use of fly-ash shall conform to the Ministry of Environment and Forest guidelines. Where fly-ash is used the embankment construction shall conform to the physical and chemical properties and requirements of IRC:SP:38-2001, "Guidelines for Use of Flyash in Road Construction". The term fly-ash shall cover all types of coal ash such as pond ash, bottom ash or mound ash.

Embankment constructed out of fly ash shall be properly designed to ensure stability and protection against erosion in accordance with IRC guidelines. A suitable thick cover may preferably be provided at intervening layers of pond ash for this purpose. A thick soil cover shall bind the edge of the embankment to protect it against erosion. Minimum thickness of such soil cover shall be 500 mm.

#### 305.2.2.4 Compaction Requirements

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 specified design CBR value of the sub-grade.

**Table 300-2 : Compaction Requirements For Embankment And Sub-Grade**

| s.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 | Not allowed |
| b) Remaining portion of embankment                     | 90–95%      |

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

(iii) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 8), appropriate for each of the fill materials he intends to use.

(iv) A graph of dry density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

### **305.3 Construction Operations**

#### **305.3.1 Setting Out**

After the site has been cleared to Clause 201, the work shall be set out to Clause 301.3.1 The limits of embankment/sub-grade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/sub-grade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

#### **305.3.2 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 for the damage at his own cost.

If the embankment is to be constructed under water, Clause 305.4.6 shall apply.

#### **305.3.3 Stripping And Storing Topsoil**

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 subjected to traffic 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.

#### **305.3.4 Compacting Ground Supporting Embankment/Sub-Grade**

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 in accordance with Clauses 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the sub-grade level (top of the sub-grade 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 sub-grade level, watered and compacted in layers in accordance with Clauses 305.3.5 and 305.3.6 to achieve dry density not less than 97 percent relative compaction as given in Table 300-2.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation (500 mm portion just below the sub-grade) shall be removed, suitably disposed and replaced by approved materials laid in layers to the required degree of compaction.

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 such material types (a) to (f) in Clause 305.2.1.1 at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

### 305.3.5 Spreading Material In Layers And Bringing To Appropriate Moisture Content

305.3.5.1 The embankment and sub-grade material shall be spread in layers of uniform thickness in the entire width with a motor grader. The compacted thickness of each layer shall not be more than 250 mm when vibratory roller/vibratory soil compactor is used and not more than 200 mm when 80-100 kN static roller is used. 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.

305.3.5.2 Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed 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 variable widths of surface but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, using disc harrow 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 percent above to 2 percent below

the optimum moisture content determined in accordance with 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 graders, harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

Clods or hard lumps of 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 sub-grade.

305.3.5.3 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 construction vehicles. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength of the material before it was damaged.

Embankments and unsupported fills shall not be constructed with steeper side slopes or to greater widths than those shown in the drawings, 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 to 4 horizontal, such faces shall be benched as per Clause 305.4.1 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill 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.

### 305.3.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self-propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, 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 self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the 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 the site trials shall 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 903.2.2 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 provided the gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/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 using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

#### 305.3.7 Drainage

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

#### 305.3.8 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 305.3.6. 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.

#### 305.3.9 Finishing Operations

Finishing operations shall include the work of shaping 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 902. 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 (Clauses 301.3.2 and 305.3.3) 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 307. If seeding and mulching of slopes is prescribed, this shall be done to the requirements of Clause 308.

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.

#### **305.4 Construction Of Embankment And Sub-Grade Under Special Conditions**

##### **305.4.1 Earthwork For Widening Existing Road Embankment**

When an existing embankment and/or sub-grade 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/sub-grade 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 light weight vibratory roller, double drum walk behind roller, vibratory plate compactor or vibratory tamper 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.

##### **305.4.2 Earthwork For Embankment And Sub-Grade 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 305.4.1 before placing the embankment/sub-grade 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 309 in proper sequence with the embankment and sub-grade work as approved by the Engineer.

##### **305.4.3 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:

If the existing road surface is of granular type and lies within 1 m of the new formation levels, it shall be scarified to a depth of 50 mm or as directed so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new sub-grade level is compacted to the desired density;

If the existing road surface is of bituminous type or cement concrete and lies within 1 m of the new formation level, the bituminous or cement concrete layer shall be removed completely;

If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be roughened after ensuring that the minimum thickness of 500 mm of subgrade is available.

#### **305.4.4 Embankment And Sub-Grade 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 sub-grade 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 for 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 IRC:78. 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 2504 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.

#### **305.4.5 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 geosynthetic 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 305.3.

#### **305.4.6 Embankment Construction Under Water And Waterlogged Areas**

##### **305.4.6.1 Embankment 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 be of GW, SW, GP, SP as per IS:1498 and 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.

##### **305.4.6.2 Embankment Construction In Waterlogged And Marshy Areas**

The work shall be done as per IRC:34.

#### **305.4 Earthwork For High Embankment**

The material for high embankment construction shall conform to Clause 305.2.1.7. In the case of high embankments (more than 6 m), the Contractor shall normally use fly ash in conformity with Clause 305.2.1.1 or the material from the approved borrow area.

Where provided, stage construction of embankment and 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 the Contractor shall bring the resultant level up to formation level with acceptable material for use in fill.

##### **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, wing wall, 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.

#### **305.5 Plying of Traffic**

Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or sub-grade 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 cost as directed by the Engineer.

surface finish and Quality control of work

The surface finish of construction of sub-grade shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised in accordance with Clause 903.

sub-grade strength

It shall be ensured prior to actual execution that the material to be used in the sub-grade satisfies the requirements of design CBR.

Sub-grade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed sub-grade shall be determined on remoulded samples, compacted to the field density at the field moisture content and tested for soaked/unsoaked condition as specified in the Contract.

### **Measurements for payment**

Earth **embankment**/sub-grade construction shall be measured separately by taking cross sections at intervals given in Sub-Section 113.3 after completion of clearing and grubbing and after completion of embankment/sub-grade. The volume of earthwork shall be computed in **cubic metres** by the method of average end areas.

The measurement of **fill material** from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought 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.

The embankment constructed with fly ash will be measured in cu.m, separately for the fly ash portions and for the soil cover and intervening layers of soil, unless otherwise specified in the Contract.

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 top soil shall be measured in cu.m.

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

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

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

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

### **rates**

The Contract unit rates for the items of embankment and sub-grade construction shall be payment in full for carrying out the required operations including full compensation for:



- ii) Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;
- iv) Setting out;
- v) Compacting ground supporting embankment/sub-grade except where removal and replacement of suitable material or loosening and recompacting is involved;
- iv) Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and sub-grade as applicable;
- v) Cost of watering or drying of material in borrow areas and/or embankment and sub-grade during construction as required;
- vi) Spreading in layers, bringing to appropriate moisture and compacting to Specification requirements;
- xi) Shaping and dressing top and slopes of the embankment and sub-grade including rounding of corners;
- xii) Restricted working at sites of structures;
- xiii) Working on narrow width of embankment and sub-grade;
- xiv) Excavation in all soils from borrow pits/designated borrow areas including clearing and grubbing and transporting the material to embankment and sub-grade site with all leads and lifts unless otherwise provided for in the Contract;
- xi) All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;
- xv) Dewatering; and
- xvi) Keeping the embankment/completed formation free of water as per Clause 311.
- xvii) Transporting unsuitable excavated material for disposal with all leads and lifts.

Clause 301.9.5 shall apply as regards Contract unit rates for items of stripping and storing top soil including reapplication of topsoil.

Clause 301.9.2 shall apply as regards Contract unit rate for the item of loosening and recompacting the embankment/sub-grade foundation.

Clauses 309.1.1 and 305.8 shall apply as regards Contract rates for items of removal of unsuitable material and replacement with suitable material, respectively.

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 also

comprise of handling, giving credit towards salvage value and disposal of the dismantled materials with all leads and lifts or as otherwise specified.

Clause 202.7 shall apply as regards Contract unit rate for dismantling and removal of existing cement concrete pavement.

The Contract unit rate for providing and laying filter material 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.

The Contract unit rate for providing and compacting backfill material behind abutments and retaining walls 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.

Clause 305.4.6 shall apply as regards Contract unit rate for construction of embankment under water.

Clause 305.4.7 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.

#### **Item No. 20**

**Providing & laying weep hole in Abutments, and returns by using A.C. pipe of 100mm including laying in proper grede and jointing the completed as per detailed specification.**

#### **MORTH V<sup>th</sup> REVISION Cl. No. 2706, Pg. no. 755**

Weep holes shall be provided on all plain concrete, reinforced concrete, brick masonry and stone masonry structures such as, abutment, wing wall and return walls as shown on the drawings or as directed by the Engineer to permit water to flow out without building up pressure in the back fill. Weep holes shall be provided with 100 mm diameter AC/PVC/HDPE pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be of rectangular shape 80 mm wide, 150 mm high or circular with 150 mm diameter. Weep holes shall extend through the full width of concrete/masonry with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes shall be 1 m in either direction or as shown in the drawings with the lowest at 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.

#### **2707 Tests and Standards of Acceptance**

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria and requirements.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

#### **2708 Measurements for Payment**

The measurement for payment for wearing coat, railing/crash barrier, approach slab, drainage spout and weep holes shall be made as under:

- a. Bituminous and cement concrete wearing coat shall be measured in cubic metres. Steel reinforcement in wearing coat shall be measured in tonnes.
- b. Railing and metal beam crash barriers shall be measured in running metres.
- c. For concrete crash barriers concrete shall be measured in cubic metres and steel shall be measured in tonnes.
- d. Approach slab and its base shall be measured separately in cubic metres.
- e. Drainage spouts shall be measured in numbers. **Weep holes** in concrete/brick masonry structure shall be measured in **numbers**. For structures in stone masonry, weep holes shall be deemed to be included in the item of stone masonry work and shall not be measured separately.

## **2709 Rate**

The contract unit rate for wearing coat shall include the cost of all labour, material, tools and plant and other costs necessary for completion of the work as per these specifications.

The contract unit rate of railing and crash barrier shall include the cost of all labour, material, formwork, tools and plant required for completing the work as per these Specifications.

The contract unit rate for approach slab shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. The rate for base shall include cost of all labour, material, tools and plant required, including preparation of surface and consolidation complete in all respects.

The contract unit rate for drainage spout shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. It shall also include the cost of providing runners and down pipes with all fixtures upto 500 mm above high flood level or up to the drains at ground, as applicable or as shown on the drawings.

The contract unit rate for weep holes shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications.

## **Item No. 21**

**Providing and laying - Fitter Media 600mm thick directed at the back of abutments, returns and wing walls as per detailed specifications.**

## **Item No. 22**

**Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications.Stone**

**Item No. 23**

**Providing and laying Filter material underneath pitching in slopes complete as per drawing and Technical specification**

**MORTH V<sup>th</sup> IREVISION: Cl. No. 2504, Pg. no. 709.**

**2504 PITCHING/REVETMENT ON SLOPES**

**2504.1 Description**

The work shall consist of covering the river side slopes of guide bunds, training works and road embankments with stone, boulders, cement concrete blocks or stones in wire crates over a layer of granular material which will act as a filter. The rear slopes, not subjected to direct attack of the river, may be protected by 300 mm - 600 mm thick cover of clayey or silty earth and turfing.

**2504.2 Pitching and Filter Medium**

**2504.2.1 Pitching**

The pitching shall be provided with stones of thickness and shape as indicated on the drawings.

The stones shall be obtained from quarries and shall be sound, hard, durable and fairly regular in shape. Round boulders shall not be allowed'. Stones showing marked deterioration by water or weather shall not be accepted.

The size and weight of stone shall conform to Clause 5.3.5,1 of IRC: 89. No stone, shall weigh less than 40 kg. The size of spalls shall be a minimum of 25 mm and shall be suitable to fill the voids in the pitching.

Where the stones of required size are not economically available, cement concrete blocks in minimum M15 grade concrete conforming to Section 1700 of these Specifications or stones in wire crates, shall be used.

Geosynthetics, if used in pitching, shall conform to Section 700 of these Specifications.

**2504.2.2 Filter Medium**

The material for the filter shall consist of coarse sand, gravel or stone. One or more layers of graded materials, to act as a filter medium, shall be provided underneath the pitching, to prevent loss of the embankment material and build up of uplift head on the pitching.

$$\frac{D_{15} \text{ (Filter)}}{D_{85} \text{ (Base)}} < 5$$

D 15 (Filter)

$$4 < \frac{\text{D 50 (Filter)}}{\text{D 15 (Base)}} < 20$$

$$\frac{\text{D 50 (Filter)}}{\text{D 50 (Base)}} < 25$$

Notes :

Filter design may not be required if embankment consists of CH or CL soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its D 85 size shall be at least twice the maximum void size in pitching in the foregoing, D 15 means the size of that sieve which allows 15 percent by weight of the filter material to pass through it and similar is the meaning of D 50 and D 85 (15 being replaced with 50 and 85 respectively).

If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as base material for selection of coarser filter. The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.

### **2504.3 Construction Operations**

Before laying the pitching, the side of banks shall be trimmed to the required slope and profiles by means of lines and pegs at intervals of 3 m. Depressions shall be filled and thoroughly compacted.

The filter granular material shall be laid over the prepared base and compacted to the thickness specified on the drawings by means of suitable equipment.

The lowest course of pitching shall be started from the toe wall and built up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 1405.3, of these Specifications in case of dry rubble pitching. It shall be in nominal mix cement concrete (M 15) conforming to Clause 1704.3, of these Specifications in case of cement concrete block pitching.

The stone pitching shall commence in a trench below the toe of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the drawings. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching.

The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

In hand placed pitching, the stone of flat stratified nature should be placed with the principal bedding plane normal to the slope. The pattern of laying shall be such that the joints are broken and voids are minimum by packing with spalls, wherever necessary, and the top surface is as smooth as possible.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spells of the proper size wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals all along the length and width of the pitching. Within these walls the stones shall be hand packed as specified.

#### **2504.4 Toe Protection**

A toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to prevent the slope pitching from sliding down. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Section 1400 of these Specifications or in cement concrete of M15 grade. The pitching/revetment shall be of stones in wire crates or cement concrete blocks in M15 grade. For protection of ties of bank slopes terminating either in short aprons at bed levels or anchored in flooring/rocky bed, the provision of Clause 8.2.2 of IRC:89 may be complied with.

#### **2505 Rubble Stone/Cement Concrete Block Flooring Over**

Cement Concrete Bedding

**2505.1** The work shall consist of constructing rubble stone/cement concrete block flooring laid over a bedding of cement concrete (M15).

##### **2505.2 Construction Operations**

Excavations for laying the bedding and floor protection works shall be carried out as per specifications under proper supervision. Before laying the foundation and protection walls, the excavated trenches shall be inspected by the Engineer to ensure that:

There are no loose pockets and unfilled depressions left in the trench.

The soil at the founding level is properly compacted to true lines and level So as to have an even bedding.

All concrete and other elements are laid in dry bed.

Bedding of cement concrete nominal mix (grade M15) of 300 mm thickness shall then be laid in accordance with Section 1700 of these Specifications except that the surface of the concrete shall not be given a smooth finish.

Flooring shall consist of 150 mm thick flat stone/cement concrete block M15 grade conforming to Section 1700 of these Specifications. It shall be bedded on a layer of cement mortar (1:3) prepared to Section 1300 of these Specifications. Spells shall be used to fill in the voids. The joints shall be filled with cement mortar and finished neat. The stone shall break joints and the thickness of joints shall not exceed 20 mm. The top of flooring shall be kept 300 mm below the lowest bed level.

## **2506 DRY RUBBLE FLOORING**

Dry rubble flooring shall be provided for relatively less important works such as cross drainage structures.

The base for the flooring shall be prepared to the specified levels and slopes and compacted suitably with hand rammers or other means to have even bedding.

The stones shall be laid closely on the prepared base in one or more layers with appropriate bond as specified by the Engineer.

## **2507 CURTAIN WALL AND FLEXIBLE APRON**

### **2507.1 Curtain Wall**

The rigid flooring shall be enclosed by curtain walls (tied to the wing walls) with minimum depth below floor level of 2 m on upstream side and 2.5 m on downstream side. The curtain wall shall be in cement concrete M15 grade or stone masonry in cement mortar 1:3.

### **2507.2 Flexible Apron**

A flexible apron 1 m thick comprising loose stone boulders (weighing not less than 40 kg) shall be provided beyond curtain walls for a minimum distance of 3 m on upstream side and 6 m

## **2508 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.

## **2509 Measurements For Payment**

Providing and laying of filter media shall be measured in **Sqm**.

The earth work in construction of embankment for guide bund shall be measured in cubic metres unless otherwise specified.

The boulders/cement concrete block and boulder/block filled wire crates in apron shall be measured in **cubic metres**.

The filter and stone pitching shall be measured separately in **cubic metres** unless otherwise specified.

Rubble stone/cement concrete block flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

Preparation of base for laying the flooring shall be deemed incidental to the work,

For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as per Section 300 of these Specifications. This item shall be measured in Sq. m.

If directed by the Engineer, the materials shall have to be stacked at site before laying and such stacking shall be considered incidental to the work.

## **2510 RATE**

The contract unit rate for the construction of embankment for guide bund shall cover the cost of all materials including transportation, laying, compacting, all labour, tools, equipment, sampling and testing, supervision and all incidentals necessary for completing the work according to these Specifications.

The contract unit rate for apron shall include the cost of all material, labour, tools and plant for completing the work according to these Specifications. Excavation up to an average depth of 150 mm shall also be deemed to be included in the rate as dressing of the bed. Excavation beyond the depth of 150 mm shall be paid for separately unless otherwise specified.

The contract unit rate for stone/cement concrete block pitching on slopes shall include the cost of preparing the bases, laying and compacting the filter and placing of stone pitching of dry rubble/cement concrete block revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour and materials as well as tools and plant required for the work.

The contract unit rate for rubble stone/cement concrete block flooring shall include the cost of all material, labour and tools and plant for completing the work as per specifications for the relevant item.

### **Item No. 26**

**Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.)**

### **Item No. 29**

**Providing and fixing in position premolded Asphalt filler joints as per drawing .**

## **MORTH V<sup>th</sup> REVISION Cl. No. 2600, Pg. no. 723**

### **2601 Description**

The work shall consist of fabrication and installation of expansion joints. The filler joint, asphaltic plug joint, compression seal joint and reinforced elastomeric joint of slab seal, strip seal and box seal type shall conform to these Specifications.

### **2602 General**

The type of expansion joint proposed to be used shall conform to the design and got approved by the Engineer.

Expansion joints shall be robust, durable, water-tight and easy for inspection, maintenance and replacement. Site fabricated expansion joints shall be prohibited. Expansion joints shall be procured from approved manufacturers and shall be of proven type.

Alternative proprietary type deck joints proposed by the Contractor in lieu of the type



specified shall comply in all respects with the manufacturer's specifications and meet the required range of movements and rotations and be fit for the purpose of ensuring satisfactory long term performance. For such proprietary type deck joints the following information shall be provided.

- i) Name and location of the proposed manufacturer.
- ii) Dimensions and general details of the joint including material specifications, holding down bolt or anchorage details and installation procedures.
- iii) Evidence of satisfactory performance under similar environmental conditions of similar joints being produced by the manufacturer.

Acceptance of any alternative type of expansion joint shall be at the sole discretion of the Engineer. Such deck joints shall be installed in accordance with the manufacturer's recommendations and to the requirements of these Specifications.

Vehicular traffic shall not be allowed over expansion joints after their installation for such period as may be determined by the Engineer.

The expansion joint shall be provided to cover the entire carriageway, kerb and footpath, wherever provided. It shall follow the profile of the deck including the kerb, footway and fascia. The expansion joint for kerb, footway and fascia may be of different type and specification from that used for the carriageway and it shall cater to all movements and rotations for which the carriageway expansion joint is designed and shall be water tight.

### **2603 Performance Requirements**

The expansion joint proper and the transition zone (the zone of connection of joint assembly and the adjoining deck) shall satisfy the performance requirements specified herein. The expansion joint proper shall satisfy the performance requirements of both the bridge structure and the road users.

#### **Performance Requirements with Respect to Bridge structure**

The expansion joint shall:

- i. withstand the imposed loads including the impact load from live load and other sources,
- ii. allow expansion and contraction movement due to temperature, creep, shrinkage, pre-stressing and structural deformations,
- iii. permit relative rotation in elevation and plan due to the causes mentioned above,
- iv. be waterproof,
- v. be properly sealed,
- vi. ensure long life by being resistant to corrosion,

- vii. be easy to install,
- viii. be easy to maintain.
- ix. be easy to replace. And
- x. be resistant to the materials likely to collect/spill over the deck in its normal service.

### **Performance Requirements with Respect to user**

The expansion joint shall:

- i. provide smooth continuity at the top of the deck for riding comfort,
- ii. be skid resistant,
- iii. be non-damaging to rubber tyres,
- iv. make little or no noise during passage of vehicles,
- v. ensure that animal paws and hooves do not get entangled when used by animal drawn traffic,
- vi. permit passage of steel tyre of bullock carts without being damaged, and look good aesthetically.

### **Performance Requirements for transition Zone**

The expansion joint shall:

- i) permit transfer of generated forces to the deck without distress, i.e., without getting uprooted, and
- ii) ensure that surface in the transition zone stays undisturbed during long term service.

## **2604 Filler Joints**

### **Components**

The components of this type of joint shall be corrugated copper plate at least 2 mm thick placed slightly below the wearing coat, 20 mm thick compressible fiber board to protect the edges, 20 mm thick pre-moulded joint filler filling the gap up to the top level of the wearing coat and sealant of suitable joint sealing compound.

### **Material**

- i) The material used for filling expansion joint shall be bitumen impregnated felt, elastomer or any other suitable material, as specified on the drawings. Impregnated felt shall conform to the requirements of IS:1838, and shall be got approved from the Engineer. The joint filler shall consist of large pieces. Assembly of small pieces to make up the

required size shall be avoided.

- ii) Expansion joint materials shall be handled with care and stored under cover by the Contractor to prevent damage.
- iii) Any damage occurring after delivery shall be made good to the satisfaction of the Engineer and at the expense of the Contractor.

### **Fabrication and installation**

- i) Joint gaps shall be constructed as shown on the drawings. Surfaces of joint grooves shall be thoroughly cleaned with a wire brush to remove all loose materials, dirt and debris, then washed or jetted out.
- ii) Pre-moulded expansion joint filler shall not be placed in position until immediately prior to the placing of the abutting material. If the two adjacent faces of the joint are to be installed at different times, the joint filler shall be placed only when the second face is ready to be kept in position
- iii) Sealants shall be installed in accordance with the manufacturer's recommendations.
- iv) Sealants shall be finished approximately 3 mm below the upper surfaces of the joint.
- v) Joint materials spilt or splashed onto finished surfaces of the bridge during joint filling operations shall be removed and the surfaces made good to the Engineer's approval.
- vi) No joint shall be sealed until inspected by the Engineer and approval is given to proceed with the work.

## **2605 Reinforced Elastomeric Joint**

### **Components**

Reinforced elastomeric expansion joint shall comprise of following components:

- i) **steel inserts** : The elastomeric slab units shall be fixed to the steel inserts properly anchored in the deck concrete. Fixing of elastomeric slab units with anchoring bolts directly embedded in deck concrete shall not be permitted. Steel inserts along with anchorage shall be fabricated at manufacturer's workshop and not at site.
- ii) **anchorage** : The anchorage shall either be loop anchors connected to the inserts by anchor plate or sinusoidal anchor bars welded with the horizontal leg of the steel inserts. For loop anchors with anchor plate, the thickness of the anchor plate shall not be less than 12 mm. Diameter of anchor loops shall not be less than 16 mm and the spacing of anchors shall not be more than 250 mm. For sinusoidal anchors, diameter of bar shall not be less than 12 mm.
- iii) **Fixing Bolts** : Fixing bolts and nuts shall be made of stainless steel. Tightened nuts shall be locked by using lock washers.

- iv) **elastomeric Plugs** : The plug holes provided in elastomeric slab units to house fixing bolts shall be plugged with elastomeric plugs pressed in position after applying adhesive on the surfaces.
- v) **adhesives and sealants** : Special sealant to be poured into the plug holes before plugging and special adhesive to be used for installation, shall be as per the recommendation of manufacturer.
- vi) Necessary spacer bars to ensure proper positioning of bolts and leveling and aligning steel inserts during fixing with deck as well as special jigs to be used to preset the elastomeric slab units, shall be provided by the manufacturer.

## Material

- i) Mild steel to be used for manufacture of steel reinforcing plates, inserts and anchorage shall comply with Grade B of IS:2062.
- ii) Cast steel to be used for manufacture of steel reinforcing plates shall comply with IS:1030.
- iii) The elastomer to be used for manufacture of elastomeric slab units shall comply with Clause 915.1 of IRC:83 (Part II), compounded to give hardness IRHD  $60 \pm 5$ .

## Fabrication

- i) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be sand/shot blasted to SA 2½ and provided with a coat of epoxy primer enriched with metallic zinc. Surfaces not to be in contact with or embedded in concrete shall be provided with an additional coat of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per manufacturer's specification with minimum total dry film thickness of 150 micron.
- ii) Elastomeric slab units shall be fully moulded to the required size in one single vulcanizing operation including the reinforcing plates and encasing layers as one integral and homogeneous unit. Edges of reinforcing steel sections shall be rounded. The elastomeric slab units shall be manufactured generally as per the stipulations laid down in Clause 917 of IRC: 83 (Part II). Adjoining portions of elastomeric slab units shall be provided with suitable male-female groove to ensure water tightness.
- iii) Permissible tolerances of fabrication shall be as follows:
 

|                |   |            |
|----------------|---|------------|
| Plan dimension | : | $\pm 5$ mm |
|----------------|---|------------|

Total height :  $\pm 3 \text{ mm}$

#### 2605.4 Supply and Handling

- i) The Contractor shall supply all steel-reinforced elastomeric expansion joints including bolts, nuts, sealant, plugs and all other accessories for the effective installation of the joints including angled jointing sections for kerbs.
- ii) Expansion joint material shall be handled with care and stored under cover by the Contractor to prevent damage. Any damage occurring after delivery shall be made good at the expense of the Contractor to the satisfaction of the Engineer.

#### 2606 Single Strip/Box Seal Joint

##### Components

Strip seal expansion joint shall comprise the following:

- i) **edge Beam** : This shall be either extruded or hot rolled steel section including continuously shop welded section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further, the configuration shall be such that the section has a minimum thickness of 10 mm all along its cross section (flange and web). Thickness of lips holding the seal shall not be less than 6 mm. The minimum height of the edge beam section shall be 80 mm. The minimum cross sectional area of the edge beam shall be  $1500 \text{ mm}^2$ .
- ii) **anchorage** : The edge beams of single strip/box seal joints shall be anchored in the concrete with rigid loop anchorage. The anchor loops shall be connected to the edge beam by means of anchor plate welded to the edge beam. Total cross sectional area of anchor loop on each side of the joint shall not be less than  $1600 \text{ mm}^2$  per metre length of the joint and the centre to centre spacing shall not exceed 250 mm. The thickness of anchor plate shall not be less than 0.7 times the diameter of anchor loop or 12 mm whichever is higher. The anchor loop at the edge profiles should be at right angles to the joint. Planned deviations of this direction are allowable only for the range of  $90^\circ \pm 20^\circ$ . The anchoring reinforcement of the construction must lie parallel to the anchor loops.
- iii) **sealing element** : This shall be a preformed/extruded single strip of such a shape as to promote self-removal of foreign material during normal joint operation. The seal shall possess high tear strength and be insensitive to oil, gasoline and ozone. It shall have high resistance to ageing. The specially designed proprietary type of locking system of seal in the housing of edge beam shall be such as to ensure 100% water

tightness as well as ease of installation and replacement. Mechanical fastening of sealing element with edge beam shall not be permitted. Sealing element shall be continuous over the entire joint.

The working movement range of the sealing element shall be at least 80 mm with a maximum of 100 mm at right angles to the joint and  $\pm 40$  mm parallel to the joint.

Minimum gap for inserting the Chloroprene seals in the expansion joint shall be 25 mm.

## Material

- i) The steel for edge beams shall conform to any of the steel grade equivalent to RST 37-2 or 37-3 (DIN), S235JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A 36 or A 588, CAN/CSA Standard G40.21 Grade 300 W and Grade B of IS:2062. For subzero condition, material for steel shall conform to IS:2062 Grade C.
- ii) The sealing element shall be made of Chloroprene Rubber (CR). The properties of CR shall be as specified in Table 2600-1.
- iii) Anchorage steel shall conform to Grade B of IS:2062 or equivalent standard.

**Table 2600-1 : Properties of Chloroprene seal**

| Property  | standard                            | Specific Value                            |
|---|-------------------------------------|---|
| Hardness  | DIN 53505<br>ASTM D 2240 *          | 63 + 5 Shore A<br>55 + 5 Shore A          |
| Tensile Strength  | DIN 53504<br>ASTM D 412*            | Min 11 MPa<br>Min 13.8 MPa                |
| Elongation at fracture  | DIN 53504<br>ASTM D 412*            | Min 350%<br>Min 250%                      |
| Tear propagation strength<br>longitudinal transverse  | DIN 53507<br>ASTM D 624* (Dia C)    | Min<br>10N/mm                             |
| Shock elasticity  | DIN 53512                           | Min 25%                                   |
| Abrasion  | DIN 53516                           | Max 220 mm <sup>3</sup>                   |
| Residual compression<br>strain (22h/70°C/30%)   | DIN 53517<br>ASTM D 395* (Method B) | Max 28%                                   |
| <b>ageing in hot air</b><br>(14 days/70°C)<br>Change in<br>hardness<br>Change in tensile strength<br>change in elongation at fracture | DIN 53508                           | Max + 7 Shore<br>A Max – 20%<br>Max – 20% |
| Ageing in ozone<br>(24h/50pphm/25°C/20% strain)   | DIN 53509                           | No cracks                                 |

|   |             |   |
|---|-------------|---|
| <b>swelling behavior in oil</b><br>(168h/25°C)<br>ASTM oil No. 1<br>Volume Change<br>Change in<br>hardness ASTM oil<br>No. 3 Volume<br>Change Change<br>in hardness | DIN 53521   | Max + 5%<br>Max – 10 Shore A<br><br>Max + 25%<br>Max – 20 Shore A |
| <b>Cold hardening point</b>   | ASTM D 1043 | Min -35°C   |

Note : \* Only one specification viz., ASTM or DIN shall be followed depending on the source of supply.

### **Fabrication (Pre-installation)**

- i) Rolled steel profiles for edge beams shall be long enough to cater for the full carriageway width. These shall be cut to size as per actual requirements. Alignment of the steel profiles shall then be made on work tables in accordance with the actual bridge cross-section. For this purpose, the contour of bridge cross-section shall be sketched on the tables. After the steel profiles are aligned, these will be fixed to the tables by means of screw clamps and tacked by arc welding.
- ii) Anchor plates shall be cut to the required size by gas cutting. These shall be welded to the edge beams.
- iii) Anchor loops shall be bent to the required shape and welded to anchor plates.
- iv) All steel sections shall be protected against corrosion by either hot dip galvanizing with a minimum thickness of 150 micron or by epoxy coating.
- v) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be given treatment as mentioned in Clause 2605.3 (i).
- vi) The finally assembled joints shall then be clamped and transported to the work site.

### **Handling and storage**

- i) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- ii) The manufacturer shall supply either directly to the Engineer or to the Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the joint.
- iii) Expansion joint material shall be handled with care. It shall be stored under cover on suitable wooden padding to prevent damage.

Any damage occurring after delivery shall be made good at the cost of Contractor to the satisfaction of the Engineer

## **2607 Modular strip/box seal expansion Joints**

### **Components**

A modular expansion joint shall consist of two or more modules/cells of individual capacity 80 mm to cater to a horizontal movement in excess of 80 mm. It shall allow movements in all three directions and rotation about all three axes as per the design requirements. The structural system shall consist of two edge beams, one or more central/separation beams or lamellas and cross support bars supporting individuals or multiple central beams to transfer the loads to the bridge deck through the anchorage system.

- i) **edge Beams and Central Beams/lamella** : These shall be as per Clause 2606.1 (i).
- ii) **anchorage** : Anchorage of edge beam shall be as per Clause 2606.1 (ii). Studs and/or loop anchors with anchor plate may be used as anchorage of other components like joist box and covers of controlling system.
- iii) **sealing element** : This shall be as per Clause 2606.1 (iii). Minimum gap for inserting the neoprene seals in the expansion joint shall be 25 mm.
- iv) **support and Control system** : The control system should allow closing and opening of the joint and also ensure that all modules open and close equally during all movement cycles of the joint. The overall support and control system shall be either single/multiple support bar control system or swivel joint system comprising of resilient/shock absorption components and elastic/sliding control system conforming to the specifications recommended by the manufacturer. The gap between the consecutive centre beams at the joint surface shall be limited to 80 mm when the joint opens fully due to maximum contraction of deck.

### **Material**

- i) The steel for edge beams, centre beam/lamella, transverse support bar and other steel components shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 or 52-3 (DIN), S235JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A588, CAN/CSA standard G40.21 Grade 300 W.
- ii) The sealing element shall be of Chloroprene Rubber (CR). The properties of CR shall be as specified in Table 2600-1.
- iii) The specification for all other materials shall be as per manufacturer's recommendation.

### **Fabrication (Pre-installation)**



- i) Profile of edge beam, centre beam/lamella shall be long enough to cater for full carriageway width.
- ii) The fabrication of all components of the joints including anchorage system and transportation of assembled joints shall be as per manufacturer's specification.
- iii) All steel sections shall be suitably protected against corrosion as stated in Clause 2606.3 (iv).
- iv) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be given treatment as mentioned in Clause 2605.3 (i).

### Handling and storage

- i) Arrangement for transportation and storage shall be as per manufacturer's specification.
- ii) The manufacturer shall supply either directly to the Engineer or to the Contractor all the materials of strip seal joints including all sealants and other accessories for the effective installation of the joint.

## 2608 Asphaltic plug joint

### General

- i) This joint shall consist of a polymer modified bitumen binder, carefully selected single size aggregate, closure/bridging metallic plate and heat resistant foam caulking/backer rod
- ii) The joint shall be capable of performing satisfactorily, within the temperature (ambient) range of -5°C to +50°C.

### Material

- i) **Binder:** The polymer modified bitumen binder shall have the capacity to fill the gaps and voids between single size aggregates and to impart flexibility to accommodate various design movements. It shall be a patented blend of bitumen, synthetic polymer, filler and surface active agent and shall be so formulated as to combine necessary fluidity for the installation process, low temperature flexibility and flow resistance at high ambient temperature. The binder shall satisfy following requirement:
  - Softening point : 100°C minimum
  - Cone penetration at 25°C, 0.1 mm (BS:2499) : 100 mm max
  - Flow resistance at 70°C, 5 hours (BS:2499) : 3 mm max

- Extension Test  
5 cycle of extension to 50% (blocks prepared to ASTM D1190 at a rate of 3.2 mm/hour at and tested to limits BS:2499) : 25°C
- Safe heating temperature. : 210°C

- ii) **aggregates** : The aggregate shall be of single size chosen from basalt granite, grit stone or gabro group. The nominal size of aggregate shall be 12.5 mm for joints up to 75 mm depth and 20 mm for joints of larger depth. The flakiness index shall not be more than 25 percent. The aggregate shall satisfy grading requirements stipulated in Table 2600-2.

**table 2600-2 : Grading Requirements of aggregate**

| is sieve designation | nominal size of aggregate              |          |
|----------------------|--|----------|
|                      | 20 mm                                  | 25 mm    |
|                      | Percentage by Weight Passing the sieve |          |
| 26.5 mm              | 100                                    | -        |
| 19.9 mm              | 85 - 100                               | 100      |
| 13.0 mm              | 0 - 35                                 | 85 – 100 |
| 9.5 mm               | 0 - 7                                  | 0 – 35   |
| 6.3 mm               | -                                      | 0 – 7    |
| 2.3 mm               | 0 - 2                                  | 0 – 2    |
| 75 micron            | 0 - 1                                  | 0 – 1    |

The Polished Stone Value (PSV), Aggregate Abrasion Value (AAV), Aggregate Impact Value (AIV) and Aggregate Crush Value (ACV) shall be as below:

$$\text{PSV} > 60$$

$$\text{AAV} > 05$$

$$\text{AIV} < 18$$

$$\text{ACV} = 10-25$$

The surface characteristics should promote proper adhesion.

- iii) **Closure Plate :** The closure plate shall be weld able structural steel conforming to IS:2062. The minimum thickness of steel plate shall be 6 mm and the width shall not be less than 200 mm. Closure plate shall preferably be of single length but it shall not have more than 2 pieces per traffic lane width which shall be welded together to form the required length. It shall be provided with equidistant holes at a maximum spacing of 300 mm centers for anchorage to the caulking/backerrod along the longitudinal centre line of the plate. The plate shall be protected against corrosion by galvanizing or by any other approved anti-corrosive coating paint with a minimum thickness of 100 micron.
- iv) **Foam Caulking/Backer Rod:** The foam caulking shall be closed cell polyolefin or open cell polyurethane foam cylindrical type. The backer rod shall be of diameter equal to 150 percent of the joint opening. It shall be heat resistant and possess good flexibility and recovery characteristics with density of  $25 \text{ kg/m}^3$  to  $30 \text{ kg/m}^3$ .

## **2609 Compression Seal Joint**

### **Components**

- i) Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomer or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder.
- ii) **steel nosing :** The steel nosing shall be of angle section ISA 100 x 100. The thickness of legs shall not be less than 12 mm. The top face of the angle shall be provided with bleeder holes of 12 mm diameter spaced at maximum 100 mm centres so as to ensure that there are no voids in the concrete beneath the angle.
- iii) **anchorage :** The steel nosing shall be anchored to the deck by headed shear studs or anchor plates cast in concrete or a combination of anchor loops. Anchor bars shall engage the main structural reinforcement of the deck and in case of anchor plates and anchor loops, transverse bars shall be passed through them. The minimum thickness of anchor plates shall be 12 mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600 sq. mm per metre length of the joint and the centre to centre spacing shall not exceed 250 mm for loop anchors and 150 mm for headed shear studs. The ultimate resistance of each anchorage shall not be less than 600 in kN/m any direction. Steel shall conform to Grade B of IS:2062. For sub zero condition material for steel shall conform to IS:2062, Grade C.

- iv) **Joint seal** : The sealing element shall be a preformed continuous chloroprene/closed cell foam seal with high tear strength, insensitive to oil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be continuous for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement upto 40 mm and vertical movement of 3 mm.

## Material

- i) The steel for nosing and anchorage shall conform to weldable structural steel as per IS:2062 Grade B.
- ii) The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:
- a) **Chloroprene seal** : Shall be preformed extruded multi-web cellular section of chloroprene of such a shape as to promote self removal of foreign material during normal service operations. Chloroprene of joint seal shall satisfy the properties stipulated in Table 2600-1.
- b) **Closed Cell Foam seal** : This shall be of preformed non-extruded non-cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically blown using nitrogen. The material shall have properties as indicated in the Table 2600-3.

**Table 2600-3 : Properties of Closed Cell Foam seal**

| Property  | Value   |
|---|---|
| Density   | 41.7 - 51.3 kg/cum  |
| Compression set on 25 mm (ASTM D 3575)                      | 50 percent compression samples for 22 hours at 23°C, 2 hour recovery; 13 percent set. |
| Working temperature   | -70°C to +70°C  |
| Water absorption (total immersion for 3 months) (ASTM 3575) | 0.09766 kg/sq.m   |
| Tensile Strength  | 0.8 MPa   |
| Elongation at break (ASTM D 3575)                           | 195 ± 20 percent  |

- c) **Chemical tests**: Chemical tests shall be performed on specimens of elastomer and the properties of elastomer shall conform to the values/standards indicated in Table 2600-4.

**Table 2600-4 : Properties of elastomer**

|                           |                  |  |
|---------------------------|------------------|--|
| Adhesion Strength         | IS:3400 Part XIV | 7kN/m                                      |
| Low temperature stiffness | ASTM D 797       | Young's modulus 70 N/mm <sup>2</sup> (max) |

|  |                   |   |
|--|-------------------|---|
| Ash Content  | IS:3400 Part XXII | 5%                                      |
| Polymer identification test<br>(infrared spectro photometry) | ASTM D 3677       | Comparison of spectra with<br>reference |

- iii) **lubricant cum adhesive** : The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer/supplier of the seal system.
- iv) **Corrosion Protection** : All steel sections shall be suitably protected against corrosion as stated in Clause 2606.3 (iv).

## 2610 Installation of expansion joints

### General Procedure

- i) Expansion Joints shall be installed under close supervision of the manufacturer's/supplier's engineer in order to ensure the quality of installation and its function as intended during the entire life span. Detailed Installation Manual shall be supplied by the manufacturer/supplier.
- ii) The dimensions of the recess in the deck shall be established in accordance with the drawings or design data of the manufacturer, taking into account the width of gap for movement of the joint.
- iii) The pre-setting of expansion joint shall be done by means of an auxiliary construction.
- iv) The road surfacing/wearing coat shall be laid before commencing installation of joint. Before laying wearing coat, the recess portion shall be filled with sand and wearing coat shall be laid in a continuous manner over the deck slabs and recess portion. Prior to installation of the joints, portion of wearing coat over the recess shall be removed by a suitable method e.g. saw cutting and the infill sand shall also be removed.
- v) **Preparation of the Recess** : The size and form of recess shall suit the geometry of the expansion joint. However, the width shall not be less than the specified value for a particular type of joint. In order to avoid difficulties during installation, the following points must be checked and considered:
  - a) Dimension of recess
  - b) Levels
  - c) Skew and slope
  - d) Designed gap between bridge deck and abutment and/or between adjoining decks
  - e) Existing structural reinforcement according to the drawings

Reinforcing bars that would obstruct the installation of expansion joint shall be bent to accommodate the expansion joint anchorages. Cutting off or removal of interfering reinforcing bars shall only be done after consultation with the Engineer. The recess shall be cleaned thoroughly. If necessary, the surface should be roughened. All loose dirt and debris shall be removed by wire brushing, air blowing and dried with hot compressed air.

- vi) **shuttering** : Shuttering must be used to seal the space between the underside of the joint and the vertical face of the recess. The shuttering must be fitted in such a way that it forms an appropriate seal against the edge of the recess. The recess shall be shuttered in such a way that dimensions shown on the drawing are maintained. The formwork shall be rigid and firm.
- vii) **Placing in the Recess** : Level marks shall be set next to the recess. This enables a controlled leveling of the expansion joint. Lowering the expansion joint/joint construction/insert into the recess shall be done in such a way that the entire length of the joint is evenly lowered into the recess. Thereafter, the joint/joint construction/insert is precisely leveled and adjusted in the longitudinal, transverse and vertical planes. If required, the joint must also be adjusted to the gradient of the final surface level.
- viii) **Connection**
  - a) The expansion joint/joint construction/insert shall be installed preferably in the early morning when the temperature is distributed almost uniformly over the whole bridge. Immediately before the installation, the actual temperature of the bridge shall be measured. If it is not within the considered tolerance, the preset adjustment shall be corrected. The joint/joint construction/insert shall be lowered in a predetermined position. Following placement of the joint/joint construction/insert in the prepared recess, the joint/joint construction/insert shall be leveled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side. With the expansion joint/joint construction/ insert finally held at both sides, the auxiliary brackets shall be released, allowing it to take up the movement of the structure. After carrying out the final fixing, the protection against corrosion shall be completed.
  - b) For fully assembled joints with one end fixed and other end movable e.g. modular strip/box seal joint, connection shall be as detailed below:

**the 1<sup>st</sup> side** : The fixed side of the assembled joint (either the abutment

or the bridge deck side) is designated the 1st side for connecting the joint. The preliminary fixing is made by evenly placing and welding of reinforcing bars over the entire length between the anchor loops and the

deck reinforcement. To facilitate concreting, the gap between recess and shuttering is sealed by a grout seam. The seam must be left to dry prior to final concreting. After this, additional reinforcing bars are welded until all anchor loops are firmly connected to the deck reinforcement. The expansion joint shall be considered sufficiently fixed when no vibration is noted when it is lightly tapped. The expansion joint shall not be subjected to any loads that could in any way displace the precise location of this fixing.

**the 2<sup>nd</sup> side :** Depending on the size of the expansion joint and the expected movement during installation, the most suitable time must be determined for fixing of the 2<sup>nd</sup> (moveable) side. Usually this is the early morning hours with the smallest temperature deviations. The procedure is identical to that for the 1st side. The joint shall be provisionally fixed to the reinforcement as fast as possible.

Immediately afterwards, the fixation brackets shall be removed. Thereafter, the gap between recess and shuttering shall be sealed with grout seam and the remaining reinforcing bars welded as described previously.

ix) **Concreting**

- a) Prior to final concreting, the position of the joint/joint construction/insert must be recorded. The Engineer must give written confirmation of the correct position of the joint and recess concreting. The recess shall be thoroughly watered. Before pouring the concrete the joint construction should be protected by a cover. Controlled concrete having strength not less than that in superstructure subject to a minimum of M35, shall be filled into the recess. The water cement ratio shall not be more than 0.4. If necessary, admixtures may be used to improve workability. The concrete must exhibit low shrinkage. The freshly placed concrete shall be properly vibrated. Damage to the shuttering shall be avoided during vibration. The concrete shall be finished flush with the carriageway surfacing. The concrete shall be kept damp until it has cured in order to avoid fissures caused by drying too fast. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.
- b) For modular strip seal joint the space beneath the joint boxes shall be completely filled with concrete. So that traffic loads are safely

transmitted into the structure.

As soon as the concrete in the recess has become initially set, a sturdy ramp shall be placed over the joint to protect it from traffic at site. Expansion joint shall not be exposed to traffic loading before completion of carriageway surfacing.

- x) The elastomeric sealing element may be field installed. For strip seal and modular strip seal joints the sealing element shall be in continuous lengths spanning the full carriageway width. Proper fit of the seal of the sealing element must be ensured. The seal shall be installed by suitable methods in such a way that it is not damaged.

#### **Specific Procedure for Asphaltic Plug Joint**

- i) The recess in the deck slab, if required, shall be repaired with epoxy mortar and cleaned and dried again.
- ii) The foam caulking/backing rod shall be placed about 25 mm down into the joint opening.
- iii) The aggregate shall be washed, cleaned and heated to a temperature between 120°C and 180°C prior to placement.
- iv) The binder shall be preheated to temperature of 170°C to 190°C before application.
- v) While sealing the joint opening with preheated binder, care shall be taken that the binder does not spill on to the surface of the deck.
- vi) The joint shall not be installed when the ambient temperature goes below 5°C or above 35°C or while it is raining/ snowing. Planning for installation shall take into account the weather condition.
- vii) When work is resumed after stoppage due to weather condition, the joint installation shall be continued after the upper layer and/or exposed surface of the partially completed joint has been prepared by heating and/or coating with binder as necessary.
- viii) The joint shall be provided over the entire width of the structure including kerb and/or footpath. A recess in the kerb and/or footpath shall be made to allow the joint to pass beneath them. The expansion gap in the adjoining kerbs and/or footpaths shall be sealed with a suitable sealant such as polysulphide sealant.
- ix) The joint shall extend to the full depth of the wearing course down to structural concrete. Where needed, a recess may be cut into the deck slab concrete to accommodate the minimum required depth (75 mm) of the joints.
- x) The minimum width (in traffic direction) of the joint shall be 500 mm and maximum width shall be 750 mm.
- xi) Minimum depth of joint shall be 75 mm and maximum depth shall not exceed 100 mm.



### **Specific Procedure for Compression Seal Joint**

- i) The dimension of the joint recess and the width of the gap shall conform to the approved drawing.
- ii) Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.
- iii) The width of the recess shall not be less than 300 mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.
- iv) At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.
- v) The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.
- vi) The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation which shall be between 5°C and 35°C.
- vii) The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

### **Specific Procedure for Single Strip/Box Seal Joint**

- i) The width of the gap to cater for movement due to thermal effect, pre- stress, shrinkage and creep, superstructure deformations (if any) and substructure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is likely to be installed, the gap dimension shall be preset.
- ii) Immediately prior to placing the joint, the pre-setting shall be inspected. In case the actual temperature of the structure is different from that taken for pre-setting, suitable correction shall be done. After adjustment, the brackets shall be tightened again.
- iii) Rolled up neoprene strip seal shall be cut to the required length and inserted between the edge beams by using a crow bar pushing the bulb of the seal into the steel grooves of the edge beams.

The carriageway surfacing shall be finished flush with the top of the steel sections. The actual junction of the surfacing/wearing coat with the steel edge section shall be formed by a wedge shaped joint with a sealing compound. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

### **Specific procedure for Modular Strip/Box Seal Joint**

- i) The procedure given Clause 2610.4 (i) and (ii) applies to modular strip/box seal joint also.
- ii) To ensure proper fit of the seal, dirt, spatter or standing water shall be removed from the steel cavity using a brush, scraper or compressed air.
- iii) The actual junction of the surfacing/wearing coat with the block out concrete/steel edge section shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

### **Specific Procedure for Reinforced Elastomeric Joint**

Expansion joints shall be installed as per approved drawing. The procedure for installation of various components shall be as follows:

- iv) **Steel inserts**
  - a) Deck casting shall be done leaving pockets or recesses for steel inserts and anchors of the expansion joint as per drawing.
  - b) Steel inserts shall be lowered at the appropriate location inside the pocket.
  - c) The top of the insert shall be flush with the finished level of wearing course maintaining the camber.
  - d) Spacer bars, duly set appropriately to the month of installation, shall be fitted under proper supervision.
  - e) Anchor rods shall be tied/welded with the existing deck main reinforcement, maintaining level and alignment.
  - f) Welding between anchor rods and deck reinforcement is preferable. If welding is not possible, strong steel tie wires shall be used for fastening under proper supervision.
- v) **Spacer Bar**
  - a) Spacer bars shall be used to ensure proper positioning of bolts and also leveling of the steel inserts during fixing of the same with the deck reinforcement and casting second stage concreting in the pocket thereafter.
  - b) The 2<sup>nd</sup> stage concreting operation shall preferably be started within 24 hours of fixing the steel inserts. In such cases, spacer bars should be removed just after concreting is finished. If there is a substantial time lag between fixing of inserts and concreting, then any one of the following methods shall be adopted, depending on the support condition:

For simply supported bridge resting on simple elastomeric bearings, (with no dowel pins), insert shall be placed in position with spacer bars at every alternate joints. Such joints shall be called restrained joints hereafter. In other words, inserts shall not be fixed simultaneously at two ends of one span. If the above condition is satisfied, inserts with spacer bars shall be kept in position for a substantially longer period at such restrained joints. Spacer bars shall be removed after concreting of such restrained joints and inserts placed in position with spacer bars at the other unrestrained joints thereafter.

For bridges resting on other than elastomeric bearings (including bearings with dowel pins at one end), after placing and aligning the inserts and securing the same, the spacer bars shall be removed. Concreting shall be done with great care so that inserts are not dislocated or distorted.

- c) While removing the spacer bar after concreting, one must take care to see that the concrete is not damaged during withdrawal of spacer bar. If the spacer bar happens to be snugly fitted, it shall not be pulled by any means; it shall be gas cut in two pieces and then removed.

**vi) Concreting of Pocket**

- a) Concreting of pocket shall be done with great care using proper mix conforming to grade similar to that of the deck casting besides ensuring efficient bonding between deck and steel insert. Also proper care shall be given for ensuring efficient bonding with the already cast concrete. Requirement of concrete as per Clause 2610.9.1 shall be followed.
- b) Needle vibrators shall be used. Care shall be taken so that the position of steel insert is not disturbed during vibration.
- c) Spacer bar shall be removed within an appropriate time before the joint is required to permit movement.

**vii) Fixing of elastomeric slab unit (esu)**

- a) Special jig shall be used to preset the ESU during installation
- b) ESU (mounted on the jig, if preset) shall be lowered to position.
- c) The line and level on the ESU should be adjusted.
- d) ESU shall be removed and coated with special adhesive
- e) ESU shall be placed in position again, ensuring waterproof joining at required faces.

- f) ESU shall be tightened with stainless steel nuts and lock washers in position. Tightened nuts shall be locked with lock washers.
- g) Special sealant shall be poured inside the plug holes.
- h) The elastomeric plugs shall be pressed in position after applying adhesive on the appropriate surface.
- i) ESU shall be fitted in position after completion of wearing course. While completing this part of the wearing course, adequate care shall be taken to ensure a waterproof joining with the already existing wearing course.

viii) **Pre-setting**

- a) The main purpose of pre-setting of the steel inserts at the time of its installation is to ensure as closely as possible the condition that in the long run at the mean average annual temperature, the ESU remains at its nominal state.

The steel insert unit of expansion joint can be fixed in any month of the year. The expansion gap between bridge super structures may vary from time to time; hence the initial fixing distance between fixing points will obviously depend on the month of installation of steel insert. The c/c distance between stainless steel fixing of bolts as indicated in the drawing can be taken as only nominal. The same shall be modified by pre-setting depending on:

The difference between the mean temperature of the month of fixing of steel insert and the annual average temperature, and

The elapsed period between the casting and/or pre-stressing and fixing of steel insert for calculating the remnant creep and shrinkage.

ix) **Special requirements for installation**

- a) The supplier shall provide detailed working drawings showing the location of all bolts, recesses and holes necessary for the installation of the joint shall be obtained from the supplier before construction of bridge deck area adjacent to the joint. If required detailing of reinforcing bars in superstructure shall be modified to ensure that there will be no interference in the installation of the joint.
- b) All bearing surfaces and recesses which are in contact with the joint assembly shall be checked with a straight edge to ensure flatness of profile.
- c) No holes shall be drilled for fixing bolts within 7 days of concreting. Holes for the bolts shall be drilled to the size and depth shown on the drawings.

- d) Sections of the jointing making the completed joint shall follow a straight line.
- e) The fixing bolts shall not be placed in a position until at least 4 weeks after stressing is completed in post-tensioned box or beam and slab structures. Prior to placing sections of jointing, contact surfaces shall be cleaned to remove all grease, tar, paint, oil, mud or any other foreign material that may affect adhesion of the sealant.
- f) Sealant shall only be applied to dry contact surfaces. Sufficient quantity shall be applied to the contact surfaces so that sealant is extruded when the jointing is fixed in position.
- g) Final sealing of the finished expansion joint shall be completed immediately after installation. All exposed ends, joints between units, other areas of possible leakage, voids between the sides of the jointing and concrete or plates, shall be filled with sealant.
- h) Bolt cavities shall be cleaned and plugged with neoprene cavity plugs. Prior to placing the plugs sufficient sealant shall be placed in the cavities to cause extrusion of the sealant by the plugs.
- i) All excess sealant shall be removed from the jointing and adjacent areas.

**2611** Procedure for installation of various joints, shall also take into account suppliers own specific procedures for installation of each type of joint as the suppliers shall be responsible for performance of the joints for the period of guarantee.

## **2612 Testing and acceptance standards**

Before installing joints in a bridge, sufficient evidence of the reliability of the proprietary products shall be furnished. A copy of the fatigue and wear test reports, as applicable depending upon the type of joint, carried out by a recognized laboratory/university/ institute on the joint components as a part of product development test, shall be furnished once for the entire lot of supply. The tests covered in Clauses 2612.1. (i) to 2612.1. (vi) need not be carried out on the materials of the joints of supply lot but shall be carried out from time to time by the original manufacturer as per their product development and quality plan for the same type of joints to ensure the performance requirement of the particular joint component against fatigue and/or wear.

- i) For single strip seal and modular strip seal joints, the manufacturer shall produce complete report of the test of anchorage system from a recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading in support of the efficacy of the anchorage system adopted for the entire lot of joints.
- ii) For modular strip seal joints the manufacturer shall produce a test report from a recognized laboratory that the sliding bearings (suspension system) have been fatigue tested for six million load cycles with a frequency of 5 Hz and the loads of 80 kN, 120 kN and 160 kN.

- iii) For modular strip seal joints the manufacturer shall produce a test report from a recognized laboratory that the wearing of sliding interface of bearings of modular joints has been tested for a total sliding distance of 5000 m at a load of 48 kN.
- iv) For modular strip seal joints the manufacturer shall also produce a test report from a recognized laboratory that the sliding material of sliding springs of expansion joints has been tested for a total sliding distance of 20,000 m with a load equivalent to a stress of 30 MPa.
- v) For modular strip seal joints the manufacturer shall also produce a test report from a recognised laboratory that the butt-welded splicing of centre beams has been tested with two million load cycles with a load equivalent to a stress of 165 MPa.
- vi) In case of reinforced elastomeric joints abrasion resistance test shall be carried out in accordance with IS:3400 (Part 3) or DIN 53516.

### **Pre-installation Criteria**

The pre-installation criteria shall include the routine tests and acceptance tests as described below:

#### **Routine tests**

Routine tests including tests for materials conforming to specifications shall be carried out by the original manufacturer i.e., in case of imported joints, by the foreign manufacturer as part of their quality control procedure for all joints to be supplied by them. Detailed documentation of all the tests and inspection data as per complete quality control procedure shall be supplied by the original manufacturer in the form of Quality Control Report. Routine tests shall include:

Raw materials inspection, Process inspection, and Complete dimensional check as per approved drawings.

- i) **Raw Material inspection** : Test on all raw materials used for the manufacturing of joints as per relevant material standard based on these Specifications shall be carried out by the manufacturer.
  - a) **Confirmation of the Grade of Steel** : Grade of the steel for the edge beam shall be confirmed by conducting tests for yield stress, tensile strength and elongation. Corresponding to RST 37-2 or 37-3 or 52-3 (DIN), S235 JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A 588, CAN/CSA standard G 40.21 grade 300 W or equivalent to Grade B of IS: 2062. The manufacturers/ suppliers shall have in-house testing facilities for conducting these tests.
  - b) Tests for steel for the anchorage shall conform to IS:2062.
  - c) The tests as indicated in Table 2600-1 shall be made for checking the following properties of the chloroprene seal: (a) hardness, (b) tensile strength, (c) elongation at fracture, (d) tear propagation

strength, (e) residual compressive strain, (f) change in hardness, (g) change in tensile strength, (h) change in elongation at fracture, (i) ageing in ozone, and (j) swelling behaviour in oil. The manufacturers/suppliers shall have in-house testing facilities for conducting these tests.

- ii) **Process inspection** : Process inspection including inspection of all manufacturing processes adopted to manufacture the joints e.g., welding, corrosion protection, clamping, pre-setting, greasing, bonding by adhesives and riveting, as appropriate, shall be carried out by the manufacturer.
- iii) **Complete dimensional Check** : Complete dimensional check of all components of joint as well as the assembled joint with respect to the approved drawings and tolerances as per these Specifications, shall be carried out by the manufacturer.

### Acceptance tests

In addition to the tests specified under Clause 2612.1, the manufacturer as well as the local supplier in case of imported joints shall have complete in-house testing facilities for the following tests. The Engineer shall insist upon these tests before acceptance of the joint.

- i) **Cyclic Motion** : Cyclic motion test may be carried out once on one complete joint assembly or one meter sample piece selected at random from the entire lot of supply for each type of joint irrespective of movement capacity. The test sample shall be subjected to 5000 expansion and contraction cycles at minimum 30 cycles per hour. The test movement shall be 10 percent more than the design expansion/contraction movement. Any sign of distress or permanent set of any component or the assembly due to fatigue, will lead to rejection of entire lot of supply.
- ii) **Ponding** : Prior to acceptance, 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25 mm above the highest point of deck. The width of ponding shall be at least 50 mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25 mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- iii) **Debris expelling test** : Debris expelling test shall be carried out on one metre sample piece selected at random from the entire lot of supply. The fully open gap shall be filled flush with granular debris and cycled 25 times for full opening and closing. The mass of debris repelled after 25 cycles shall be expressed as the percentage of initial mass. The percentage expelled shall not be less than 75.
- iv) **Pull-out test** : Pull-out test shall be carried out on one meter sample piece selected at random from the entire lot of supply. The joint shall then be stretched until the sealing element slips off from its housing. The minimum stretching of the joint before slip-off shall be least 150



percent of the rated movement capacity of the seal.

- v) **Vehicular Braking/traction test** : This is the only initial acceptance (in-house) test. This test may be carried out once on one complete joint assembly or one metre sample piece selected at random from the entire lot of supply for each type of Joint irrespective of movement capacity. The test sample shall be installed between two blocks of concrete in its mean position. A truck wheel load of 40 kN shall be drawn across the specimen with an engaged ratchet with wheel locked to stimulate locked brakes and then rolled back. The cycle shall be repeated for 50,000 times with a period of 2 seconds. Continuous water cooling will be necessary to control excessive heat generated during the test.
- vi) **Erosion Protection test** : Adequacy of the treatment for protection of steel sections against corrosion should be checked.

### Applicability of acceptance tests on different types of Joints

The acceptance tests described in Clause 2612.2.1 shall be applicable as per Table 2600-5 for different types of joints.

**Table 2600-5 : applicability of acceptance tests on different types of Joints**

| Performance evaluation tests    | asphaltic Plug Joint | Compression seal Joint | Reinforced elastomeric Joint | single Gap strip/Box seal Joint | Modular strip/Box seal Joint |
|---------------------------------|----------------------|------------------------|------------------------------|---------------------------------|------------------------------|
| Cyclic motion                   | Not Applicable       | Applicable             | Applicable                   | Applicable                      | Applicable                   |
| Ponding                         | Not Applicable       | Applicable             | Applicable                   | Applicable                      | Applicable*                  |
| Debris expelling test           | Not Applicable       | Applicable             | Applicable                   | Applicable                      | Applicable*                  |
| Pull-out test                   | Not Applicable       | Not Applicable         | Not                          | Applicable                      | Applicable*                  |
| Vehicular braking/traction test | Not Applicable       | Not Applicable         | Applicable                   | Applicable                      | Applicable*                  |

\* For modular strip seal expansion joint ponding test, debris expelling test, pull-out test and vehicular braking/traction test shall be carried out on one metre edge beam samples only, complete with sealing element and anchorage, to be supplied by manufacturer.

**Note:** For all expansion joints which are proprietary a minimum guarantee of 10 years for their satisfactory performance shall be given by the contractor.

### 2613 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.

### 2614 Measurements For Payment



The Strip Seal Expansion joint shall be measured in **running meters**.

Asphalt filler joint shall be measured in **Sq.m**.

## **2615 Rate**

In the case of supply and installation contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for procuring and fixing the joints complete in all respects as per these Specifications. For filler joints, the rate per running meter shall include the cost of sealant for the depth provided in the drawing.

In the case of supply contract, the contract unit rate shall include cost of all components of expansion joint including anchorage system, pre-installation fabrication, transportation of assembled joints, handling and other incidental charges.

In the case of installation only contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for installation of the joints complete in all respects as per these Specifications.

**Item No. 27**

**Providing and fixing the continuity arrangement in deck slab as per the detailed drawing with fixtures, components, filler etc. complete as directed by Engineer in charge.**

**Scope**

Providing, fabricating, and fixing the continuity arrangement in the bridge deck slab including all fixtures, components, filler materials, and associated works, complete as per approved drawings and in accordance with MoRTH Specifications and relevant IRC codes such as IRC:112, and as directed by the Engineer-in-Charge.

**2. Materials****2.1 Reinforcement Steel**

- High Yield Strength Deformed (HYSD) bars conforming to IS:1786
- Grade: Fe500/Fe500D or as specified
- Free from rust, oil, grease, and loose mill scale

**2.2 Structural Steel Components (if applicable)**

- Mild Steel/Structural Steel conforming to IS:2062
- Used for plates, connectors, brackets, or shear keys if detailed in drawings

**2.3 Concrete**

- Grade: As per drawing (generally M30 or higher)
- Conforming to MoRTH Section 1700
- Designed for durability and workability suitable for deck slab conditions

**2.4 Filler Material**

- Compressible filler board (e.g., bitumen-impregnated fiberboard or equivalent)
- Thickness and type as per drawings
- Shall allow controlled movement while maintaining continuity behavior

**2.5 Jointing / Bonding Materials**

- Epoxy bonding agent (if required) conforming to relevant IS standards
- Sealants (if specified) for preventing ingress of water and debris

**3. Components of Continuity Arrangement**

The continuity system may include (as per drawings):

- Continuity reinforcement across joints
- Shear connectors / dowel bars
- Closure pour (stitch concrete)
- Filler board and gap control elements
- Anchorage systems
- Any embedded fixtures or inserts

**4. Execution****4.1 Preparation**

- Existing concrete surface shall be roughened, cleaned, and made free of laitance, dust, and loose particles.
- Surface preparation may include wire brushing, sand blasting, or hydro jetting.
- Bonding agent shall be applied where specified before placing fresh concrete.

#### 4.2 Fixing of Reinforcement and Fixtures

- Reinforcement shall be placed strictly as per approved drawings with correct spacing, cover, and alignment.
- Proper anchorage and lapping shall be ensured.
- Fixtures, inserts, and connectors shall be securely fixed to prevent displacement during concreting.

#### 4.3 Placement of Filler Material

- Filler boards shall be placed accurately in position as per drawings.
- Care shall be taken to maintain required gaps and alignment.

#### 4.4 Concreting (Closure Pour)

- Concrete shall be placed in layers and properly compacted using vibrators.
- Special care shall be taken to avoid segregation and honeycombing.
- Construction joints shall be treated as per specifications.

#### 4.5 Curing

- Curing shall be carried out for a minimum of 7–14 days or as specified.
- Methods may include water curing, curing compounds, or wet coverings.

#### 5. Quality Control

- Materials shall be tested as per relevant IS codes.
- Reinforcement placement shall be checked before concreting.
- Cube tests shall be conducted for concrete strength verification.
- Alignment, level, and finish shall be inspected and approved.

#### 6. Tolerances

- All dimensions, positioning of reinforcement, and gaps shall conform to drawing tolerances and MoRTH specifications.
- Any deviation shall require prior approval of the Engineer.

#### 7. Measurement

- Measurement shall be **per running meter (Rm)**.

**Item No. 28**

**Providing and casting in situ controlled cement concrete M-40 for average 100 mm thick wearing coat laid as directed including tamping, vibrating, finishing, curing and filling in joints with bitumen complete**

**MORTH V<sup>th</sup> REVISION Cl. No. 602, Pg. no. 263**

**602 Cement Concrete Pavement****scope**

The work shall consist of construction of un-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.

The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc. shall be as stipulated in the drawings.

**Materials****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 in trial length. If the Contractor subsequently proposes to obtain materials from a different source during the execution of main work, he shall notify the Engineer, with relevant test data, for his approval, at least 45 days before such materials are to be used.

**cement**

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but preference shall be to use at least the 43 grade or higher.

| <b>s.no.</b> | <b>type</b>                       | <b>conforming to</b> |
|--------------|-----------------------------------|----------------------|
| i)           | Ordinary Portland Cement 43 Grade | IS:8112              |
| ii)          | Ordinary Portland Cement 53 Grade | IS:12269             |
| iii)         | Portlant slag cement              | IS:455               |
| iv)          | Portland Pozzolana Cement         | IS:1489-Part I       |

If the soil around concrete pavement has soluble salts like sulphates in excess of 0.5 percent, the cement used shall be sulphate resistant and shall conform to IS:12330.

Cement to be used may preferably be obtained in bulk form. If cement in paper bags is

proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them off suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with Clause 1014. The cement shall be subjected to acceptance test.

Fly-ash upto 20 percent by weight of cementitious material may be used in Ordinary Portland Cement 43 and 53 Grade as part replacement of cement provided uniform blending with cement is ensured. The fly ash shall conform to IS:3812 (Part I).

Site mixing of fly ash shall be permitted only after ensuring availability of the equipments at site for uniform blending through a specific mechanised facility with automated process control like batch mix plants conforming to IS:4925 and IS:4926. Site mixing will not be allowed otherwise.

The Portland Pozzolana Cement produced in factory as per IS:1489-Part I shall not have fly-ash content more than 20 percent by weight of cementitious material. Certificate from the manufacturer to this effect shall be produced before use.

### **Chemical admixtures**

Admixtures conforming to IS:9103 and IS:6925 shall be permitted to improve workability of the concrete and/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 before use. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in the trial length paving. If air entraining admixture is used, the total quantity of air shall be  $5 \pm 1.5$  percent for 31.5 mm maximum nominal size aggregate (in air-entrained concrete as a percentage of the volume of the mix).

### **Silica fumes**

Silica fume conforming to a standard approved by the Engineer may be used as an admixture in the proportion of 3 to 10 percent of cement. Silica fume shall comply with the requirements given in IS:15388-2003, IS:456-2000, IRC:SP:76 and IRC:44-2008.

### **Fibres**

Fibres may be used subject to the provision in the design/approval by the Engineer to reduce the shrinkage cracking and post-cracking. The fibres may be steel fibre as per IRC:SP:46 or polymeric Synthetic fibres within the following range of specifications:

|   |   |
|---|---|
| Effective Diameter  | 10 micron – 100 micron  |
| Length  | 6-48 mm   |
| Specific gravity  | more than 1.0   |
| Suggested dosage  | 0.6-2.0 kg/cu.m (0.2 - 0.6% by weight of cement in mix)<br>Usage will be regulated as stipulated in IRC:44/IS:456 |
| Water absorption  | less than 0.45 percent  |
| Melting point of this fibre shall not be less than 160°C.             |   |
| The aspect ratio generally varies from 200 to 2000.                   |   |
| These synthetic fibres will have good alkali and UV light resistance. |   |

When fibres are used, the mix shall be so designed that the slump of concrete at paving site is  $25 \pm 15$  mm.

### aggregates

Aggregates for pavement concrete shall be natural material complying with IS:383 but with a Los Angeles Abrasion Test value not exceeding 35 percent. The limits of deleterious materials shall not exceed the requirements set out in Table 600-2.

**Table 600-2 : permissible limits of deleterious substances in fine and coarse aggregates**

| s. no. | deleterious substance   | Method of test         | fine aggregate percentage by weight, (Max) |          | coarse aggregate percentage by weight (Max) |          |
|--------|---|------------------------|--|----------|---|----------|
|        |   |                        | uncrushed                                  | crushed* | uncrushed                                   | crushed* |
| (1)    | (2)   | (3)                    | (4)  | (5)      | (6)   | (7)      |
| i)     | Coal and lignite  | IS:2386 (Part II)-1963 | 1.0  | 1.0      | 1.0   | 1.0      |
| ii)    | Clay lumps  | do                     | 1.0  | 1.0      | 1.0   | 1.0      |
| iii)   | Materials finer than 75 $\mu$ IS Sieve  | IS:2386 (Part I)-1963  | 3.0  | 8.0      | 3.0   | 3.0      |
| iv)    | Soft fragments  | IS:2386 (Part II)-1963 | –  | –        | 3.0   | –        |
| v)     | Shale   | IS:2386 (Part II)-1963 | 1.0  | –        | –   | –        |
| vi)    | Total of percentages of all deleterious materials (except mica) including SI No. (i) to (v) for col 4, 6 and 7 and SI No. (i) and (ii) for col 5 only |                        | 5.0  | 2.0      | 5.0   | 5.0      |

\* Crushed aggregate at least one face fractured

Note: The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are underway to determine the extent of the deleterious effect of mica. It is advisable, therefore, to investigate the mica content of fine aggregate and make suitable allowances for the possible reduction in the strength of concrete or mortar; in cases where the stretch of the project road passes through micaceous belt

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalis in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 percent by weight and the total sulphate content expressed as sulphuric anhydride ( $\text{SO}_3$ ) shall not exceed 0.25 percent by weight. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for atleast 72 hours before batching, as directed by the Engineer.

### **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 coarse aggregate shall not exceed 31.5 mm for pavement concrete. No aggregate which has water absorption more than 2 percent 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 percent if sodium sulphate solution is used or 18 percent if magnesium sulphate solution is used. The Los Angeles Abrasion value shall not exceed 35. The combined flakiness and elongation index of aggregate shall not be more than 35 percent.

### **fine aggregates**

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

### **combined gradation of fine and coarse aggregates**

The combined gradation of fine and coarse aggregates shall be as per Table 600-3.

**Table 600-3 : aggregate gradation for pavement Quality concrete**

| <b>sieve designation</b> | <b>percentage by weight passing the sieve</b> |
|--------------------------|---|
| 31.5 mm                  | 100   |
| 26.5 mm                  | 85-95   |
| 19.0 mm                  | 68-88   |
| 9.5 mm                   | 45-65   |
| 4.75 mm                  | 30-55   |

|            |      |
|------------|------|
| 600 micron | 8-30 |
| 150 micron | 5-15 |
| 75 micron  | 0-5  |

## **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 finished concrete. It shall meet the requirements stipulated in IS:456.

## **steel for dowels and tie Bars**

Steel shall conform to the requirements of IS:432 and IS:1786 as relevant. The dowel bars shall conform to IS:432 of Grade I. Tie bars shall be either High yield Strength Deformed bars conforming to IS:1786 and grade of Fe 500 or plain bars conforming to IS:432 of Grade I. The steel shall be coated with epoxy paint for protection against corrosion.

## **Joint filler Board**

Synthetic Joint filler board for expansion joints shall be used only at abutting structures like bridges and 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, with a compressibility more than 25 percent. 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. If two pieces are joined to make up full width, the joint shall be taped such that no slurry escapes through the joint. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

## **Joint sealing compound**

The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide/polyurethane/silicone type having flexibility, resistance to age hardening and durability as per IRC:57. 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 mentioned below. The samples shall meet the requirements as mentioned in IRC:57.

If sealant is of hot poured type, it shall conform to

Hot applied sealant : IS:1834 or ASTM : 3406-95, as applicable Cold

poured sealants shall be one of the following :

|      |              |                                      |
|------|--------------|--------------------------------------|
| i)   | polysulphide | IS:11433 (Part I), BS:5212 (Part II) |
| ii)  | polyurethane | BS:5212                              |
| iii) | silicone     | ASTM 5893-04                         |

## **preformed seals**

The pre-formed joint sealing material shall be a vulcanized elastomeric compound using polychloroprene (Neoprene) as the base polymer.

The joint seal shall conform to requirements of ASTM D 2628 as given in Table 600-4.



**table 600-4 : requirement of preformed seals as per astM d 2628**

| <b>s. no.</b> | <b>description</b>   | <b>requirements</b> | <b>astM test Methods</b> |
|---------------|--|---------------------|--------------------------|
| 1)            | Tensile strength, min  | 13.8 MPa            | D 412                    |
| 2)            | Elongation at break  | Min. 250%           | D 412                    |
| 3)            | Hardness, Type A durometer   | 55 +/-5 points      | D 2240                   |
| 4)            | Oven aging, 70 h at 100°C Tensile strength loss                              | 20% max             | D 573                    |
| 5)            | Elongation loss  | 20% max             |                          |
| 6)            | Hardness Change Type A durometer   | 0 to +10 points     | D 471                    |
| 7)            | Oil Swell, ASTM Oil 3, 70 h at 100°C Weight Change                           | 45% max             | D 1149                   |
| 8)            | Ozone resistance 20 percent strain, 300 pphm in air, 70 h at 40°C            | No cracks           | D 2240                   |
| 9)            | Low temperature stiffening, 7 days at -10°C Hardness Change type A durometer | 0 to +15 points     |                          |
| 10)           | Low temperature recovery, 22h at -10°C, 50% deflection                       | 88% min             | D 2628                   |
| 11)           | Low temperature recovery, 22h at -29°C, 50% deflection                       | 83% min             | D 2628                   |
| 12)           | Low temperature recovery, 70h at -100°C, 50% deflection                      | 85% min             | D 2628                   |
| 13)           | Compression, deflection, at 80% of normal width (min)                        | 613 N/m             | D 2628                   |

### **storage of Materials**

All materials shall be stored in accordance with the provisions of Clause 1014 of the Specifications. All efforts shall 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 platform where aggregates are stock piled shall be paved and elevated from the ground atleast by 150 mm. The area shall have slope 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 prior to their use.

### **Proportioning of concrete**

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 vide Clause 602.3.4. The mix design shall be submitted at least 30 days prior

to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IRC:44 or IS:10262. The target mean strength for the design mix shall be determined as indicated in Clause 602.3.3.1. The mix design shall be based on the flexural strength of concrete.

### **Cement content**

When Ordinary Portland Cement (OPC) is used the quantity of cement shall not be less than 360 kg/cu.m. In case fly ash grade I (as per IS:3812) is blended at site as part replacement of cement, the quantity of fly ash shall be upto 20 percent by weight of cementitious material and the quantity of OPC in such a blend shall not be less than 310 kg/cu.m. The minimum of OPC content, in case ground granulated blast furnace slag cement blended, shall also not be less than 310 kg/m<sup>3</sup>. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary by the contractor at his own cost.

### **Concrete strength**

The characteristic flexural strength of concrete shall not be less than 4.5 MPa unless specified otherwise. Target mean flexural strength for mix design shall be more than  $4.5 \text{ MPa} + 1.65s$ , where  $s$  is standard deviation of flexural strength derived by conducting test on minimum 30 beams. 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 specimens. 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 as approved by the Engineer and the maximum free water cement ratio shall be 0.45 when only OPC is used and 0.50 when blended cement (Portland Pozzolana Cement or Portland Slag Cement or OPC blended with fly ash or Ground Granulated Blast Furnance Slag, at site) is used.

The ratio between the 7 and 28 day strength 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.

If during the construction of the trial length or during some 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 percent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for in conformity with the requirements as per Clause 602.3.3.1. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

### **workability**

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.

The workability requirement at the batching and mixing plant and paving site shall be established by slump tests carried during trial paving. These requirements shall be established from season to season and also when the lead from batching and mixing 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  $25 \pm 15$  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 tipping truck/dumper at batching and mixing plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate tipping trucks or as per the instructions of the Engineer.

### **Design Mix**

The Contractor shall carry out laboratory trials of design mix with the materials from the approved sources to be used as per IRC:44. 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 these Specifications, and conform to the requirements of the design/drawings.

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.

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 of length not less than 50 m 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.

### **Sub-base**

The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and Specifications. It shall be ensured that the sub-base is not damaged before laying the concrete pavement. If the dry lean concrete sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired with fine cement concrete (aggregate size 10 mm and down) or bituminous concrete before laying separation membrane layer.

### **Separation Membrane**

A separation membrane shall be used between the concrete slab and the sub-base. Separation membrane shall be impermeable PVC sheet 125 micron thick transparent or white in colour laid flat with minimum 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 sheathing shall be replaced at the Contractor's cost. The separation membrane may be nailed to the

lower layer with concrete nails. The separation membrane shall be omitted when two layers of wax-based curing compound is used.

#### **602.4 Joints**

The locations and type of joints shall be as shown in the drawing. Joints shall be constructed depending upon their functional requirement. The location of the joints should be transferred accurately at the site and mechanical saw cutting of joints done as per stipulated dimensions. It shall be ensured that the required depth of cut is made from edge- to-edge of the pavement. Transverse and longitudinal joints in the pavement and Dry Lean Concrete sub-base shall be staggered so that they are not coincident vertically and are at least 800 to 1000 mm and 300 to 400 mm 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 crew members without damaging the texture of the pavement.

Sawing operation could start as early as 4-8 hours after laying of concrete pavement but not later than 8 to 12 hours depending upon the ambient temperature, wind velocity, relative humidity and required maturity of concrete achieved for this purpose.

When the kerb is cast integrally with the main pavement slab, the joint cutting shall also be extended to the kerb.

Where the use of maturity meter is specified, sawing should not be initiated when the compressive strength of the concrete is less than 2 MPa and should be completed before it attains the compressive strength of 7 MPa.

#### **Transverse Joints**

Transverse joints shall be contraction, construction 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.

- i) Deviations of the performed filler board (IS:1838) in the case of expansion joints from the intended line of the joint shall not be greater than  $\pm 10$  mm.
- ii) 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.
- iii) Deviations of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.
- iv) 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 602.10.

#### **contraction Joints**

The contraction joints shall be placed transversely at pre-specified locations as per drawings/

design using dowel bars. These 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.

Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and one-fourth to one-third depth of the slab  $\pm 5$  mm or as stipulated in the drawings and dowel bars complying with Clause 602.6.5.

Contraction joint shall be widened subsequently to accommodate the sealant as per Clause 602.10, to dimensions shown on drawings or as per IRC:57.

### **Expansion Joints**

The expansion joint shall consist of a joint filler board complying with Clause 602.2.9 and dowel bars complying with Clause 602.6.5 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 602.6.2.1. The adjacent slabs shall be completely separated from each other by the joint filler board.

### **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 location of contraction joints using dowel bars. If sufficient concrete has not been mixed to form a slab extending upto a contraction joint, and if an interruption occurs, the concrete placed shall be removed upto the last preceding joint and disposed of. At all construction joints, steel bulk heads shall be used to retain the concrete. 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 to enable the movement of joint cutting machine so that joint grooves may be cut and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

After minimum 14 days of curing, in case OPC cement is used and 16 days of curing when flyash or blended cement is used, the construction joint shall be widened to accommodate the sealant as per Clause 602.10 to dimensions shown on drawing or as per IRC:57.

### **longitudinal Joint**

The longitudinal joints shall be constructed by forming or by sawing as per details of the joints shown in the drawing. Sawn longitudinal joints shall be constructed when the concrete pavement placement width exceeds 4.5 m. The groove may be cut after the final set of the concrete. Joints should be sawn to at least one-third the depth of the slab  $\pm 5$  mm as indicated in the drawing. The joint shall be widened subsequently to dimensions shown on the drawings.

Where adjacent lanes of pavement are constructed separately using slip form pavers or side forms, the tie bars may be bent at right angles against the vertical face/ side of the first lane constructed and straightened before placing concrete in the adjacent lane. Broken or damaged tie bars shall be repaired or replaced as required.

The groove for sealant shall be cut in the pavement lane placed later.

### **Tie Bars**

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with Clause 602.6.6. The direction of the tie bars at curves shall be radial in the direction of the radius.

### **dowel Bars**

Dowel bars shall be mild steel rounds in accordance with Clause 602.2.8 with details/dimensions as indicated in the drawings 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. Any protrusions shall be removed by grinding the ends of the dowel bars. 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.

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 centered 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 here-in-under, the compliance of which shall be checked as per Clause 602.11.7.

- i) For bars supported on cradles prior to the laying of the slab:
  - a) All bars in a joint shall be within  $\pm 2$  mm per 300 mm length of bar
  - b) 2/3rd of the number of bars shall be within  $\pm 3$  mm per 500 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.
- ii) For all bars inserted after laying of the slab except those inserted by a

Dowel Bar Inserter the tolerance for alignment may be twice as indicated in (i) above.

The transverse joints at curves shall be radial in the direction of the radius.

Dowel bars, supported on cradles in assemblies, when subject to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and in both directions horizontally) shall conform to be within the limits given in Clause 602.6.5.2.

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:-

- i) 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 load shall be not more than 3 mm.
- ii) The fixings for joint assembly 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.
- iii) 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.

Dowel bars in the contraction joints, construction joints and expansion joints shall be covered by a thin plastic sheath. The thickness of the sheath shall not exceed 0.5 mm and shall be tightly fitted on the bar for at least two-thirds of the length from one end for dowel bars in contraction/construction joints and half the length plus 50 mm for expansion joints. The sheathed bar shall comply with the following pull-out tests:

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 mm x 150 mm x 600 mm, made of the same mix proportions to be used in the pavement, but 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 bond stress to achieve this movement shall not be greater than 0.14 MPa.

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 expansion space (about 25 mm) 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 into the annular space between the sheathing and dowel bar shall be taped around its mouth.

### **Tie Bars**

Tie bars in longitudinal joints shall be deformed steel bars of strength 500 MPa complying with IS:1786 and in accordance with the requirements given in this Clause. The bars shall be free from oil, dirt, loose rust and scale.

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. In the case of coastal region and high rainfall areas, tie bars shall be epoxy coated in their full length as per IS:13620.

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 placements of the bars and recompaction of the concrete around the tie bars.

Tie bars shall be positioned to remain in the middle from the top or within the upper 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 within a tolerance of  $\pm 50$  mm, and with a minimum cover of 30 mm below the joint groove. Spacing of tie bars on curves of radius less than 360 m shall not be less than 350 mm.

To check the position of the tie bars, one metre length, 0.5 m on either side of the longitudinal joint shall be opened when the concrete is green (within 20 to 30 minutes). The pit shall be refilled with the fresh concrete of same mix after checking.

### **Weather and seasonal limitations**

#### **concreting during Monsoon Months**

Concreting should be avoided during rainy season. However, when concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other waterproof 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 directions of the Engineer.

#### **Temperature limitation**

No concreting shall be done when the temperature of the concrete reaching the paving site is above 30°C. Besides, in adverse conditions like high temperature, low relative humidity,



excessive wind velocity, imminence of rains etc., tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of. When the ambient temperature is more than 35°C, no concreting shall be permitted. The ice flakes should not be manufactured from chlorinated water. Generally the rate of evaporation of water shall not exceed 1 kg/sqm/hour as per IRC:15.

No concreting shall be done when the concrete temperature is below 5°C and the temperature is further falling.

### **Fixed form paving**

#### **Side forms and rails**

These shall be provided in case of fixed form paving. All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface irregularity of the sub-base. The forms can be placed in 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. Side forms 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 for every 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 m 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 by the Engineer for his approval 12 hours before construction of the slab and shall not be removed until at least 12 hours afterwards. No concreting shall commence till formwork has been approved by the Engineer.

At all times sufficient forms shall be used and set to the required alignment for at least 300 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.

#### **slip form paving**

##### **use of guidewires**

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.

The guidewires shall be supported on stakes 5–6 m apart by connectors capable of fine horizontal and vertical adjustment. The guidewire shall be tensioned on the stakes so that a

500 gm 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. On the curves, the stakes shall be fixed at not more than 3 m centre-to-centre.

The stakes shall be positioned and hammered into the ground and the connectors will be maintained at their correct height and alignment from 12 hours on the day before concreting takes place till after finishing of texturing and spraying of curing compound on the concrete.

However, the guidewire shall be erected and tensioned on the connectors at any section for at least 2 hours before concreting that section.

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 next day. Such approval shall be obtained atleast 12 hours before commencement of paving operation. 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.

## **Construction**

### **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, indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work. This 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 500 m in one day. The paving speed of slip-form paver shall not be less than 1.0 m per minute. The concreting should proceed continuously without stops and starts.

### **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 stationary water tanks. This shall be located at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor

### **Equipment for proportioning of Materials and paving**

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. Water shall be measured by volume. Specified percentage of plasticizer in volume will be added by weight of cement. 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 percent higher than the proposed capacity of the laying/paving equipment.

**Batching plant and equipment :**

- 1) **general** : The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregates and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. There shall be a separate bin for flyash, if this additive is specified. 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. A continuous type of mixing plant can also be used provided the ingredients are weighed through electronic sensors before feeding.
- 2) **automatic weighing devices** : Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The weighing devices shall have an accuracy within  $\pm 1\%$  in respect of quantity of cement, admixtures and water and  $\pm 2\%$  in respect of aggregates and the accuracy shall be checked at least once a month.
- 3) **Mixer** : 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 specified mixing period, and of discharging the mix, without segregation. Each stationary 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 in 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 mixer 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.

- 4) **control cabin** : An air-conditioned centralized computer control cabin shall be provided for automatic operation of the equipment.
- 5) The design features of the batching plant should be such that it can be shifted quickly.

## **Paving equipment**

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i) 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 minimum 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 sensor controls to control the line and grade from either one side or both sides of the machine.

Vibrators shall operate at a frequency of 8000-10000 impulses per minute under load at a maximum spacing of 600 mm. The variable vibration setting shall be provided in the machine.

## **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 hose and pump shall be made available for this activity on priority basis. The Contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

## **Hauling and placing of concrete**

Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of tipping trucks or transit mixers 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. While loading the concrete truck shall be moved back and forth under the discharge chute to prevent segregation. The tipping trucks 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 day's work. Tipping trucks shall be washed at a regular frequency as prescribed by the Engineer to ensure that no left-over mix of previous loading remains stuck.

## **Placing of concrete**

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°C and 90 minutes when the concrete temperature is between 25°C and 30°C. When the time between mixing and laying exceed these values, the concrete shall be

rejected and removed from the site. Tipping trucks delivering concrete shall normally not run on plastic sheathing nor shall they run on completed slabs until after 28 days of placing the concrete.

The placing of concrete in front of the PQC paver should preferably be from the side placer to avoid damage to DLC by concrete tipping trucks. In case of unavoidable situation, truck supplying concrete to the paver may be allowed to ply on the DLC with the approval of the Engineer. The paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

Where fixed form pavers are to be used, forms shall be fixed in advance as per Clause 602.8. 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 these Specifications. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the concrete in the pavement.

In areas inaccessible to paving equipment, the pavement shall be constructed using side forms, as per Clause 602.9.7.

In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

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.

### **construction by fixed form paver**

The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

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 of 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 slab. 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 changes in slab thickness or crossfall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by over working.

### **Semi-mechanised construction**

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 the same as in the case of machine laid work. Guidelines on the use of plants, equipment, tools, hauling of mix, compaction floating, straight edging, texturing, edging etc. shall be as per IRC:15.

## Transition slabs

At the interface of rigid and flexible pavement, at least 3 m long reinforced buried slab shall be provided to give a long lasting joint at the interface. The details shall be as given in IRC:15.

## Anchor Beam and terminal slab Beam adjoining Bridge structures

RCC anchor beams shall be provided in the terminal slab adjoining bridge structures as per drawings and IRC:15.

## The treatment of concrete pavement on culverts

The concrete pavement shall be taken over the culverts. At both ends of the culvert slab, a contraction joint shall be provided in the concrete pavement. Nominal reinforcement of 10 mm dia bars at 150 mm spacing in both directions shall be provided at 50 mm below the top of the slab. The reinforcement shall be stopped 50 mm short of the contraction joint. Such reinforcement shall also be provided in the next slab panel on either side.

## Surface texture

### Tining

After final floating and finishing of the slab and before application of the liquid curing membrane, the surface of concrete slabs shall be textured either in the transverse direction (i.e., at right angles to the longitudinal axis of the road) or in longitudinal direction (i.e., parallel to the centreline of the roadway). The texturing shall be done by tining the finished concrete surface by using rectangular steel tines. A beam or a bridge mounted with steel tines shall be equipped and operated with automatic sensing and control devices from main paver or auxiliary unit. The tining unit shall have facility for adjustment of the download pressure on the tines as necessary to produce the desired finish. The tining rakes shall be cleaned often to remove snots of slurry. The tines shall be inspected daily and all the damaged and bent tines shall be replaced before commencing texturing. Tined grooves shall be 3 mm wide and 3 to 4 mm deep. Before commencing texturing, the bleeding water, if any, shall be removed and texturing shall be done on a firm surface. The measurement of texture depth shall be done as per Clause 602.12.

- a) **transverse tining** : When the texturing is specified in transverse direction, a beam of at least 3 m length mounted with tines shall be moved in transverse direction to produce the texture. The grooves produced shall be at random spacing of grooves but uniform in width and depth. The spacing shall conform to a pattern shown below:

**random spacing in mm**

|    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 10 | 14 | 16 | 11 | 10 | 13 | 15 | 16 | 11 | 10 | 21 | 13 | 10 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|

- b) The above pattern shall be repeated. Texturing shall be done at the right time such that the grooves after forming shall not close and they shall not get roughened. Swerving of groove patterns will not be permitted. The **longitudinal tining** : Longitudinal tining shall be done, if specified in the Contract. The texturing bridge shall be wide enough to cover the entire width of the carriageway but within 75 mm from the pavement edge. The centre to centre spacing between the tines



shall be 18 to 21 mm. The width of fine texture shall be 3 mm and depth shall be 3 to 4 mm.

completed textured surface shall be uniform in appearance.

### Brush texturing

Alternatively on the instructions of the Engineer, the brush texturing shall be applied. 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 wider brushes normally of 3 m length are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts placed 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 one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90 mm long.

The texture depth shall be determined by the Sand Patch Test as described in the Clause 602.12. 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.

Texture depths shall not be less than the minimum required depth when measurements are taken as given in Table 600-5 nor greater than an average of 1.25 mm.

**table 600-5 : texture depth**

| time of test |  | number of Measurements       | required texture depth (mm) |                |
|--------------|--|------------------------------|-----------------------------|----------------|
|              |  |                              | Specified Value             | tolerance      |
| 1)           | Between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles | An average of 5 measurements | 1.00                        | ±0.25          |
| 2)           | Not later than 6 weeks before the road is opened to traffic  | An average of 5 measurements | 1.00                        | +0.25<br>-0.35 |

After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

Where the texture depth requirements are found to be deficient, the Contractor shall make

good the texture across the full lane width over the length directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

## **Curing**

Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminized reflective curing compound which hardens into an impervious film or membrane with the help of mechanical sprayer

The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks of 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. The curing compound shall be sprayed in two applications to ensure uniform spread.

Curing compounds shall contain sufficient flake aluminum 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 not less than 90 percent in accordance with BS Specification No. 7542 or as per ASTM C-309-81 Type 2.

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 mounted on mobile trusses as described in Clause 602.7.2, during adverse weather conditions as directed by the Engineer. After three hours, the pavement shall be covered by moist hessian laid in two layers 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.

The Contractor shall be liable at his cost to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint as per procedure in IRC:SP:83.

## **preparation and sealing of Joint grooves**

### **general**

All joints shall be sealed using sealants described in Clause 602.2.10.

### **preparation of Joint grooves for sealing**

Grooves are saw cut in the first instance just to provide minimum width (3-5 mm) to



facilitate development of crack at joint locations, as shown in the drawing.

Subsequently before sealing, grooves are widened by sawing as per the dimensions in the drawing. Dimension of the grooves shall be controlled by depth/width gauge.

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 upto 10° from the perpendicular to the surface, the overhanging edge of the groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degree, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects upto a maximum width, including any chamfer, of 20 mm for transverse joints and 10 mm for longitudinal joints. If the spalling cannot be so eliminated then the arises shall be repaired by an approved thin bonded arrises repair using cementitious/epoxy mortar materials.

All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. The Engineer shall instruct cleaning by pressurized water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves shall be sand blasted to increase the bondage between sealant and concrete.

The groove shall be cleaned and dried at the time of priming and sealing. If sand blasting is recommended by the supplier, the same shall be carried out.

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 where hot poured sealant is used. When cold poured sealant is used a debonding tape of 1.0-2.0 mm thickness and 6 to 8 mm width shall be inserted to plug the groove so that the sealant does not enter in the initially cut groove.

### **Sealing with sealants**

When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with his instructions. 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°C.

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 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. The Movement Accomodation Factor of the sealant shall be more than 10 percent.

### **Approval and acceptance**

Approval of the materials, plant, equipment and construction methods shall be given when the trial length complies with the Specifications. The Contractor shall not proceed with normal working until the trial length has been approved. If the Engineer does not notify the Contractor of any deficiencies in any trial length within 7 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, provided that the 28 days strength of cubes and cores extracted from trial length meet the requirement of the Specified strength.

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 this Clause to demonstrate that the changes will not adversely affect the permanent works.

Trial lengths which do not comply with the Specifications, with the exception of areas which are deficient only in surface texture and which can be remedied in accordance with Clause 602.9.11.6 shall be removed immediately upon notification of deficiencies by the Engineer and the Contractor shall construct a further trial length.

### **Inspection of dowel Bars**

Compliance with Clause 602.6.5. for the position and alignment of dowel bars at contraction and expansion joints shall be checked by measurements relative to the side forms or guide wires.

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 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 days 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. This joint shall be treated as construction joint. The position of dowel bars in any type of transverse joint ie, contraction, construction or expansion can alternatively be tested by suitable device like MIT SCAN with the permission of the Engineer.

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.

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 602.6.5.5 shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per Clause 602.10.

### **Inspection of tie Bars**

To check the position of the tie bars, one metre length 0.5 m on either side of the longitudinal joint shall be opened when the concrete is green (within 20 to 30 minutes of its laying). The pit shall be refilled with the fresh concrete of same mix after checking.

### **602.12 Measurement of texture depth – sand patch Method**

The following Apparatus shall be used:

- i) A cylindrical container of 25 ml internal capacity;
- ii) A flat wooden disc 64 mm diameter with a hard rubber disc, 1.5 mm thick, next to one face, the reverse face being provided with a handle;
- iii) Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

### **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 the sand is spread into a circular patch with the surface depressions filled with sand to the level of peaks.

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.

### **Measurement of texture depth - tining**

The following apparatus shall be used :

- i) Tire Tread Depth Gauge  
A stainless steel tire tread depth gauge with graduations with least count of 1.0 mm. The gauge end may be modified to measure depth of fine texture.
- ii) A stainless steel caliper to measure spacing of tines. If necessary the caliper may be modified to measure the spacing and width of fine texture. The gauge shall be used after making necessary calibration.
- iii) Wire brush
- iv) Corborundum stone
- v) Steel straight edge to remove snots etc. sticking to the surface. The straight edge may be of 6 x 25 x 300 mm size.

### **Test section**

A unit of testing shall be 75 m per lane. If the length of construction is less than 75 m it shall be taken as one unit.

### **Test procedure**

In each 75 m section, along the diagonal line, 10 points shall be selected for making checks of depth, width and spacing of fine grooves. The surface where tests are to be conducted shall be cleared carefully with a wire brush or a steel straight edge or using a corborundum plate to remove any upward projection of concrete. When the base plate of the gauge is in contact with the concrete surface, the gauge shall be pressed to the bottom of groove and the depth shall be measured and recorded at this location. At the same location, the spacing of tines shall be measured to verify whether the pattern recommended in Clause

602.9.11.1 is complied or not.

The average of depth and width at 10 locations shall be calculated and recorded to the nearest 1 mm. The spacing of spectrum measured at 10 locations shall be recorded separately.

The average depth shall be 3 to 4 mm. When the depth is less than 2.5 mm and in excess of 4.5 mm, the Contractor shall stop concreting till he corrects his tine brush or replaces it. The sensors associated with work shall be again calibrated to achieve the required texture. The textured groove less than 2.5 mm shall be re-grooved using concrete saw at the cost of Contractor. Variation in texture width in the range of 3+1 mm and 3 - 0.5 mm will be acceptable. If the variation of width is in excess of this range, the Contractor shall stop work and correct the brush and technique. When the spacing of spectrum is not satisfactory, the Contractor shall replace the entire brush.

### **602.13 Opening to Traffic**

No vehicular traffic shall be allowed to ply on the finished surface of a concrete pavement within a period of 28 days of its construction and until the joints are permanently sealed and cured. 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.

### **602.14 Acceptance criteria in Quality and distress**

- i) **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.
- ii) **tolerances in distress :** The acceptance criteria with regard to the types of distresses in rigid pavement shall be as per IRC:SP-83. "Guidelines for Maintenance, Repair and Rehabilitation of Cement Concrete Pavements". The cracks (of severity rating not more than 2) which may appear during construction or before completion of Defect Liability Period shall be acceptable with suggested treatments as given in IRC:SP-83.

Cement Concrete Pavement slabs having cracks of severity rating more than 2 i.e. cracks of width more than 0.5 mm for single discrete cracks, multiple and transverse cracks and cracks of width more than 3 mm in case of longitudinal cracks and of depth more than half of the concrete pavement slabs, shall be removed and replaced as per IRC:SP-83.

## **602.15 Measurements for payment**

Cement Concrete pavement shall be measured as a finished work in **cubic metres** of concrete placed based on the net plan area and thickness as measured in accordance with Clause 602.15.2.

The finished thickness of concrete for payment on volume basis shall be computed in the manner described in Clause 113.3 with the following modifications:

- i) The levels shall be taken before and after construction at grid points 5 m centre to centre longitudinally in straight as well as at curves.
- ii) 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 10 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.

## **602.16 Rate**

The Contract unit rate for the construction of the cement concrete pavement shall be payment in 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, equipment, providing all materials i.e. aggregates, dowel bars, tie bars, PVC membrane, cement, stabilizers (lime, cements or any other stabilizers approved by the Engineer), storing, mixing, transportation, placing, compacting, finishing, curing, testing, all royalties, fees, rents where necessary, all leads and lifts and incidentals to complete the work as per Specifications.

The unit rate shall all include the full costs of construction, expansion, contraction and longitudinal joints including joint filler, sealant, primer, debonding strip and all other operations for completing the work. The construction and testing of trial length shall be included in the contract unit rate for the pavement and shall not be paid separately.

Where the average thickness for the lot is deficient by the extent shown in Table 600-6, payment for cement concrete pavement shall be made at a price determined by adjusting the contract unit price as per Table 600-6.

**Table 600-6 : Payment Adjustment for Deficiency in Thickness**

| <b>Deficiency in the Average Thickness of Day's work</b> | <b>percent of contract unit price payable</b> |
|--|---|
| Up to 5 mm   | 100   |
| 6–10 mm  | 87  |

No additional payment shall be made for the extra thickness of the slab than shown on the drawings.

**Item No. 30**

**Carrying out load test of super structure as directed including all necessary materials plant equipment, instruments, labour and arrangements for test directed.**

"Carrying out proof load test of bridge superstructure as directed by Engineer-in-Charge in accordance with IRC:SP:51 and relevant IRC provisions including supply of all materials, calibrated instruments, loading vehicles, labour, staging, traffic management, data acquisition, analysis, submission of test reports and all incidental works complete."

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**Detailed Scope & Specification****1. Applicable Codes**

The load test shall be conducted in accordance with:

- IRC:SP:51-2014
- IRC:SP:37-2010
- Relevant provisions of IRC:6
- Relevant provisions of IRC:112 where applicable.

The testing shall generally be proof load testing of bridge superstructure for evaluation of flexural behavior and serviceability.

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**2. Scope of Work**

The contractor/agency shall carry out:

- Detailed visual inspection before testing
  - Identification of critical spans/sections
  - Preparation of load test methodology
  - Structural analysis for positioning of vehicles
  - Arrangement of calibrated loading vehicles
  - Weighment of vehicles at approved weighbridge
  - Installation of instrumentation
  - Deflection, strain and crack monitoring
  - Incremental/staged loading and unloading
  - Recovery measurements
  - Preparation of observations and final report
  - Submission of certified test results
- 

**3. Loading Arrangement**

The test loading shall be applied using:

- Calibrated loaded trucks/trailers
- Water tankers / concrete blocks / kentledge where required
- Vehicle positioning as per analytical influence line diagrams

The loading arrangement shall induce maximum:

- Bending moment
- Deflection
- Stress at critical sections

Typical staged loading:

- 25%
  - 50%
  - 75%
  - 100% proof load
-

#### 4. Instruments & Equipment

The item rate shall include supply, installation, calibration and operation of:

##### Deflection Measurement

- LVDTs (Linear Variable Displacement Transducers)
- Dial gauges with magnetic stands
- Digital displacement sensors

##### Strain Measurement

- Electrical resistance strain gauges
- Vibrating wire strain gauges if required

##### Inclination / Settlement Monitoring

- Tilting meters
- Precision level instruments
- Auto levels / total station

##### Temperature Monitoring

- Digital thermometers
- Surface temperature sensors

##### Data Recording

- Data logger
- Computerized data acquisition system
- Cabling and power supply

All instruments shall be calibrated from approved/NABL accredited laboratory before testing.

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#### 5. Temporary Works & Arrangements

The item shall include:

- Scaffolding/platforms below bridge
  - Access ladders and working platforms
  - Lighting arrangements for night testing
  - Safety barricading
  - Traffic diversion and control
  - Communication system
  - Generator and backup power
  - Whitewashing/marking for crack observation
  - Measuring scales and crack width gauges
- 

#### 6. Testing Procedure

The procedure shall generally include:

1. Initial inspection and zero readings
2. Placement of instrumentation
3. Application of load in stages
4. Recording of:
  - Instantaneous deflection
  - Residual deflection
  - Strain
  - Crack development
5. Holding load at each stage
6. Unloading sequence
7. Recovery observations after unloading
8. Final inspection

Recovery observations may be taken immediately and after 24 hours as directed.

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## 7. Acceptance Criteria

Bridge superstructure shall satisfy IRC criteria including:

- Measured deflection  $\leq$  theoretical permissible deflection
- Adequate elastic recovery after unloading

Typical recovery requirements:

- RCC / Composite bridges: minimum 75%
  - PSC / Steel bridges: minimum 85%
- 

## 8. Test Report

Final report shall include:

- Bridge details
- Test methodology
- Design calculations
- Instrument calibration certificates
- Vehicle weighment slips
- Instrument locations
- Loading sequence
- Recorded observations
- Deflection and strain plots
- Photographs/videos
- Comparison with theoretical values
- Conclusions and recommendations

Measurement shall be in M.T.

**Item No. 34**

**Providing G.I. 100mm diameter water spouts including necessary iron gratings as per drawings.  
MORTH V<sup>th</sup> REVISION Cl. No. 2705, Pg. no. 754**

**2705 Drainage Spouts**

Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be of corrosive resistant material such as galvanised steel with suitable cleanout fixtures. The spacing of drainage spouts shall not exceed 10 m. The discharge from drainage spout shall be kept away from the deck structure by means of suitable down pipes upto 500 mm above High Flood Level. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located runners and down pipes to discharge the surface run-off into drains provided at ground level.

**Fabrication**

The drainage assembly shall be fabricated to the dimensions shown on the drawings. All materials shall be corrosion resistant;. Steel components shall be of mild steel conforming to IS:226. The drainage assembly shall be seam welded for water tightness and then hot-dip galvanised.

**Placement**

The galvanised assembly shall be given two coats of bituminous paint before placement. The whole assembly shall be placed in true position, lines and levels as shown on the drawings with necessary cutouts in the shuttering for deck slab and held in place firmly. Where the reinforcements of the deck are required to be cut, equivalent reinforcements shall be placed at the corners of the cut out.

**Finishing**

After setting of the deck slab concrete, the shrinkage cracks around the assembly shall be sealed with polysulphide sealant or bituminous sealant as per IS:1834 and the excess sealant trimmed to receive the wearing coat. After the wearing coat is completed, similar sealant shall be provided to cover at least 50 mm on the wearing coat surface all round the drainage assembly.

**2708 Measurements For Payment**

Drainage spouts shall be measured in **Each/numbers**.

**2709 Rate**

The contract unit rate for drainage spout shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. It shall also include the cost of providing runners and down pipes with all fixtures upto 500 mm above high flood level or up to the drains at ground, as applicable or as shown on the drawings.

**Item No. 35**

**"Providing & laying approved make Double walled corrugated pipes (DWC) of polyethylene (conforming to IS14930 II) with necessary connecting accessories of same material at required depth in existing trench for laying of cable. below ground/road surface for enclosing cable (A) 50 mm outer dia"**

As per detail specification Sample must be approved from Engineer In Charge.

DWC pipes shall be measured in Rmt and Payment shall be made on Rmt.

**Item No. 36**

**Providing and applying one coat Epoxy Phenolic primer of DFT 50 micron and two coats of Epoxy Phenolic coating of DFT 100 microns each or any other equivalent epoxy coating system to all concrete surfaces exposed to atmosphere in substructure and superstructure including cost of material, labour, transportation, scaffolding and preparing the surfaces by cleaning, washing, brushing, sand / grit blasting etc. complete and as directed by Engineer and as per specification. (Paint shall be got approved from Engineer and tested from approved laboratory).**

**Item No. 37**

**Painting Two Coats on New Concrete Surfaces (Painting two coats after filling the surface with synthetic enamel paint in all shades on new plastered concrete surfaces)**

**MORTH V<sup>th</sup> REVISION Cl. No. 2809, Pg. no. 775****2809 PROTECTIVE SURFACE COATING OF CONCRETE BY PATENTED SYSTEMS OF COATING**

Patented system of protective coating like epoxy polyurethane painting system, epoxy phenolic protective system and other systems shall be used only with the approval of Engineer after the assessment of the performance of the product, backed by certificates from users, acceptance tests as per published standards, pertinently to cover the material, processes, carbonation resistance, water vapour diffusion property, crack bridging properties, and UV resistance. The Engineer shall take performance guarantee from the agency responsible for the execution of the work for a minimum period of 5 years.

**2814 Measurements For Payment**

Measurement for application of epoxy mortar/protective surface coating of concrete for specified thickness shall be in **square metre** of surface area of application.

**2815 Rate**

The contract unit rate for application of epoxy mortar/protective surface coating for specified thickness shall include cost of all materials, labour, tools and plant, placing in position, testing and other incidental expenses including surface preparation for the satisfactory completion of the work as per these Specifications and as shown on the drawings.

**Item No. 38**

**Providing and fixing marble slab including engraving and painting complete.(i) Size 75cm x 60cm x 4cm.**

Marble plate shall be white and of approved quality and shall be of size as mentioned in the item. Lettering shall be done by V-shape engraving and shall be filled with black paint of approved quality, letting shall be done as directed by the Engineer-in-charge. The Marble plate shall be fixed in neat cement at a place as directed by the Engineer-in-charge. Cement shall conform to relevant IS Specification.

Measurement shall be **per number** of marble plate fixed.

Unit rates includes cost of all material labour and tools to complete the work

**Item No. 39**

**Providing, Designing , Supplying and Installation of Extruded Bi-Axial Polypropylene 40kN Geogrid including all Labours & Etc. Complete as directed by Engineer-In-Charge**

**MORTH V<sup>th</sup> REVISION Cl. No. 703, Pg. no. 307**

**703.1 Scope**

The work covers the use of geogrids in sub-base of pavement, erosion control of slopes, reinforced soil slopes and reinforced soil walls including supplying and laying as per design, drawing and these specifications.

The use of geogrids as a component for reinforced soil slopes and walls shall be as per Section 3100.

**703.2 Materials****703.2.1 General**

Geogrids shall be either made from high tenacity polyester yarn jointed at cross points by weaving, knitting or bonding process with appropriate coating or from polypropylene or polyethylene or any other suitable polymeric material by an appropriate process. Geogrids manufactured by extrusion process are integrally jointed, mono or bi-directionally oriented or stretched meshes, in square, rectangular, hexagonal or oval mesh form. The geogrids manufactured by weaving/knitting/bonding process shall be formed into a stable network such that ribs, filaments or yarns retain their dimensional stability relative to each other including selvages.

**703.2.2 Sub-base reinforcement**

Geogrid for use as reinforcement of sub-base layers of flexible pavements shall meet the requirement as per the design subject to the minimum requirements as given in Table 700-7.

**703.2.3 Erosion control**

The geogrid for erosion control application shall have the minimum tensile strength of 4 kN/m, when tested as per ASTM D5035 (Minimum Average Roll Value in Machine Direction). The aperture opening size shall be minimum 20 mm x 20 mm and average grid thickness shall be minimum 1.0 mm. Geogrid for erosion control application shall be UV stabilized. The geogrid shall have ultraviolet stability of 70 percent after 500 hrs exposure as per ASTM D 4355.

**Table 700-7** : Minimum requirements for geogrid for sub-Base of flexible pavement

| property                                  | test Method                  | unit | requirement   |
|---|------------------------------|------|---|
| Stiffness at 0.5% strain                  | ISO-10319                    | kN/m | ≥350; both in machine and cross-machine direction           |
| Tensile strength @2% strain               | ASTM D6637                   | kN/m | ≥15% of T ; both in machine and ult cross-machine direction |
| Tensile strength @5% strain               | ASTM D6637                   | kN/m | ≥20% of T ; both in machine and ult cross-machine direction |
| Junction Efficiency for extruded geogrids | GRI- GG2-87 or ASTM-WK 14256 | -    | 90% of rib ultimate tensile strength                        |
| Ultraviolet stability                     | ASTM D4355                   | -    | 70% after 500 hrs exposure                                  |

Note :

- 1) All numerical values in the Table represent MARV in the specified direction.
- 2) All geogrids shall be placed along machine direction parallel to the centre line of roadway alignment.

#### **703.2.4 Reinforced soil slopes and walls**

The strength and other requirements shall be as per Section 3100.

### **703.3 Installation and construction operations**

#### **703.3.1 Sub-base reinforcement**

Prior to laying of geogrid, the surface shall be properly prepared, cleaned and dressed to the specified lines and levels as shown on the drawings.

The geogrid shall be laid within the pavement structure as shown on the drawings.

Geogrid reinforcement shall be placed flat, pulled tight and held in position by pins or suitable means until the subsequent pavement layer is placed.

No vehicle shall be allowed on geogrid unless it is covered by at least 150 mm thick sub-base material.

#### **703.3.2 Erosion control**

The geogrid for erosion control applications shall be installed in accordance with the manufacturer's recommendation and as per Clause 706.3.

#### **703.3.3 Reinforced slopes and walls**

The geogrid for reinforced slopes and walls shall be installed in accordance with the manufacturer's recommendation and as per Section 3100.

#### **703.4 Measurement for payment**

The geogrid shall be measured in **square metres** as per planned dimensions with no allowance for overlapping at joints, anchoring at toe and crest of the slope. Excavation, back fill, bedding and cover material shall be measured separately as per relevant clauses of the Specifications. Reinforced soil slopes and walls shall be measured as per Section 3100.

#### **703.5 Rate**

The contract unit rate for the accepted quantities of geogrid in place shall be in full compensation for furnishing, preparing, hauling, and placing geogrid including all labour, freight, tools, equipment, and incidentals to complete the work as per specifications.

For reinforced soil slopes and walls, Section 3100 shall govern.

**Item No. 40**

"Fabricating, supply and erecting in position Standard Structural steel sections conforming to IS 2062 for railing, gates of underspace or other works using ISMB, ISA, ISMC, MS plate, flat, square bars, pipe, square pipe ,etc. including welding, cutting, wastage, etc. complete.

The rate is inclusive of welding rod, supply & fixing of correct size nut, bolts, washers, paint, with all contractor's materials, labour, tools & plants, in bolted / welded construction as directed by Engineer-in-Charge.

Anticorrosive paint must be applied before applied any paint. The rate shall inclusive of providing and applying Epoxy Coating of approved shade, brand and manufacture on new structural steel work with one coat of 30 micron (DFT) of Epilux 4 Zinc Rich primer of Berger Paint India Ltd or equivalent as primer and Two coat each of 35 micron (DFT) of Epilux 84 High Gloss CR enamel of Berger Paint India Ltd or equivalent at all levels. (Total DFT is 30+35+35=100 microns)

The waste cut pieces shall not be included in the paying quantity."

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**1901 Description**

This work shall include furnishing, fabricating, transporting, erecting and painting structural steel, rivet steel, cast steel, steel forgings, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the drawings and these Specifications or as directed by the Engineer.

**1902 General**

General requirements relating to the supply of material shall conform to the Specifications of IS:1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. It shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.

The acceptance of any material on inspection at the rolling mill, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective.

Unless otherwise specified, high tensile steel rivets conforming to IS:1149 shall be used only for members of high tensile steel conforming to IS:961 and shall not be used for members of mild steel.

Unless otherwise specified, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS:4000.

Cast iron shall not be used in any part of the bridge structure, except where it is subject to direct compression.

### **1903 Materials**

All materials shall conform to Section 1000 of these Specifications. Special requirements are given below:

Mild steel for bolts and nuts shall conform to IS:226 but have a minimum tensile strength of 44 kg/sq.mm and minimum percentage elongation of 14.

High tensile steel for bolts and nuts shall conform to IS:961 but with a minimum tensile strength of 58 kg/sq.mm.

Use of high strength friction grip bolts shall be permitted only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Engineer or as laid down in special provisions.

For cast steel, the yield stress shall be determined and shall not be less than 50 percent of the minimum tensile strength.

Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

Parallel barrel drifts shall have a tensile strength not less than 55 kg/sq.mm with elongation of not less than 20 percent measured on a gauge length of  $4\sqrt{S_0}$ .

( $S_0$  = cross-sectional area).

Materials for castings and forgings, fasteners, welding consumables and welding shall be as under :

### **Castings and Forgings**

Steel castings and forgings shall comply with the requirements of the following Indian Standards, as appropriate :

|         |  |
|---------|--|
| IS:1030 | Carbon Steel Castings for General Engineering purposes   |
| IS:1875 | Carbon Steel Billets, blooms, slabs, bars for forgings   |
| IS:2004 | Carbon Steel Forgings for General Engineering purposes   |
| IS:2644 | High Tensile Steel Castings                              |
| IS:2708 | 1.5 Percent Manganese Steel Castings                     |
| IS:4367 | Alloy and tool steel forgings for general industrial use |



## Fasteners

Bolts, nuts washers and rivets shall comply with the following or relevant Indian Standards as appropriate :

|         |   |
|---------|---|
| IS:1148 | Hot rolled rivet bars (up to 40 mm dia) for structural purposes             |
| IS:1149 | High tensile steel rivet bars for structural purposes                       |
| IS:1363 | Hexagon head bolts, screw and nuts product grade C (Parts 1 to 3)           |
| IS:1364 | Hexagon head bolts, screw & nuts product grade A and B (Parts 1 to 3)       |
| IS:1367 | Technical supply conditions for threaded steel fastener (Parts 1 to 18)     |
| IS:1929 | Hot forged steel rivets for hot closing (12-36 mm dia)                      |
| IS:2155 | Cold forged steel rivets for hot closing (6-16 mm dia)                      |
| IS:3640 | Hexagon fit bolts   |
| IS:3757 | High strength structural bolts  |
| IS:4000 | High strength bolts in steel structures                                     |
| IS:5369 | Plain washers and lock washers – general requirements                       |
| IS:5370 | Plain washers with outside dia = 3 X inside dia                             |
| IS:5372 | Taper washers for channels (ISMC)   |
| IS:5374 | Taper Washers for I beams (ISMB)  |
| IS:5624 | Foundation bolts  |
| IS:6610 | Heavy washers for steel structures  |
| IS:6623 | High strength structural nuts IS:6639<br>Hexagon bolts for steel structures |
| IS:6649 | Hardened and tempered washers for high strength structural bolts and nuts.  |
| IS:7002 | Prevailing torque type steel hexagon nuts                                   |

## Welding Consumables

Welding consumables shall comply with the following Indian Standards as appropriate :

|                    |  |
|--------------------|--|
| IS:814<br>(Part 1) | Covered Electrodes for Metal Arc Welding of Structural steel for welding other than sheets |
| IS:814<br>(Part 2) | For welding sheets   |
| IS:1395            | Low and medium alloy steel covered electrodes for manual Metal Arc Welding                 |
| IS:3613            | Acceptance Tests for wire flux combinations for submerged arc welding of structural steel  |

|         |  |
|---------|--|
| IS:6419 | Welding rods and bare electrodes for gas shielded arc welding of structural steel                                |
| IS:6560 | Molybdenum and chromium-molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding |
| IS:7280 | Bare wire electrodes for gas shielded arc welding of structural steel  |

## **Welding**

|         |  |
|---------|--|
| IS:812  | Glossary of terms relating to welding and cutting of metals  |
| IS:816  | Code of practice for use of metal arc welding for general construction in mild steel               |
| IS:822  | Code of procedure for inspection of welds  |
| IS:1024 | Code of practice for use of welding in bridges and structures subject to dynamic loading           |
| IS:1182 | Recommended practice for radiographic examination of fusion welded butt joints in steel plates     |
| IS:4853 | Recommended practice for radiographic inspection of fusion welded butt joints in steel pipes       |
| IS:5334 | Code of practice for magnetic particle flaw detection of welds                                     |
| IS:7307 | Approval tests for welding procedures : Part 1 fusion welding of steel                             |
| IS:7310 | Approval tests for welders working to approved welding procedures : Part 1 fusion welding of steel |
| IS:7318 | Approval tests for welders when welding procedure is not required : Part 1 Fusion welding of steel |
| IS:9595 | Recommendations for metal arc welding of carbon and carbon manganese steels                        |

Corrosion resistant steel to be used in aggressive environment shall be low alloy steels containing a total of 1 percent to 2 percent alloys, in particular copper, chromium, nickel and phosphorous.

## **Paints**

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer.

The type of paints which can be used shall be as follows :

- a) Ordinary i.e. paints based on drying oils, alkyd resin, modified alkyd

resin, phenolic varnish epoxy

- b) Chemical Resistant – one pack type (ready for use) or two pack type (mixed before use).
- c) Vinyl
- d) Chlorinated rubber
- e) Bituminous - (IS:9862)
- f) Epoxy - (IS:14925)
- g) Polyurethane - (IS:13759)
- h) Zinc rich - (IS:14589)

Unless otherwise specified, paints shall conform to the relevant Indian Standards. Paints shall be tested for the following qualities as per Specifications given in the relevant IS codes:

- Weight (for 10 litres of paint, thoroughly mixed)
- Drying time
- Consistency
- Dry thickness and rate of consumption

## **1904 Fabrication**

### **General**

All work shall be in accordance with the drawings and as per these Specifications. Fabrication work shall be taken up only after receipt of approved fabrication/working drawings. It shall be ensured that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number. Method of marking shall be commensurate with the process of manufacture and such as to ensure retention of identity at all stages.

Unless specifically required under the contract, corresponding parts need not be interchangeable, but the parts shall be match marked as required under Clause 1904.9.

Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Engineer before they are used in the finished structure.

All structural steel members and parts shall have straight edges and plane surfaces. They

shall also be free from twist. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

The Contractor shall submit his programme of work to the Engineer for his approval at least 15 days before the commencement of fabrication, which shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures. He shall also submit for approval of Engineer, a Quality Assurance Plan according to the nature of fabrication work (whether welded or riveted) which should clearly define the points of checking and inspection during the stages of fabrication as well as supply of materials.

The Contractor shall prepare shop drawings for fabrication of any member and obtain approval of the Engineer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop drawings. These drawings shall distinguish between shop and field welds.

### **laminations in Plates**

The following areas of plates shall not have laminations:

- a) Steel plates and sections in which tension stresses are transmitted through thickness of plate or in region in which lamination could affect the buckling behavior and bending compression.
- b) On each side of welded bearing diaphragm, strip of flange and web plate for a length equal to 25 times their thickness.
- c) The strip of web plate for a length of 25 times its thickness on each side of single sided bearing stiffener welded to web.
- d) For welded cruciform joints transmitting tensile stress through the plate thickness, for a length 4 times the thickness of plate on each side of attachment.
- e) For edges of plates where corner welds are provided on the surface of such plates.
- f) Other areas of plates or sections as may be specified by the Engineer.

### **straightening and Bending**

The straightening of plates, angles and other shapes shall be done by methods not likely to produce fracture or any injury to the metal. Hammering shall not be permitted. Heating, if permitted by the Engineer in special cases, shall be followed by as slow cooling as possible. Following the straightening of a bend or buckle, the surface shall be carefully inspected for evidence of fracture. Sharp kinks and bends may lead to rejection of material.

Straightening by heating shall be done under controlled procedure. Temperature of the steel shall not be more than 650°C. Heating and cooling rate shall be appropriate to the particular type of steel and shall be as agreed and approved by the Engineer. Accelerated cooling shall not be carried out without the approval of the Engineer.

### **Bending and Curving**

Steel having yield stress more than 360 MPa shall not be heat curved. Rolled beams and girders may be curved by either continuous or V-type heating as approved by Engineer.

- a) For the continuous method, a strip of sufficient length along the edge of top and bottom flange shall be heated simultaneously to desired temperature to obtain required curve.
- b) For V-type of heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. The truncate triangular pattern shall have an angle 15 to 30 with base not more than 250 mm long. The spacing and temperature shall be as required to obtain the required curvature and heating shall be at approximately the same rate along the top and bottom flanges.

For flange thickness of 32 mm or more, both inside and outside surfaces shall be heated concurrently.

The heat bending shall be conducted so that the temperature of steel does not exceed 620°C. The girder shall not be artificially cooled until temperature comes down to 315°C by natural cooling. The method of artificial cooling shall be as approved by Engineer.

Camber for rolled beams may be obtained by heat curving methods approved by Engineer. For camber in plate girders, the web shall be cut to prescribed camber with suitable allowance for shrinkage due to cutting, welding and heat curving.

### **Preparation of edges and ends**

All structural steel parts, where required, shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape. Material shall be cleaned and any burrs, scales or abnormal irregularities shall be removed.

End/edge planing and cutting shall be done by any one of the following prescribed methods or left as rolled:

- a) Shearing, cropping, sawing, machining, machine flame cutting.
- b) Hand flame cutting with subsequent grinding to a smooth edge.

Sheared edges of plate not more than 16 mm thick, which are for secondary use such as stiffeners and gussets, shall be subsequently ground to smooth profile.

If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 percent of the contact area does not exceed 0.25 mm.

Where flame cutting or shearing is done, at least one of the following requirements shall be satisfied.

- a) The cut edge is not subjected to applied stress.
- b) The edge is incorporated in weld.
- c) The hardness of cut edge does not exceed 350 HV 30.
- d) The material is removed from edge to the extent of 2 mm or minimum necessary, so that the hardness is less than 350 HV 30.
- e) Edge is suitably heat treated by approved method to the satisfaction of the Engineer and it is shown by dye penetrant or magnetic particle test that cracks have not developed.
- f) Thickness of plate is less than 40 mm for machine flame cutting of materials conforming to IS:2062 up to Grade E250 (Fe 410w). The requirement of hardness below 350 HV 30 of flame cut edges shall be specified by the Engineer.

The flame cut edges shall be ground or machined over and above the requirements in (a) to (f), wherever specified by the Engineer.

Where machining for edge preparation in butt joint is specified, the ends shall be machined after the members have been fabricated.

Outside edges of plate and section, which are prone to corrosion shall be smoothed by grinding or filing.

In the case of high tensile steel at least 6 mm of the material from the flame cut edge shall be removed by machining.

Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:

- a) Rolled edges of single universal plates or flats
- b) Covers to single flange plates.

Edges of single plates in compression and edges of single plates of thickness 25 mm or less, in tension, where machine flame cutting is acceptable. All edges of splice and gusset

plates 12 mm thick and over, shall be machined and those less than 12 mm thick shall be sheared and ground.

The ends of plates and sections forming the main components of plate girders or of built-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground or hand flame cut and ground.

The ends of lacing bar shall be rounded unless otherwise specified.

Other edges and ends of mild steel parts shall be sheared and any burrs at edges shall be removed.

## **Preparation of Holes**

### **Drilling and Punching**

Holes for rivets, black bolts, high strength bolts and countersunk bolts/rivets (excluding close tolerance and turn fitted bolts) shall be either punched or drilled. For bolts/rivets less than 25 mm dia, the diameter of holes shall be 1.5 mm larger while for those of 25 mm dia or more, the diameter of holes shall be 2 mm larger than the diameter of the bolt/rivet.

All holes shall be drilled except those for secondary members such as floor plates, hand rails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for material conforming to IS:2062 up to Grade E250 (Fe 410w).

Holes through material of more than one thickness or through main material thickness exceeding 20 mm for steel conforming to IS:2062 up to Grade E250 (Fe 410w) or 16 mm for steel conforming to IS:2062 up to Grade E300 (Fe 440w) and above, shall either be sub-drilled or sub-punched to a diameter of 3 mm less than the required size and then reamed to the required size. The reaming of material more than one thickness shall be done after assembly.

Where several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tacking bolts and the holes shall be drilled through the group in one operation. Alternatively, and in the case of repetition work, the plates and sections may be drilled separately from jigs and templates. Jigs and templates shall be checked at least once after every 25 operations. All burrs shall be removed.

In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted

to ensure strict interchangeability. In such cases, one span in ten or any number less than ten of each type shall be erected from pieces selected at random by the Engineer and should there be any failure of the pieces to fit, all similar spans shall be erected complete. In the event of spans being proved completely interchangeable, all corresponding parts shall carry the same mark so that sorting of the materials at site is facilitated.

### **Block drilling**

Where the number of plates to be riveted exceeds three or the total thickness is 90 mm or more, the rivet holes, unless they have been drilled through steel bushed jigs, shall be drilled out in place 3 mm all round after assembling. In such cases, the work shall be tightly bolted together.

### **Size of Holes**

The diameters of rivet holes in millimetres are given in Table 1900-1.

**Table 1900-1 : diameters of Holes for Rivets**

| <b>nominal dia of Rivets (mm)</b> | <b>dia of Holes (mm)</b> |
|-----------------------------------|--------------------------|
| 12                                | 13.5                     |
| 14                                | 15.5                     |
| 16                                | 17.5                     |
| 18                                | 19.5                     |
| 20                                | 21.5                     |
| 22                                | 23.5                     |
| 24                                | 25.5                     |
| 27                                | 29.0                     |
| 30                                | 32.0                     |
| 33                                | 35.0                     |

### **Close tolerance Bolts and Barrel Bolts**

For close tolerance or turn fitted bolts, the diameter of the holes shall be equal to the nominal diameter of the bolt shank + 0.15 mm to - 0.0 mm.

The members to be connected with close tolerance or turn fitted bolts shall be firmly held together by service bolts or clamped and drilled through all thicknesses in one operation and subsequently reamed to required size within specified limit of accuracy as specified in IS:919 tolerance grade H8.

The holes not drilled through all thicknesses in one operation shall be drilled to smaller size and reamed after assembly.



## Holes for High strength Friction Grip Bolts

All holes shall be drilled after removal of burrs. Where the number of plies in the grip does not exceed three, the diameters of holes shall be 1.5 mm larger than those of bolts. Where the number of plies in the grip exceeds three, the diameters of holes shall be as follows, unless otherwise specified by the Engineer:

- in outer plies                      1.5 mm larger than diameter of bolts
- in inner plies                      not less than 1.5 mm and not more than 3.0 mm  
larger than diameter of bolts

## Removal of Burrs

The work shall be taken apart after drilling and all burrs left by drilling and the sharp edges of all rivet holes completely removed.

## Rivets and Riveting

The riveting shall be done by hydraulic or pneumatic machine unless otherwise specified by Engineer. The driving pressure shall be maintained on the rivets for a short time after the upsetting is completed.

The diameter of rivets shown on the drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimensions as given in IS handbook on Steel Sections, Part-I. The underside of the head shall be free from burrs.

The tolerance on the diameter of rivets shall be in accordance with IS:1148 for mild steel rivets and IS:1149 for high tensile steel rivets. Unless otherwise specified, the tolerance shall be minus.

When countersunk head is required, the head shall fill the countersunk hole and projection after countersinking shall be ground off wherever necessary. The included angle of the head shall be as follows:

- a) For plates over 14 mm thickness                      90 degree
- b) For plates upto and including 14 mm thickness                      120 degree

Mild steel rivets shall be heated uniformly to a light cherry red colour between 650°C to 700°C for hydraulic riveting and orange colour for pneumatic riveting. High tensile steel rivets shall be heated up to 1100°C. The rivets shall be red hot from head to the point when inserted and shall be upset in its entire length so as to fill the hole as completely as possible when hot. After being heated and before being inserted in the hole, the rivet shall be made free from scale by striking it on a hard surface. Any rivet whose point is heated more than the prescribed limit, shall not be driven.

Where flush surface is required, any projecting metal shall be chipped or ground off.

Before riveting is commenced, the parts/members to be riveted shall be firmly drawn together with bolts, clamps or tack welds so that the various sections and plates are in close contact throughout. Every third hole of the joint shall have assembly bolts till riveted. Drifts shall only be used for drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a larger size than the nominal diameter of the hole shall not be used.

Driven rivets, when struck sharply on the head by a quarter pound rivet testing hammer, shall be free from movement and vibrations. Assembled riveted joint surfaces, including those adjacent to the rivet heads, shall be free from, dirt, loose scale, burrs, other foreign materials and defects that would prevent solid seating of parts.

All loose or burnt rivets, rivets with cracked or badly formed defective heads or rivets with heads which are unduly eccentric with the shanks, shall be removed and replaced. In removing rivets, the head shall be sheared off and the rivet punched out so as not to damage the adjacent metal. If necessary, the rivets shall be drilled out. Re-cupping or re-caulking shall not be permitted. The parts not completely riveted in the shop shall be secured by bolts to prevent damage during transport and handling.

## **Bolts, nuts and Washers**

### **Black Bolts (Black all over)**

Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions as shown on the drawings.

### **Close tolerance Bolts**

Close tolerance bolts shall be faced under the head and turned on the shank.

### **Turned Barrel Bolts**

The diameter of the screwed portion of turned barrel bolts shall be 1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Engineer. The diameter of the bolts as given on the drawing shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

## **High strength Friction Bolts and Bolted Connections**

The general requirement shall be as per relevant IS Specifications mentioned in **Clause 1903.2.2**. Unless otherwise specified by the Engineer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS:4000.

### **Washers**

In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a steel washer under the nut of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up, from bearing on the bolt.

For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole diameter not less than 1.5 mm larger than the barrel and thickness not less than 6 mm so that the nut, when screwed up, will not bear on the shoulder of the bolt.

Taper washer, with correct angle of taper, shall be provided under all heads and nuts bearing on bevelled surfaces.

Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.

Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of bolts or round washers having a diameter of  $3\frac{1}{2}$  times the diameter of bolts and with a thickness not less than one quarter of diameter, shall be provided.

### **Studs**

Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread of the stud. Countersunk studs may be used for making connections where the surfaces are required to be clear of all obstruction, such as protruding heads of bolts or rivets. Studs may also be welded on the steel work in the positions required.

### **Service Bolts**

Service bolts shall have the same clearance as black bolts and where it is required that there should be no movement prior to final riveting, sufficient drifts or close tolerance bolts shall be used to locate the work.

### **Tightening Bolts**

Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of codal requirements.

All joint surfaces for bolted connection including bolts, nuts and washers shall be free of scale, dirt, burrs, other foreign material and other defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nuts shall not exceed 1:20 plane normal to bolt axis; otherwise suitable tapered washer shall be used.

All fasteners shall have a washer under nut or bolt head, whichever is turned in tightening.

Each fastener of joint shall be tightened to specified value or to 70 percent of specified minimum tensile strength by hand wrenches (turn of nut method) or calibrated wrenches, manual torque wrenches, impact wrench or any other method specified by the Engineer.

When 'turn of nut' method is used for tightening the bolts in a joint, all bolts shall be first brought to snug-tight condition i.e. tightening by full manual effort using ordinary wrench or by a few impacts of any impact wrench. All bolts in the joint shall then be tightened additionally by applicable amount of nut rotation as specified in IS:4000.

The Engineer shall observe the installation and tightening of bolts to ensure that correct tightening procedure is used and all bolts are tightened. Regardless of tightening method used, tightening of bolts in a joint should commence at the most rigidly fixed or stiffest point and progress towards the free edges, both in initial snugging and in final tightening.

The tightness of bolts in connection shall be checked by inspection wrench, which can be torque wrench, power wrench or calibrated wrench.

Tightness of 10 percent bolts, but not less than two bolts, selected at random in each connection shall be checked by applying inspection torque. If no nut or bolt head is turned by this application, connection can be accepted as properly tightened, but If any nut or head has turned, all bolts shall be checked and, if necessary, re-tightened.

### **Drifts**

The barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass. The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of +0 mm and - 0.125 mm. Both ends of the drift for a length equal to 1½ times the diameter of the parallel portion of the bar, shall be turned down with a taper to a diameter at the end equal to one-half that of parallel portion.

### **Pins and Pin Holes**

#### **Pins**

The pins shall be parallel throughout and shall have a smooth surface free from flaws. They

shall be of sufficient length to ensure that all parts that they connect, shall have a full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place. To facilitate insertion and extraction, pins may be chamfered beyond the required length and provided with suitable holes in the chamfered portion. Pins more than 175 mm in length or diameter shall be forged and annealed.

### **Pin Holes**

Pin holes shall be bored smooth, straight and true to gauge at right angles to the axis of the member and parallel with each other, unless otherwise required. The tolerance in the length of tension members from outside to outside of pin holes and of compression members from inside to inside of pin holes shall be 1 mm. In built-up members, the boring shall be done only after the members have been finally riveted, welded or bolted unless otherwise approved by Engineer. The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1 mm.

### **Shop erection and Match Marking**

Before being dispatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Engineer either wholly or in such portion as the Engineer may require, so that he may be satisfied in respect of both the alignment and fit of all connections. For this purpose, sufficient number of parallel drifts and service bolts tightly screwed up, shall be employed. All parts shall fit accurately and be in accordance with drawings and specifications. The steel work shall be temporarily assembled at place of fabrication. Assembly shall be of full truss or girder, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly, is specified by the Engineer.

The camber diagram showing camber at each panel point, method of shop assembly and any other relevant detail, shall be submitted to Engineer for approval.

The field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame shall be assembled, aligned and accuracy of holes and camber checked by the Engineer. Only thereafter shall reaming of sub-sized holes to specified size, be taken up.

The assembly shall be dismantled only after final drilling of holes has been completed and the work has been passed by the Engineer. Before dismantling, each part shall be carefully marked for re-erection with distinguishing marks and stamped with durable markings. Drawings showing these markings correctly shall be supplied to the Engineer.

Unloading, handling and storage of steel work as per these Specifications shall be the responsibility of the Contractor. The cost of repairs, removal of rejected material, and transportation of replacement material to the site, shall be borne by the Contractor.

In cases where close tolerance or turned barrel bolts are used and interchangeability is not insisted upon, each span shall be erected and its members marked distinctly.

## **Welding**

All welding shall be done with the prior approval of the Engineer and the workmanship shall conform to the specifications of the relevant Indian Standards as appropriate.

When material thickness is 20 mm or more, special precautions like pre-heating shall be taken as laid down in IS:9595. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.

The general welding procedures including particulars of the preparation of fusion faces for metal arc welding, shall be carried out in accordance with IS:9595.

The welding procedures for shop and site welds including edge preparation of fusion faces shall be as per details shown on the drawings and shall be submitted in writing for the approval of the Engineer, in accordance with Clause 22 of IS:9595, before commencing fabrication.

Any deviation from this procedure has to be approved by the Engineer. Preparation of edges shall, wherever practicable, be done by machine methods.

Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planing and shall be left free of slag. Manual flame cutting shall be permitted by the Engineer only where machine cutting is not practicable.

Electrodes to be used for metal arc welding shall comply with relevant Indian Standards mentioned in Clause 1903.2.3. Procedure test shall be carried out as per IS:3613 to find out suitable wire-flux combination for welded joint.

Assembly of parts for welding shall be in accordance with provisions of Clauses 14 to 16 of IS:9595.

Welded temporary attachment should be avoided as far as possible. If unavoidable, the method of making any temporary attachment shall be as approved by the Engineer. Any scars from temporary attachment shall be removed by cutting and chipping and surface shall be finished smooth by grinding to the satisfaction of the Engineer.

Welding shall not be carried out when the air temperature is less than 10°C, when the surfaces are wet, during periods of strong winds and in snowy weather, unless the work and the welding operators are adequately protected.

For welding of any particular type of joint, welders shall undergo the appropriate welders qualification test as prescribed in any of the relevant Indian Standards IS:817, IS:1966, IS:1393, IS:7307 (Part I), IS:7310 (Part I) and IS:7318 (Part I) to the satisfaction of the Engineer.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimize shrinkage stress.

All requirements regarding pre-heating of parent material and interpass temperature shall be in accordance with provisions of IS:9595.

Peening of weld shall be carried out wherever specified by the Engineer :

- a) If specified, peening may be employed to be effective on each weld layer except the first filling layer.

After weld has cooled, the peening should be carried out by light blows from a power hammer using a round nosed tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.

Where the Engineer has specified that the butt welds are to be ground flush, the loss of parent metal shall not be greater than that allowed for minor surface defects. The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by use of extension pieces, cross runs or other means approved by the Engineer. Extension pieces shall be removed after the joint has cooled and the ends of the weld shall be finished smooth and flush with the faces of the abutting parts.

The following joints and welds which do not perform well under cyclic loading, are prohibited.

- a) Butt joints not fully welded throughout their cross-section
- b) Groove welds made from one side only without any backing grip
- c) Intermittent groove welds
- d) Intermittent fillet welds
- e) Bevel-grooves and J-grooves in butt joints for other than horizontal position
- f) Plug and slot welds

The run-on and run-off plate extension shall be used for providing full throat thickness at the end of butt welded joints. These plates shall comply with the following requirements.

- i) One pair of run-on and one pair of run-off plates prepared from same

thickness and profile as the parent metal shall be attached to start and finish of all butt welds, preferably by clamps.

- ii) When run-on and run-off plates are removed by flame cutting, they shall be cut at more than 3 mm away from the parent metal and the remaining metal of the plate shall be removed by grinding or by any other method approved by the Engineer.

### **Welding of stud shear Connectors**

The stud shear connectors shall be welded in accordance with the manufacturer's instructions including those relating to pre-heating.

The stud and the surface to which it is to be welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding.

The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs.

The procedural trial for welding the stud shall be carried out when specified by the Engineer.

### **Tolerances**

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 1900-2.

A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5 m.

**Table 1900-2 : Fabrication tolerances - individual Components**

|    |               |  |                  |
|----|---------------|--|------------------|
| 1) | <b>length</b> |  |                  |
|    | a)            | Member with both ends finished for contact bearing         | $\pm 1$ mm       |
|    | b)            | Individual components of members with end plate connection | + 0 mm<br>- 2 mm |
|    | c)            | Other members of length                                    |                  |
|    |               | i) Upto and including 12 M                                 | $\pm 2$ mm       |
|    |               | ii) Over 12 M  | $\pm 3.5$ mm     |
| 2) | Width         |  |                  |
|    | a)            | Width of built-up girders                                  | $\pm 3$ mm       |



|     |  |   |  |
|-----|--|---|--|
|     | b)   | Deviation in the width of members required to be inserted in other members                  | + 0 mm<br>- 3 mm   |
| 3)  | Depth  |   |  |
|     | Deviation in the depths of solid web and open web girders  |   | + 3 mm<br>- 2 mm   |
| 4)  | Straightness   |   |  |
|     | a)   | Deviation from straightness of columns  | L/3000 subject to maximum of 15 mm<br>where L is length of member                                      |
|     |  | i) in elevation   | + 5 mm<br>- 0 mm   |
|     |  | ii) In plan   | L/1000 subject to a maximum of 10 mm   |
| 5)  | Deviation of centre line of web from centre line of flanges in built-up members at contact surface   |   | 3 mm   |
| 6)  | Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the members   |   | 0.005 d to a maximum of 2 mm where d is depth of the member  |
| 7)  | Tilt of flange of plate girders  |   |  |
|     | a)   | At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings | 0.005 b to a minimum of 2 mm where b is width of the member  |
|     | b)   | at other places   | 0.015 b to a maximum of 4 mm where b is width of the member  |
| 8)  | Deviation from squareness of flange to web of columns and box girders  |   | L/1000, where L is nominal length of the diagonal  |
| 9)  | Deviation from squareness of fixed base plate (not machined) to axis of columns. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate |   | D/500, where D is the distance from the column axis to the point under consideration on the base plate |
| 10) | Deviation from squareness of machined ends to axes of columns  |   | D/1000, where D is as defined in 9 above   |
| 11) | Deviation from squareness of machined ends to axes of beams  |   | D/1000, where D is as defined in 9 above   |
| 12) | Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends   |   | 1/600 of depth of member subject to a maximum of   |

### Annealing and stress Relieving

The members to be annealed or stress relieved as indicated in the contract or specified

by Engineer, shall have finish machining, boring, etc., done subsequent to heat treatment. The stress relief treatment shall conform to the following unless otherwise specified by Engineer:

- a) The temperature of the furnace shall not be more than 300°C at the time welded assembly is placed in it.
- b) The rate of heating shall not be more than 220°C per hour divided by maximum metal thickness, subject to maximum of 220°C per hour.
- c) After maximum temperature of 600°C is reached, the assembly shall be held within specified limit of time based on weld thickness. The temperature shall be maintained uniformly throughout the furnace during holding period such that temperature at no two points on the member will differ by more than 80°C.
- d) The cooling shall be done in closed furnace when temperature is 300°C, at the maximum rate of 260°C per hour divided by maximum metal thickness. The local stress relieving shall be carried out if specified and procedure approved by Engineer.

#### **1904.13 Rectification of Surface Defects**

The surface defects revealed during fabrication or cleaning shall be repaired as specified. The repair by welding on any surface defect or exposed edge lamination shall be carried out only with approval of Engineer.

#### **1904.14 Alignment at splice and Butt Joints**

Bolted splice shall be provided with steel packing plates where necessary, to ensure that the sum of any unintended steps between adjacent surfaces does not exceed 1 mm for HSFG bolted joints and 2 mm for other joints.

In welded butt joints, misalignment of parts to be joined shall not exceed the lesser of 0.15 times the thickness of thinner part or 3 mm. However, if due either to different thicknesses arising from rolling tolerances or a combination of rolling tolerances with above permitted misalignment, this deviation is more than 3 mm, it shall be smoothened by a slope not steeper than 1:4.

### **1905 Erection**

#### **General**

These provisions shall apply to erection of steel bridge superstructures or steel main members of

bridge superstructures, which span between supports.

If the substructure and the superstructure are built under separate contracts, the Employer will provide the substructure, constructed to correct lines, dimensions and elevations properly finished and will establish the lines and the elevation required for erection purposes.

The Contractor shall erect the structural steel, remove the temporary construction and do all work required to complete the construction included in the contract, in accordance with the drawings and the specifications and to the entire satisfaction of the Engineer.

### **Organisation and equipment**

The Contractor shall submit erection plans prepared by the fabricator showing the method and procedure of erection, compatible with the details of fabrication.

A detailed scheme shall be prepared showing stage-wise activities, with complete drawings and working instructions. This should be based on detailed stage-wise calculations taking into account specifications and capacity of erection equipment machinery, tools and tackles to be used and temporary working loads as per codal provisions.

The scheme shall also take into account site conditions such as hydrology, rainfall, flood timings and intensity, soil and subsoil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space.

The scheme shall indicate details of materials required with specifications, quantities, type of storage, etc. It shall also indicate precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection. The working drawings should indicate clearly the temporary jigs, fixtures, clamps, spacer supports, etc.

All components of the bridge shall be got checked for their adequacy to take care of temporary forces to which they are subjected during erection so as to ensure safety of the structure at all stages of erection.

Unless otherwise provided in the contract, the Contractor shall supply and erect all necessary falsework and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects.

The Contractor shall supply all rivets, bolts, nuts, washers, etc. required to complete erection at site with an allowance for wastage of 12½ percent of the net number of field rivets, bolts, washers required, or a minimum of five numbers of each item.

Service bolts and nuts, washers and drifts for use in erection shall be supplied at 60 percent (45 percent bolts and 15 percent drifts) of the number of field rivets per span in each size (this includes wastage). A reduction in the numbers of service bolts, etc., may however, be

specified by the Engineer if more than one span of each type is ordered.

Prior to actual commencement of erection, all equipment, machinery, tools, tackles, ropes, etc. need to be tested to ensure their efficient working. Frequent visual inspection of vulnerable areas is essential to detect displacements, distress, damages, etc.

Deflection and vibratory tests shall be conducted on supporting structures, launching truss and also the structure under erection. Any unusual deviation or looseness of fittings, is to be noted and reviewed.

For welded structures, welders' qualifications and skills are to be checked as per standard norms. Non-destructive tests of joints are to be carried out as per designer's directives.

Precision non-destructive testing instruments should be used for frequent checking of various important parameters of the structures and systematic records should be maintained.

Safety requirements shall conform to IS:7205, IS:7273 and IS:7269 as applicable and all aspects of safety commensurate with economy and speed of construction, shall be considered. Erection work should start with complete resources mobilized as per latest approved drawings and after a thorough survey of foundations and other related structural work. For works of large magnitude, mechanization is to be adopted to the maximum extent possible.

The structure should be divided into erectable modules as per the scheme. The module should be pre-assembled in a suitable yard / platform and its matching with members of the adjacent module checked by trial assembly before erection.

The structure shall be set out to the required lines and levels. The steelwork should be erected, adjusted and completed in the required position to the specified lines and levels with sufficient drifts and bolts. Packing materials shall be available to maintain this condition. Quality surveillance checks need to be carried out frequently.

Before starting work, the Contractor shall obtain necessary approval of the Engineer for the methodology/procedure of erection, drawings of temporary works, use of erection equipments and the number and character of tools and plant. The approval of the Engineer shall not relieve the Contractor of his responsibility for the safety of his methodology and equipment or from carrying out the work fully in accordance with the drawings and specifications.

During execution, the Contractor shall have a competent engineer or foreman in charge of the work, who has adequate experience in steel erection and is acceptable to the Engineer.

### **Handling and storing of Materials**

Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during the working period and the storage area should be on firm levelled ground.

The store should be provided with adequate handling equipment viz. mobile crane, gantries, derricks, chain pulley blocks, winch etc., of capacity as required. Stacking area should be planned and have racks, stands sleepers, access tracks etc. and proper lighting.

Storage should be planned to suit erection work sequence and avoid damage or distortion of material. Excessively rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not, shall be subject to the approval of the Engineer.

Fabricated materials are to be stored with erection marks visible. They should not come into contact with earth surface or water and should be accessible to handling equipment.

All materials, consumables, including raw steel or fabricated material shall be stored specification-wise and size-wise above the ground upon platforms, skids or other supports. They shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion. Electrodes shall be stored specification-wise and shall be kept in dry warm condition in properly designed racks. The bolts, nuts, washers and other fasteners shall be stored in gunny bags on racks above the ground with protective oil coating. Paint shall be stored under cover in air-tight containers. Small hand tools shall be kept in containers in covered stores.

IS:7293 and IS:7969 dealing with handling of materials and equipment for safe working should be followed. Safety nuts and bolts as directed are to be used while working. The Contractor shall be held responsible for loss or damage to any material paid for by the Employer while in his care or for any damage to such material resulting from his work.

### **Formwork**

The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor of his responsibility for adequacy and effective performance of the formwork.

### **Assembling steel**

The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tendon chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings, shall not be driven until the span has been swung.

All joint surface for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, in a plane normal to bolt axis; in case it does, suitable tapered washer shall be used.

All fasteners shall have a washer under nut or bolt head, whichever is turned in tightening.

Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 percent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

Field riveting, welding, bolting and pin connections shall conform to the requirements of Clause 1904 as appropriate.

The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer. In such cases, the method of correction shall be approved by the Engineer and carried out in his presence.

## **Field inspection**

### **General**

All materials equipment and work of erection shall be subject to the inspection of the Engineer who shall be provided with all facilities required for this purpose, including labour and tools, at all reasonable times. Any work found defective is liable to be rejected.

No protective treatment shall be applied to the work until the appropriate inspection and testing have been carried out. The stage inspection shall be carried out for all operations so

as to ensure correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

## **Testing of Material**

Structural steel shall be tested for mechanical and chemical properties as per appropriate Indian Standards as may be applicable and shall conform to requirements specified in IS:226, IS:2062, IS:11587, IS:1977, IS:8500 and IS:961.

Rivets, bolts, nuts, washers, welding consumables, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in accordance with the appropriate Indian Standards.

Rolling and cutting tolerance shall be as per IS:1852. The thickness tolerance check measurements for plates and rolled sections shall be taken at not less than 15 mm from edge.

Check for laminations in plates shall be carried out for areas specified in Clause 1904.2, by ultrasonic testing or any other specified method. Flame cut edges without visual signs of laminations need not be tested for compliance with Clause 1904.2, unless otherwise specified by Engineer.

Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for his decision.

Chipping, grinding, machining or ultrasonic testing shall be used to determine depth of imperfection.

## **Testing of Connections**

### **Bolted Connections**

Bolts and bolted connection joints with high strength friction grip bolts, shall be inspected and tested according to IS:4000.

Bolted connection joints with black bolts and high strength bolts shall be inspected and tested for compliance or requirements mentioned in Clause 1904.7.8.

### **Riveted Connections**

Rivets and riveted connection shall be inspected as per **Clause 1904.6** and tested for compliance of codal requirements.

The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted.

Driven rivets shall be checked with rivet testing hammer. When struck sharply on the head with the hammer, the rivet shall be free from movement and vibration. All loose rivets and rivets with cracks, badly formed or deficient heads or with heads which are eccentric with shanks, shall be cut out and replaced.

The alignment of plates at all bolted splice joints and welded butt joints shall be checked for compliance with codal requirements.

Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

### **Welded Connections**

Welding procedure, welded connections and testing shall be in compliance with codal requirements.

Welders qualification test shall be carried out as per requirements laid down in IS:7318 (Part 1). For approved welding procedures, the approval tests shall be as per requirements of IS:7310 (Part 1).

All facilities necessary for stage inspection during welding and on completion shall be provided to the Engineer or his inspecting authority by fabricator.

Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom its welding was carried out.

All metal arc welding shall be in compliance with IS:9595 provisions.

The method of inspection shall be in accordance with IS:822 and extent of inspection and testing shall be in accordance with the relevant standards or as agreed with the Engineer.

### **Procedure tests for Welds**

The destructive and non-destructive test of weld shall be carried out according to IS:7307 (Part I).

### **Non-destructive testing of Welds**

One or more of the following methods may be applied for inspection or testing of weld :



- i) **Visual inspection** : All welds shall be visually inspected, to cover all defects of weld such as size, porosity, crack in the weld or in the HAZ (Heat Affected Zone) etc. Suitable magnifying glass may be used for visual inspection. A weld shall be acceptable by visual inspection if it is seen that :
- a) The weld has no cracks.
  - b) Thorough fusion exists between weld and base metal and between adjacent layers of weld metal.
  - c) Weld profiles are in accordance with relevant Clauses of IS:9595 or as agreed with the Engineer.
  - d) The weld is of full cross section, except for the ends of intermittent fillet welds outside their effective length.
  - e) When weld is transverse to the primary stress, undercut shall not be more than 0.25 mm deep in the part that is undercut. When the weld is parallel to the primary stress, undercut shall not be more than 0.8 mm deep in the part that is undercut.
  - f) The fillet weld in any single continuous weld shall be permitted to under run the nominal fillet weld size specified by 1.6 mm without correction, provided that the undersized portion of the weld does not exceed 10 percent of the length of the weld. On the web-to- flange welds of girders, no under-run is permitted at the ends for a length equal to twice the width of the flange.
  - g) The piping porosity in fillet welds shall not exceed one in each 100 mm of weld length and the maximum diameter shall not exceed 2.4 mm, except for fillet welds connecting stiffeners to web, where the sum of diameters of piping porosity shall not exceed 9.5 mm in any 25 mm length of weld and shall not exceed 19 mm in any 300 mm length of weld.
  - h) The full penetration groove weld in butt joints transverse to the direction of computed tensile stress, shall have no piping porosity. For all other groove welds, the piping porosity shall not exceed one in 100 mm of length and the maximum diameter shall not exceed 2.4 mm.
- ii) **Magnetic Particle and Radiographic inspection** : Welds that are subject to radiographic or magnetic particle testing in addition to visual inspection, shall have no crack.

Magnetic particle test shall be carried out according to IS:5334 for detection of crack and other discontinuity in the weld.

Radiographic test shall be carried out for detection of internal flaws in the weld such as crack, piping porosity inclusion, lack of fusion, incomplete penetration, etc. This test may be carried out as per IS:1182 and IS:4853.

- iii) **ultrasonic inspection** : Ultrasonic testing, in addition to visual inspection, shall be carried out for detection of internal flaws in the weld such as cracks, piping porosity inclusion, lack of fusion, incomplete penetration, etc. Acceptance criteria shall be as per IS:4260 or any other relevant IS Specification and as agreed to by the Engineer.

Bearing stiffeners or bearing diaphragms adjacent to welds, flange plates adjacent to web/flange welds, plates at cruciform welds, plates in box girder construction adjacent to corner welds or other details where specified by the Engineer, shall be ultrasonically tested after fabrication.

- iv) **liquid Penetration inspection** : The liquid penetrant test in addition to visual inspection, shall be carried out for detection of surface defect in the weld, as per IS:3658.
- v) Non-destructive testing of the following welds shall be carried out using any of the methods described at (ii), (iii) and (iv) above, as may be agreed to by the Engineer.
  - a) All transverse butt welds in tension flanges
  - b) 10 percent of the length of longitudinal and transverse butt welds in tension flanges.
  - c) 5 percent of the length of longitudinal and transverse butt welds in compression flanges.
  - d) All transverse butt welds in webs adjacent to tension flanges as specified by the Engineer.

The particular length of welds in webs to be tested shall be agreed with the Engineer, in case (b) or (c).

Any lamination, lamellar tearing or other defect found shall be recorded and reported to the Engineer for his decision.

### **Testing of Welds for Cast steel**

The testing of weld for cast steel shall be carried out as agreed to and directed by the Engineer.

### **Stud shear Connectors**

Stud shear connectors shall be subjected to the following tests:

- a) The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Engineer.
- b) The selected stud head shall not show displacement of more than 0.25 times the height of the stud, from its original position, if struck once with a 6 kg hammer. The stud weld shall not show any sign of a crack or lack of fusion.

The studs whose welds have failed the tests given in (a) and (b) shall be replaced.

## **Inspection of Members**

### **Inspection Requirement**

The fabricated member/component made out of rolled and built-up section shall be checked for compliance of the tolerances given in Table 1900-2. Inspection of member/components for compliance with tolerances, and the check for deviations shall be made over the full length.

During checking, the inspection requirement shall be indicated in such a manner that local surface irregularities do not influence the results.

For plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of plate.

The cross girder or cross frame deviation shall be checked over the middle third of its length between each pair of webs and at the end of member for cantilever.

The web of rolled beam or channel section shall be checked for out-of-plane deviation in a longitudinal direction over a length equal to the depth of the section.

During inspection, the component/member shall not have any load or external restraint.

### **Inspection stages**

The stages of inspection to be carried out for compliance of tolerances shall include, but not be limited to, the following :

- a) For completed parts, component/members - on completion of fabrication and before any subsequent operation such as surface preparation, painting, transportation, erection.
- b) For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints - on completion of site joint.

- c) For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased - on completion of site assembly.

Where, on checking member/component for out-of-plane or out-of-straightness at right angles to the plate surface, and any other instances, the deviation exceeds the tolerance, the maximum deviation shall be measured and recorded. The record shall be submitted to the Engineer who will determine whether the component/member may be accepted without rectification, accepted with rectification or rejected.

## **1906                      Painting**

### **General**

Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include preparation of metal surfaces, application of protective covering and drying of the paint coatings along with all tools, scaffolding, labour and materials necessary.

Coatings shall be applied only to dry surfaces and the coated surfaces shall not be exposed to rain or frost before they are dry. The coatings shall be applied to all surfaces excluding shear connectors and inner surfaces of fully sealed hollow sections. While coating adjacent surfaces, care shall be taken to ensure that primer is not applied on the shear connectors.

### **types of Paints**

- i) Ordinary Paints

These include paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy, etc.

Ordinary painting can generally be sub-divided into two types:

- a) Primary Coats :

This shall be applied immediately after the surface preparation and should have the properties of adhesion, corrosion inhibition and imperviousness to water and air.

- b) Finishing Coats :

This shall be applied over the primary coat and should have the properties of durability, abrasion resistance, aesthetic appearance and smooth finish.

- ii) Chemical Resistant Paints

The more highly corrosion resistant paints can be divided into two main groups :

- a) One pack paints (ready for use)

- b) Two pack paints (mixed before use)

The two pack paints shall be mixed together just before use since

they remain workable thereafter only for a restricted period of time.

- iii) Other types of paints as mentioned in Clause 1903.4 of this Section may also be used, subject to approval by the Engineer.

All paints shall conform to relevant IS Standards as appropriate.

Surfaces which are inaccessible for cleaning and painting after fabrication shall be painted as specified before being assembled for riveting.

All rivets, bolts, nuts, washers etc., are to be thoroughly cleaned and dipped into boiling linseed oil conforming to IS:77.

All machined surfaces are to be well coated with a mixture of white lead conforming to IS:34 and mutton tallow conforming to IS:887.

In site painting, the whole of the steel work shall be given the second cover coat after final passing and after touching up the primer and cover coats, if damaged in transit.

### **Quality of Paint**

Only paints which have been tested for the following qualities as per the specifications given in the relevant IS codes, should be used :

- Weight test (weight per 10 litre of paint thoroughly mixed)
- Drying time
- Flexibility and adhesion
- Consistency
- Dry thickness and rate of consumption

Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS:1477 (Part I).

### **Surface Preparation**

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer :

- a) Dry or wet grit/sand blasting
- b) Pickling which should be restricted to single plates, bars and sections
- c) Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

## **Coatings**

Prime coat to be used shall conform to the specification of primers approved by the Engineer. Metal coatings shall be considered as prime coats. Primer shall be applied to the blast cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

All coats shall be compatible with each other. When metal based coatings are used, the undercoat shall be compatible with the concerned metal base. The undercoat and finishing coat shall preferably be from the same manufacturer. Successive coats of paints shall be of different shades or colours and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. Typical guidelines for epoxy based paints and the conventional painting system for bridge girders as given below, may be complied with :

### **a) epoxy Based Painting**

- i) Surface preparation : Remove oil/grease by use of petroleum hydrocarbon solution (IS:1745) and grit blasting to near white metal surface.
- ii) Paint system : 2 coats of epoxy zinc phosphate primer = 60 micron:  
Total 5 coats = 200 micron

### **Conventional Painting system for areas where corrosion is not severe**

#### **Priming Coat :**

One coat of ready mixed, red lead primer conforming to IS:102

or

One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074

or

Two coats of red oxide zinc chrome primer conforming to IS:2074.

#### **Finishing Coats :**

Two cover coats of red oxide paint conforming to IS:123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats, if damaged in transit.

### **c) Conventional Painting system for areas where corrosion is severe**

#### **Priming Coat :**

Two coats of ready mixed red lead primer conforming to IS:102

or

One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of ready mixed zinc chrome primer conforming to IS:2074.

**Finishing Coats :**

Two coats of aluminium paint conforming to IS:2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats, if damaged in transit.

**Painting in the shop**

All fabricated steel shall be painted in the shop after inspection and acceptance with at least one priming coat, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

Field contact surfaces and surfaces to be in contact with cement, shall be painted with primer only. No paint shall be applied within 50 mm of design location of field welds. Paint shall be completely dry before loading and transporting of the fabricated steel work to site.

Surfaces not in contact but inaccessible after shop assembly shall receive the full specified protective treatment before assembly.

Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded, if the specified paint or metal coating would be harmful to welders or is likely to impair the quality of site welds.

Exposed machined surfaces shall be adequately protected.

**Painting at site**

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

Specified protective treatment shall be completed after erection.

## Methods of application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and shall be as approved by the Engineer. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas inaccessible for painting and areas shaded for spray application, shall be coated first by brushing.

Oil based red lead primers must be applied by brush only, taking care to work into all corners and crevices.

The primer, intermediate and fcoats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes shall not be accepted. Where the Engineer so directs, the coating shall be removed by abrasive blast cleaning and replaced by the Contractor at his own cost.

## Protective Coatings in different environments

Since the severity of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

Table 1900-3 gives guidelines for various types of coatings to be used in various environmental conditions. Approximate life to first maintenance is also indicated.

## 1907 Tests And Standards Of Acceptance

The materials shall be tested in accordance with relevant IS Specifications and necessary test certificates shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost.

The fabrication, furnishing, erection and painting of structural steel work shall be in accordance with these Specifications and shall be checked and accepted by the Engineer.

**Table 1900-3 : Guidelines for selection of types of Protective Coatings**

|     | Type of Coating   | Exposure Condition          |
|-----|---|-----------------------------|
| i)  | Wire brush to remove all loose rust and scale; 2 coats drying oil type primer, and 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry thickness = 150 $\mu$ m  | Moderate                    |
| ii) | Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 $\mu$ m (life up to 5 years) | Polluted inland environment |



|       |  |  |
|-------|--|--|
| iii)  | Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness   | Moderate   |
| iv)   | Blast clean the surface; 2 coats of drying type oil primer; 1 under coat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness : 165–190 µm   | Polluted inland environments                       |
| v)    | Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber primer, 1 under coat of high build chlorinated rubber; 1 finishing coat of chlorinated rubber. | Severe coastal and non-coastal interior situations |
| vi)   | Blast clean the surface; 350 – 450 µm thickness coal tar epoxy.  | Severe   |
| vii)  | Pickle; hot dip galvanised (Zinc).<br>Total thickness : 85 µm (life up to 15-20 years)   | Moderate   |
| viii) | Grit blast, hot dip galvanised. (Zinc).<br>Total thickness = 140 µm (life more than 20 years)  | Moderate   |
| ix)   | Grit blast; 1 coat of sprayed zinc/aluminum followed by suitable sealer Total thickness = 150 µm (life up to 15-20 years)  | Severe   |

## 1908 Measurements For Payment

The measurements of this item shall be in Kg, tonnes or **quintal** based on the net weight of metal in the fabricated structure, computed on the basis of nominal weight of materials.

The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis :

- Rolled or cast steel :  $7.84 \times 10^{-3}$  kg/cu.cm.
- Cast Iron :  $7.21 \times 10^{-3}$  kg/cu.cm.

Weight of structural sections shall be nominal weight.

Weight of castings shall be computed from the dimensions shown on the drawings with an addition of 5 percent for fillets and over-runs.

Weight of rivet heads shall be computed by taking the weight of 100 snap heads as given in Table 1900-4.

When specially agreed upon, allowance for snap heads may be taken as a flat 2.5 percent of the total weight.

**Table 1900-4 : Weight of Rivet Heads**

| dia of Rivet as Manufactured-mm | Weight of 100 snap Heads - kg |
|---------------------------------|-------------------------------|
|---------------------------------|-------------------------------|

|    |      |
|----|------|
| 12 | 1.3  |
| 14 | 2.1  |
| 16 | 3.4  |
| 18 | 4.45 |
| 20 | 6.1  |
| 22 | 8.1  |
| 24 | 10.5 |
| 27 | 15.0 |
| 30 | 20.5 |

The Contractor shall supply detailed calculation sheets for the weight of the metal in the fabricated structure.

No additions shall be made for the weight of protective coatings, weld fillets, bolts, nuts and washers.

Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure, deductions being made for all cuts, except for rivet holes. Additions shall be made for the rivet heads as mentioned above.

When specially agreed upon, the basis for payment may be the bridge weight complete, according to specifications included in special provisions of the contract.

### **1909 Rate**

The contract unit rate for the completed structural steel work shall include the cost of all materials, labour, tools, plant and equipment required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the drawings or as directed by the Engineer and as specified in these Specifications.

**Item No. 41**

Providing And lying 40mm thick bituminous concrete on existing bituminous surface and using specification graded machine crushed with 5.50 % bitumen VG-40 grade by Wt. of total mix as per specification MORT&H including mixing of asphalt with B.T. chips in continuous batch mix plant transporting same as by paver finisher and consolidation the same with pair of 8 tonnes to 10 tonnes vibratory roller to achieve desired density and including VG-40 grade bitumen, cost of emulsion, cost of required tools, plants, all machineries, equipment fire wood, oil, kerosene, charges etc complete,

MORTH V<sup>th</sup> REVISION: Cl. No. 507, Pg. no.188.

**507 Bituminous Concrete****507.1 Scope**

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

**507.2 MATERIALS****507.2.1 BITUMEN**

The bitumen shall conform to Clause 504.2.1.

**507.2.2 COARSE AGGREGATES**

The coarse aggregates shall be generally as specified in Clause 504.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-16 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

**TABLE 500-16 : PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR BITUMINOUS CONCRETE**

| property           | test   | Specification                    | Method of test   |
|--------------------|--|----------------------------------|------------------|
| Cleanliness (dust) | Grain size analysis  | Max 5% passing<br>0.075 mm sieve | IS:2386 Part I   |
| Particle shape     | Combined Flakiness and<br>Elongation Indices                 | Max 35%                          | IS:2386 Part I   |
| Strength           | Los Angeles Abrasion Value or<br>Aggregate Impact Value      | Max 30%<br>Max 24%               | IS:2386 Part IV  |
| Durability         | Soundness either:Sodium<br>Sulphate or<br>Magnesium Sulphate | Max 12%<br><br>Max 18%           | IS:2386 Part V   |
| Polishing          | Polished Stone Value   | Min 55                           | BS:812-114       |
| Water Absorption   | Water Absorption   | Max 2%                           | IS:2386 Part III |
| Stripping          | Coating and Stripping of<br>Bitumen Aggregate Mix            | Minimum<br>retained              | IS:6241          |

|                   |                            |         |            |
|-------------------|----------------------------|---------|------------|
| Water Sensitivity | Retained Tensile Strength* | Min 80% | AASHTO 283 |
|-------------------|----------------------------|---------|------------|

\* If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.

### 507.2.3 FINE AGGREGATES

The fine aggregates shall be all as specified in Clause 505.2.3.

### 507.2.4 FILLER

Filler shall be as specified in Clause 505.2.4.

### 507.2.5 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 filler shall fall within the limits shown in Table 500-17. The grading shall be as specified in the Contract.

**Table 500-17 : composition of Bituminous concrete pavement layers**

| grading                                | 1   | 2         |
|--|---|-----------|
| nominal aggregate size*                | 19 mm   | 13.2 mm   |
| layer thickness                        | 50 mm   | 30-40 mm  |
| is sieve <sup>1</sup> (mm)             | cumulative % by weight of total aggregate passing |           |
| 45                                     |   |           |
| 37.5                                   |   |           |
| 26.5                                   | 100   |           |
| 19                                     | 90-100  | 100       |
| 13.2                                   | 59-79   | 90-100    |
| 9.5                                    | 52-72   | 70-88     |
| 4.75                                   | 35-55   | 53-71     |
| 2.36                                   | 28-44   | 42-58     |
| 1.18                                   | 20-34   | 34-48     |
| 0.6                                    | 15-27   | 26-38     |
| 0.3                                    | 10-20   | 18-28     |
| 0.15                                   | 5-13  | 12-20     |
| 0.075                                  | 2-8   | 4-10      |
| Bitumen content % by mass of total mix | Min 5.2*  | Min 5.4** |

#### Notes :

\* The nominal maximum particle size is the largest specified sieve size up on which any of

the aggregate is retained.

\*\* Corresponds to specific gravity of aggregate being 2.7. In case aggregate have

specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is – 10°C or lower, the bitumen content may be increased by 0.5 percent

### **507.3 MIX DESIGN**

#### **507.3.1 REQUIREMENTS FOR THE MIX**

Clause 505.3.1 shall apply.

#### **507.3.2 BINDER CONTENT**

Clause 505.3.2 shall apply.

#### **507.3.3 JOB MIX FORMULA**

Clause 505.3.3 shall apply.

#### **507.3.4 PLANT TRIALS – PERMISSIBLE VARIATION IN JOB MIX FORMULA**

The requirements for plant trials shall be as specified in Clause 505.3.4, and permissible limits for variation as given in Table 500-18.

**TABLE 500-18 : PERMISSIBLE VARIATIONS IN PLANT MIX FROM THE JOB MIX FORMULA**

| <b>description</b>                         | <b>permissible Variation</b> |
|--|------------------------------|
| Aggregate passing 19 mm sieve or larger    | ± 7%                         |
| Aggregate passing 13.2 mm, 9.5 mm          | ± 6%                         |
| Aggregate passing 4.75 mm                  | ± 5%                         |
| Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm | ± 4%                         |
| Aggregate passing 0.3 mm, 0.15 mm          | ± 3%                         |
| Aggregate passing 0.075 mm                 | ± 1.5%                       |
| Binder content                             | ± 0.3%                       |
| Mixing temperature                         | ± 10°C                       |

#### **507.3.5 LAYING TRIALS**

The requirements for laying trials shall be as specified in Clause 505.3.5. The compacted

layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity ( $G_m$ ) obtained on the day of compaction in accordance with ASTM D2041.

#### **507.4 CONSTRUCTION OPERATIONS**

##### **507.4.1 Weather and seasonal limitations**

The provisions of Clause 501.5.1 shall apply.

##### **507.4.2 PREPARATION OF BASE**

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with Clauses 501 and 902 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 get access, other approved methods shall be used as directed by the Engineer.

##### **507.4.3 GEOSYNTHETICS**

Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703.

##### **507.4.4 STRESS ABSORBING LAYER**

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517.

##### **507.4.5 TACK COAT**

The provisions as specified in Clause 504.4.6 shall apply.

##### **507.4.6 MIXING AND TRANSPORTATION OF THE MIX**

The provisions as specified in Clauses 501.3, 501.4 and 504.4.7 shall apply.

##### **507.4.7 SPREADING**

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

#### **507.4.8 ROLLING**

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

#### **507.5 OPENING TO TRAFFIC**

Provisions in Clause 504.5 shall apply.

#### **507.6 SURFACE FINISH AND QUALITY CONTROL**

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

#### **507.7 ARRANGEMENTS FOR TRAFFIC**

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

#### **507.8 MEASUREMENT FOR PAYMENT**

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, **tonnes** or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

#### **507.9 RATE**

The contract unit rate shall be all as specified in Clause 504.9, except that the rate shall include the provision of bitumen at 5.2 percent & 5.4 percent for grading 1 and grading 2 by weight of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

#### **Item No. 42**

**Providing and applying primer coat with vg-10 and spraying emulsion with spray set fitted on mechanical bouzer using emulsion at the rate of 7.5 kg/ 10 Sqm. On wmm surface Incl. cleaning the surface etc. complete**

**MORTH V<sup>th</sup> REVISION Cl. No. 502, Pg. no. 166**

#### **502 PRIME COAT OVER GRANULAR BASE**

##### **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. The work shall be carried out on a previously prepared granular/ stabilized surface to Clause 501.8.

## Materials

The primer shall be cationic bitumen emulsion SS1 grade conforming to IS:8887 or medium curing cutback bitumen conforming to IS:217 or as specified in the Contract.

Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in Table 500-3.

**Table 500-3 : Quantity of Bitumen Emulsion for Various Types of Granular Surfaces**

| Type of Surface                           | Rate of Spray (kg/sq.m) |
|---|-------------------------|
| WMM/WBM                                   | 0.7-1.0                 |
| Stabilized soil bases/Crusher Run Macadam | 0.9-1.2                 |

Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given below.

**500-4 : Type and Quantity of Cutback Bitumen for Various Types of Granular Surface**

| Type of Surface                            | Type of Cutback | Rate of Spray (kg/sq.m) |
|--|-----------------|-------------------------|
| WMM/WBM                                    | MC 30           | 0.6-0.9                 |
| Stabilized soil bases/ Crusher Run Macadam | MC 70           | 0.9-1.2                 |

The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

## Weather and Seasonal Limitations

Primer shall not be applied 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. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

## Construction

### Equipment

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.



### **Preparation of Road Surface**

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

### **Application of Bituminous Primer**

After preparation of the road surface as per Clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. 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. No heating or dilution of SSI bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively through the jets of the spray and to cover the surface uniformly.

### **Curing of Primer and Opening to Traffic**

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

### **Quality Control of Work**

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

### **Arrangements for Traffic**

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

### **Measurement for Payment**

Prime coat shall be measured in terms of surface area of application in **Sq.m**.

### **Rate**

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v) 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 quantity at 0.6 kg per square metre or at the rate specified in the Contract, with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to in Clause 502.4.3,

**Item No. 43**

Providing and laying 50mm D.B.M with B.T. Aggregate as per MORT&H specification with VG-10 For Tack coat @ 2.5 Kg. /10 Sqm. With mechanical sprayer & bitumen VG-40 grade for mixing @ 45 Kg./MT. i.e. 4.5% by total weight of mix heating and mixing the aggregate & asphalt in continuous batch mix plant and transporting to site and spreading the same by sensor paver finisher & consolidation with vibratory roller including providing all materials equipments, tools & plant, fire wood, oil, kerosene, labour charges etc. Complete using contractor's own machinery batch mix plant & sensor paver finisher etc. Complete.

MORTH Cl. No. 505 Pg. no. 174

**505.1 Scope**

The work shall consist of construction in a single or multiple layer of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

**505.2 Materials****505.2.1 Bitumen**

The bitumen shall be viscosity grade (VG-40) paving bitumen complying with the Indian Standard Specification IS: 73.

**505.2.2 Coarse Aggregates**

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 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 has poor affinity for bitumen, the Contractor shall produce test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The Engineer may approve such a source and as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, at the cost of the Contractor. The aggregates shall satisfy the requirements specified in Table 500-8.

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

**505.2.3 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. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand up to 50 percent of the fine aggregate may be allowed in base courses.

**505.2.4 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 following limits:-

## 505.2.5 Grading and Binder Content

**505.2.5.1** When tested in accordance with IS:2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and filler for the particular mixture shall fall within the limits given in Table 500-10 for grading 1 or 2 as specified in the Contract. To avoid gap grading, the combined aggregate gradation shall not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

**Table 500-8: physical requirements for coarse aggregate for dense Bituminous Macadam**

| property           | test  | Specification                         | Method of test   |
|--------------------|---|---------------------------------------|------------------|
| Cleanliness (dust) | Grain size analysis   | Max 5% passing<br>0.075 mm sieve      | IS:2386 Part I   |
| Particle shape     | Combined Flakiness and<br>Elongation Indices*                 | Max 35%                               | IS:2386 Part I   |
| Strength           | Los Angeles Abrasion<br>Value or<br>Aggregate Impact Value    | Max 35%<br><br>Max 27%                | IS:2386 Part IV  |
| Durability         | Soundness either: Sodium<br>Sulphate or<br>Magnesium Sulphate | Max 12%<br><br>Max 18%                | IS:2386 Part V   |
| Water Absorption   | Water Absorption  | Max 2%                                | IS:2386 Part III |
| Stripping          | Coating and Stripping of<br>Bitumen Aggregate Mix             | Minimum<br>retained<br>percentage 95% | IS:6241          |
| Water Sensitivity  | Retained Tensile<br>Strength**                                | Min. 80%                              | AASHTO 283       |

\* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

\*\* If the minimum retained tensile test strength falls below 80 percent, use of anti-stripping agent is recommended to meet the requirement

**Table 500-9: grading requirements for Mineral filler**

| IS sieve (mm) | Cumulative Percent Passing by Weight of Total Aggregate |
|---------------|---|
| 0.6           | 100   |
| 0.3           | 95-100  |
| 0.075         | 85-100  |

**Table 500-10: Composition of Dense Graded Bituminous Macadam**

| Grading                                | 1   |
|--|---|
| Nominal aggregate size*                | 37.5  |
| Layer Thickness                        | 75 - 100 mm                                       |
| IS Sieve1 (mm)                         | Cumulative % by weight of total aggregate passing |
| 45                                     | 100   |
| 37.5                                   | 95-100  |
| 26.5                                   | 63-93   |
| 13.2                                   | 55-75   |
| 4.75                                   | 38-54   |
| 2.36                                   | 28-42   |
| 0.3                                    | 7-21  |
| 0.15                                   | 2-8   |
| 0.075                                  |   |
| Bitumen content % by mass of total mix | Min 4.0**   |

\* The nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained.

\*\* Corresponds to specific gravity of aggregates being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is - 10°C or lower, the bitumen content may be increased by 0.5 percent.

**505.2.5.2** Bitumen content indicated in above Table is the minimum quantity. The quantity shall be determined in accordance with Clause of Mix Design.

### **505.3 Mix Design**

The bitumen content required shall be determined following the Marshall Mix design procedure contained in Asphalt Institute Manual MS-2. The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2.

#### **505.3.1 Requirements for the Mix**

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 13-4.

**Table 500-11 : Requirements for Dense Graded Bituminous Macadam**

| Properties                           | Viscosity Grade Paving Bitumen        | Test Method         |
|--------------------------------------|---------------------------------------|---------------------|
| Compaction level                     | 75 blows on each face of the specimen |                     |
| Minimum stability (kN at 600C)       | 9.0                                   | AASHTO T245         |
| Marshall flow (mm)                   | 2 - 4                                 | AASHTO T245         |
| Marshall Quotient (Stability / flow) | 2 - 5                                 | MS-2 and ASTM D2041 |
| % air voids                          | 3-5                                   |                     |
| % Voids Filled with Bitumen (VFB)    | 65-75                                 |                     |
| Coating of aggregate particle        | 95% minimum                           | IS:6241             |
| Tensile Strength ratio               | 80% Minimum                           | AASHTO T 283        |
| % Voids in Mineral Aggregate (VMA)   | 11.0 – 13.0                           |                     |

### 505.3.2 Binder Content

The binder content shall be optimized to achieve the requirements of the mix set out in Table 13-4. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

**Table 500-12: Minimum Percent Voids in Mineral Aggregate (VMA)**

| Nominal Maximum Particle Size <sup>1</sup> (mm) | Minimum VMA Percent Related to Design Percentage Air voids |      |      |
|---|--|------|------|
|   | 3.0  | 4.0  | 5.0  |
| 26.5  | 11.0   | 12.0 | 13.0 |
| 37.5  | 10.0   | 11.0 | 12.0 |

Note: Interpolate minimum voids in the mineral aggregate (VMA) for designed percentage

### 505.3.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows:
  - a) Binder type, and percentage by weight of total mix;
  - 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 fraction, and the proportion of each in the combined grading;
- v) The results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;
- 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 mix 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 shall be forwarded by the Contractor to the Engineer for approval before the placing of the material.

### 505.3.4 Permissible variation from 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 below Table.

**Table 500-13 Permissible Variations in the Actual Mix from the Job Mix Formula**

| Description                                | Base/binder Course |
|--|--------------------|
| Aggregate passing 19 mm sieve or larger    | ±8%                |
| Aggregate passing 13.2 mm, 9.5 mm          | ±7%                |
| 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 |

### **505.3.5 Laying Trails**

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 and compacted all in accordance with Clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works. 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 is 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. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density equal to or more than 92% of the density based on theoretical maximum specific gravity ( $G_{mm}$ ) obtained on the day of compaction in accordance with ASTM D 2041.

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.

## **505.4 Construction Operations**

### **505.4.1 Weather and seasonal limitations**

The provisions of Clause 501.5.1 shall apply.

### **505.4.2 Preparation of Base**

The base on which Dense Bituminous Macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross sections as directed by the Engineer. The surface shall be thoroughly swept clean free from dust and foreign matter using mechanical broom and dust removed or blown off by compressed air. In portions where mechanical means cannot reach, other approved method shall be used. A priming coat where needed, shall be applied as directed by the Engineer

### **505.4.3 Geosynthetics**

Where Geosynthetics are specified in the Contract, this shall be in accordance with the Requirements stated in Clause 703.

### **505.4.3 Stress Absorbing layer**

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517.

#### **505.4.5 Prime Coat**

Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified in the tender specification or as directed by the Engineer.

#### **505.4.6 Tack Coat**

Where the material on which the dense bituminous macadam is to be laid is either bitumen bound layer or primed granular layer, tack coat shall be applied, as specified in the tender specification or as directed by the Engineer.

#### **505.4.7 Mixing and Transportation of the Mix**

The provisions as specified in Clauses 501.3 and 501.4 shall apply. Table 500-2 gives the mixing, laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

#### **505.4.8 Spreading**

The provisions of Clauses 501.5.3 and 501.5.4 shall apply.

#### **505.4.9 Rolling**

The general provisions of Clauses 501.6 and 501.7 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.

#### **505.5 Opening to Traffic**

It shall be ensured that the traffic is not allowed on the surface until the dense bituminous layer has cooled to the ambient temperature.

#### **505.6 Surface Finish and Quality Control of Work**

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

#### **505.7 Arrangement for Traffic**

During the period of construction, arrangements for the traffic shall be provided. The



Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, marking, flags, lights and flagmen as per instruction of the Engineer-in-charge.

#### **505.8 Measurements for Payment**

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, **tonnes** or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

#### **505.9 Rate**

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out all the required operations as specified and shall include, to all components listed in Clause 501.8.8.2. The rate shall include the provision of bitumen, at 4 percent and 4.5 percent by weight of the total mixture for grading 1 and grading 2 respectively.

The variation in actual percentage of bitumen used shall be assessed and the payment adjusted plus or minus accordingly.

**Item No. 44**

Providing and laying 50mm thick bituminous macadam B.T. aggregate as per MORT&H specification and VG-40 for tack coat @ 2.50 kg./10 smt. With mechanical sprayer & bitumen grade VG-40 for mixing @ 34kg/mt. i.e. 3.40% by weight of total mix including heating and mixing the aggregate & asphalt in continuous batch mix plant and spreading the same by sensor paver finisher & consolidation with vibratory roller including providing all materials equipments, tools & plant, fire wood, oil, kerosene, labour charges etc. complete using contractor's own machinery drum mix plant & paver finisher etc complete.

**MORTH V<sup>th</sup> REVISION CI. No. 504**

**504 BITUMINOUS MACADAM (MORTH Specification 5<sup>th</sup> Revision).**

504.1 Scope

This work shall consist of construction in a single course having 50 mm 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. Since the bituminous macadam is an open-graded mix, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer (shoulders) should have proper drainage quality to prevent moisture-induced damage to the BM.

504.2 Materials

504.2.1 Bitumen

The bitumen shall be viscosity graded paving bitumen complying with Indian Standard Specification for paving bitumen, IS:73 or as specified in the Contract. The type and grade of bitumen to be used would depend upon the climatic conditions and the traffic. Guidelines for selection of bitumen are given in Table 500-1.

504.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. It shall be clean, hard, durable and cubical shape, free from dust and soft organic and other deleterious substances. The aggregate shall satisfy the physical requirements specified in Table 500-6. Where crushed gravel is proposed for use as aggregate, not less than 90 percent by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces resulting from crushing operation. Before approval of the source, the aggregates shall be tested for stripping. 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.

### 504.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of two, passing 2.36 mm sieve and retained on 75 micron sieve. It shall be clean, hard, durable, free from dust and soft organic and other deleterious substances. Natural sand shall not be used in the binder course.

Table 500-6: Physical Properties of Coarse Aggregate

| Property          | Test   | Requirement                  | Test Method      |
|-------------------|--|------------------------------|------------------|
| Cleanliness       | Grain size Analysis  | Max 5 % Passing 0.075 micron | IS:2386 Part I   |
| Particle Shape    | Combined Flakiness and Elongation Indices                          | Max. 35%                     | IS:2386 Part I   |
| Strength          | Los Angeles Abrasion Value or Aggregate Impact Value               | Max. 40%                     | IS:2386 Part IV  |
|                   |  | Max. 30%                     | IS:2386 Part IV  |
| Durability        | Soundness (Sodium or Magnesium) Sodium Sulphate Magnesium Sulphate | 5 cycles                     |                  |
|                   |  | Max. 12%                     | IS:2386 Part V   |
|                   |  | Max 18%                      | IS:2386 Part V   |
| Water Absorption  | Water Absorption   | Max. 2%                      | IS:2386 Part III |
| Stripping         | Coating and Stripping of Bitumen Aggregate                         | Min. Retained Coating 95%    | IS:6241          |
| Water Sensitivity | Retained Tensile Strength*   | Min. 80%                     | AASHTO 283       |

\*If the minimum retained tensile strength falls below 80 percent, use of anti stripping agent is recommended to meet the minimum requirements.

### 504.2.4 Aggregate Grading and Binder Content

The combined grading of the coarse aggregates and fine aggregates, when tested in accordance with IS:2386 Part 1, wet sieving method, shall conform to limits given in Table 500-8. The type and quantity of bitumen and appropriate thickness is also given in Table 500-7.

### 504.2.5 Proportioning of Material

The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 500-7. The binder content shall be within a tolerance of  $\pm 0.3$  percent by weight of total mix when individual specimens are taken for quality control tests in accordance with the provisions of Section 900.

### 504.3 Construction Operation

#### 504.3.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

Table 500-7: Aggregate Grading and Bitumen Content

| Grading   | 1   | 2         |
|---|---|-----------|
| Nominal maximum aggregate size*                 | 40mm  | 19 mm     |
| Layer thickness                                 | 80 -100 mm  | 50 -75 mm |
| IS Sieve size (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   | 16-38     |
| 2.36  | 4-19  | 4-19      |
| 0.3   | 2-10  | 2-10      |
| 0.075   | 0-8   | 0-8       |
| Bitumen content ** Percent by mass of total mix | 3.3**   | 3.4**     |

\* Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

\*\* Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where highest daily mean air temperature is 30°C or lower and lowest daily mean air temperature is -10°C or lower, the bitumen content may be increased by 0.5 percent.

#### 504.3.2 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 501.8 and 902.3 as appropriate, and a prime coat, shall be applied in accordance with Clause 502 where specified, 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 get access, other approved methods shall be used as directed by the Engineer.

#### 504.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied as required under the Contract or as directed by the Engineer.

#### 504.3.4 Preparation and Transportation of the Mix

The provisions of Clauses 501.3 and 501.4 shall apply.

#### 504.3.5 Spreading

The provisions of Clause 501.5.3 shall apply.

#### 504.3.6 Rolling

Compaction shall be carried out in accordance with the provisions of Clauses 501.6 and 501.7.

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 903.

#### 504.4 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

#### 504.5 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, by the Contractor the course shall be covered by a seal coat to the requirement of Clause 512 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.

#### 504.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

#### 504.7 Measurement for Payment

Bituminous macadam shall be **measured as finished work in MT**, 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.

#### 504.8 Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include cost for all components listed in Clause 501.8.8.2.

#### **Item No. 45**

**Providing, laying, spreading and compacting stone aggregate for Wet Mix Macadam (as per table 400-12 and 400-13) specification including premixing the material with water to OMC in wet mix plant as per approved design mix, carriage of mixed material by Tipper to site, laying in uniform layers with motor grader/Front end Loader/paver finisher, in sub base/ base course on a well prepared under base and compacting with vibratory roller to achieve the desired density including lighting, guarding, barricading and maintenance of diversion etc. (MoRTH specification : Clause 406 & Clause 112) by mechanical means with all lead .**

#### **MORTH V<sup>th</sup> REVISION Cl. No. 406, Pg. no. 131**

##### **406.1 Scope**

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub- base/ base or existing pavement as the case may be in accordance with the requirements of these Specifications, The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Engineer.

##### **406.2 Materials**

##### **406.2.1 Aggregates**

##### **406.2.1.1 Physical Requirements**

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent 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 400-12.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

**Table 400-12: Physical Requirements of Coarse Aggregates for  
Wet Mix Macadam for Sub-base/Base Courses**

| Sr. | Test  | Test Method  | Requirements                           |
|-----|---|--|--|
| 1)  | Los Angeles Abrasion value or<br>Aggregate Impact value | IS:2386 (Part-4)<br>IS:2386 (Part-4) or<br>IS:5640 | 40 percent (Max.)<br>30 percent (Max.) |
| 2)  | Combined Flakiness and Elongation<br>indices (Total)    | IS:2386 (Part-1)                                   | 35 percent (Max.)*                     |

To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

#### **406.2.1.2 Grading Requirements**

The aggregates shall conform to the grading given in Table 400-13.

**Table 400-13 : Grading Requirements of Aggregates for Wet Mix Macadam**

| IS Sieve Designation | Percent by weight passing the IS Sieve |
|----------------------|--|
| 53.00 mm             | 100                                    |
| 45.00 mm             | 95-100                                 |
| 26.50 mm             | -                                      |
| 22.40 mm             | 60-80                                  |
| 11.20 mm             | 40-60                                  |
| 4.75 mm              | 25-40                                  |
| 2.36 mm              | 15-30                                  |
| 600.00 micron        | 8-22                                   |
| 75.00 micron         | 0-5                                    |

Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

### **406.3 Construction Operations**

#### **406.3.1 Preparation of Base**

Clause 404.3,1 shall apply.

### **406.3.2 Provision of Lateral Confinement of Aggregates**

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 404.3.3.

### **406.3.3 Preparation of Mix**

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. The plant shall have following features:

- i) For feeding aggregates– three/ four bin feeders with variable speed motor
- ii) Vibrating screen for removal of oversize aggregates
- iii) Conveyor Belt
- iv) Controlled system for addition of water
- v) Forced/positive mixing arrangement like pug-mill or pan type mixer
- vi) Centralized control panel for sequential operation of various devices and precise process control
- vii) Safety devices

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

### **406.3.4 Spreading of Mix**

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from



the tipper to the screed.

- ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- iii) Automatic levelling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required, The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted. Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

#### **406.3.5 Compaction**

After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement

for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the center line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and

backward until the edges have been firmly compacted. The roller shall then progress gradually towards the center parallel to the center line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material as determined by the method outlined in IS:2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

#### **406.3.6 Setting and Drying**

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

#### **4064 Opening to Traffic**

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

#### **406.5 Surface Finish and Quality Control of Work**

##### **406.5.1 Surface Evenness**

The surface finish of construction shall conform to the requirements of Clause 902.

##### **406.5.2 Quality Control**

Control on the quality of materials and works shall be exercised by the Engineer in accordance

with Section 900.

#### **406.6 Rectification of Surface Irregularity**

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and recompactd in accordance with Clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

#### **406.7 Arrangement for Traffic**

During the period of construction, arrangements for traffic shall be done as per Clause 112.

#### **406.8 Measurements for Payment**

Wet mix macadam shall be measured as finished work in position in **cubic metres**.

#### **406.9 Rate**

The Contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

**Item No. 46**

**Construction of granular sub-base by providing coarse graded material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per clause 401.By mechanical means with all lead (Grade-I)**

**MORTH V<sup>th</sup> REVISION Cl. No. 401, Pg. no. 109**

**401 Granular sub-base****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 in 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.

**Materials**

The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the gradings given in Table 400-1 and physical requirements given in Table 400-2. Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

If the water absorption of the aggregates determined as per IS:2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for Wet Aggregate Impact Value (AIV) (IS:5640). Soft aggregates like Kankar, brick ballast and laterite shall also be tested for Wet AIV (IS:5640).

**Table 400-1 : grading for granular sub-base Materials**

| is sieve<br>designation | percent by weight passing the is sieve |            |             |            |           |            |
|-------------------------|--|------------|-------------|------------|-----------|------------|
|                         | grading i                              | grading ii | grading iii | grading iv | grading V | grading Vi |
| 75.0 mm                 | 100                                    | -          | -           | -          | 100       | -          |
| 53.0 mm                 | 80-100                                 | 100        | 100         | 100        | 80-100    | 100        |
| 26.5 mm                 | 55 –90                                 | 70-100     | 55-75       | 50-80      | 55-90     | 75-100     |
| 9.50 mm                 | 35-65                                  | 50-80      | –           | –          | 35-65     | 55-75      |
| 4.75 mm                 | 25 – 55                                | 40-65      | 10-30       | 15-35      | 25-50     | 30-55      |
| 2.36 mm                 | 20- 40                                 | 30-50      | –           | –          | 10-20     | 10-25      |

|          |       |        |     |     |      |     |
|----------|-------|--------|-----|-----|------|-----|
| 0.85 mm  | –     | –      | –   | –   | 2-10 | –   |
| 0.425 mm | 10-15 | 10- 15 | –   | –   | 0-5  | 0-8 |
| 0.075 mm | <5    | < 5    | < 5 | < 5 | –    | 0-3 |

**Table 400-2 : physical requirements for Materials for granular sub-base**

|   |                                |  |
|---|--------------------------------|--|
| Aggregate Impact Value (AIV)                  | IS:2386 (Part 4)<br>or IS:5640 | 40 maximum   |
| Liquid Limit                                  | IS:2720 (Part 5)               | Maximum 25   |
| Plasticity Index                              | IS:2720 (Part 5)               | Maximum 6  |
| CBR at 98% dry density<br>(at IS:2720-Part 8) | IS:2720 (Part 5)               | Minimum 30 unless otherwise<br>specified in the Contract |

## **Construction operations**

### **Preparation of sub-grade**

Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 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.

### **Spreading and compacting**

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS:2720 (Part 8). The mix shall be spread on the prepared subgrade with the help of a motor 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.

Moisture content of the mix shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. 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 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight 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 or on super- elevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and progress towards the crown.



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 become 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 percent of the maximum dry density 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.

### **Surface finish and Quality control of work**

The surface finish of construction shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

#### **401.5 Arrangements for Traffic**

During the period of construction, arrangements for the traffic shall be provided and maintained in accordance with Clause 112.

#### **401.6 Measurements 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.

#### **401.7 Rate**

The Contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including full compensation for:

- i) making arrangements for traffic to Clause 112 except for initial treatment to verges, shoulders and construction of diversions;
- ii) supplying all materials to be incorporated in the work including all royalties, fees, rents where applicable with 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.

**Item No. 48**

**Providing and fixing pre-cast Rubber Dye / steel Dye inter locking concrete block 60mm thick with grade of concrete M300 pneumatic compressed / vibrated mechanically and as per approved design Confirming to IS 15658 : 2006 including 35 mm Sand layer for levelling and filling the joint with sand in proper line and level as per guidelines of IRC : SP 63-2018 etc. Complete.**

**MORTH V<sup>th</sup> REVISION Cl. No. 410, Pg. no. 143**

**410 Footpaths And Separators****410.1 Scope**

The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the Engineer.

The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed by the Engineer.

**410.2 Materials**

The footpaths and separators shall be constructed with any of the following types:

Cast-in-situ cement concrete of Grade M 20 as per Section 1700 of the Specifications. The minimum size of the panels shall be as specified in the drawings.

Precast cement concrete blocks and interlocking blocks/tiles of grade not less than M 30 as per Section 1700 of the Specifications. The thickness and size of the cement concrete blocks or interlocking blocks/ tiles shall be as specified in the drawings.

Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The thickness and size of the natural stone slab shall be as specified in the drawings.

**410.3 Construction operations**

Drainage pipes below the footpath originating from the kerbs shall be first laid in the required slope and connected to the drains/sumps/storm water drain/drainage chutes as per provisions of the drawings, or as specified.

Portion on back side of kerbs shall be filled and compacted with granular sub-base material as per Clause 401 of the Specifications in specified thickness.



The base for cast-in-situ cement concrete panels/ tiles/ nature stone slab shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings.

Over the prepared base, precast concrete interlocking blocks/tiles/natural stone slabs and/or cast-in- situ slab shall be set/laid as described in Clauses 410.3.4 and 410.3.5.

### **Tiles/natural stone slabs**

The blocks/tiles/slabs shall be set on a layer of average 12 mm thick cement-sand mortar (1:3) laid on prepared base in such a way that there is no rocking. The gaps between the blocks/tiles/slabs shall not be more than 12 mm and shall be filled with cement-sand mortar (1:3).

### **Cast-in-situ cement concrete**

The panels of specified size shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per Section 1700 of the Specifications.

### **Precast concrete Blocks and interlocking concrete Block pavements**

The precast concrete blocks and interlocking concrete block pavement shall be laid on a bedding of sand of thickness specified in the drawing. The grading of the sand layer shall be as in Table 400-16.

**Table 400-16**

| <b>IS sieve size</b> | <b>Percent passing</b> |
|----------------------|------------------------|
| 9.52 mm              | 100                    |
| 4.75 mm              | 95–100                 |
| 2.36 mm              | 80–100                 |
| 1.18 mm              | 50–95                  |
| 600 micron           | 25–60                  |
| 300 micron           | 10–30                  |
| 150 micron           | 0–15                   |
| 75 micron            | 0–10                   |

The joints shall be filled with sand passing a 2.35 mm size with the grading as in Table 400-17.

**Table 400-17**

| <b>IS sieve size</b> | <b>Percent passing</b> |
|----------------------|------------------------|
| 2.36 mm              | 100                    |
| 1.18 mm              | 90–100                 |
| 600 micron           | 60–90                  |
| 300 micron           | 30–60                  |
| 150 micron           | 15–30                  |
| 75 micron            | 0–10                   |

The bedding sand slightly moist, the moisture content being about 4 percent. The bedding sand shall be compacted by vibratory plate compactor.

The blocks shall be laid to the levels indicated on the drawings and to the pattern directed by the Engineer. The surface tolerance shall be  $\pm 10$  mm with respect to the design level. The blocks shall be embedded using a hammer.

#### **410.4 Measurements for payment**

Footpaths and separators shall be measured in **Sq.m** between inside of kerbs. The edge restraint block and kerb shall be measured separately in linear meter. The items pertaining to drainage shall be measured separately.

#### **410.5 Rate**

Contract unit rates shall be inclusive of full compensation for all labour, materials, tools, equipment for footpaths including the base. Cost of providing pipes and arrangement for their discharge into appropriate drainage channels shall be incidental to the construction of footpaths

**Item No. 49**

**Providing and fixing ordinary Kilometer stone of approved hard stone as per I.R.C. type design in C.C. 1:4:8 including painting and lettering etc. complete (For N.H., S.H. and M.D.R.)**

1. Kilometer stone shall be of approved quality and shall be either black Rajula stone or of precast 1:2:4 R.C.C. as specified in the item.
2. The size, manner of fixing, painting and lettering of K.M. stone shall conform specification as per I.R.C. - 8 (Type design for Highway kilometer stones). The fixing of K.M. stone shall be carried out in ordinary concrete of grade specified in the item using hand broken metal field metal or gravel. The measurement for payment shall be made per No. of K.M. stone fixed in position.
3. Unit rate for kilometer stone includes the cost of all materials, labour, tools, fixing, finishing curing, lettering and painting as directed by the Engineer-in-charge.

ordinary Kilometer stone shall be measured as finished work in position in **Nos..**

**Item No. 50**

**Providing and fixing 5th Kilometer stone of approved hard stone as per I.R.C. type design in C.C. 1:4:8 including painting and lettering etc. complete (For N.H., S.H. and M.D.R.)**

1. The work shall be carried out as per the item of ordinary kilometer stone except that the size of the fifth kilometer stone shall be bigger than that of ordinary kilometer stone as per I.R.C.-8 (Type design for highway kilometer stones). The fixing of K. M. stone shall be in ordinary concrete of grade specified in the item. The measurement for payment as well as the operation included in the unit rate shall be as per ordinary kilometer stone.

5th Kilometer stone shall be measured as finished work in position in **Nos..**

**Item No. 51**

**Providing and fixing Hectometer as per I.R.C. type design including painting, lettering etc. complete.(ii) Fixing in C.C. 1:5:10**

1. Fixing in Earth :  
The work shall be carried out as per the item of ordinary kilometer stone except that the size of Hectometer stone shall be smaller than that of ordinary kilometer stone as per I.R.C. 26 (Type design for 200 metre stones) and fixing shall be in earth. The measurement for payment as well as the operations included in the unit rate shall be as per ordinary kilometers stone.
2. Fixing in C. C. 1:5:10  
Specification same as (1) above except that the indicator stone shall be fixed in C.C. 1:5:10 which will consist of one part of cement, five part of good sand and ten parts of good brick bats. Rate includes all labour and curing etc. necessary for concrete.

5th Kilometer stone shall be measured as finished work in position in **Nos..**

**Item No. 52**

**Cat Eye / Road Stud / RPM: Supplying Raised Pavement Markers made of polycarbonate and ABS moulded body and reflective panels with Micro prismatic lens (No Glass bead lens) capable of providing total internal reflection of the light entering the lens face and shall support a load of 13635 kgs. tested in accordance to ASTM D 4280 Type H and complying to Specifications of Category A of MORTH Circular No RW/NH/33023/10-97 & DO III Dt 11.06. 1997. The height, width and length shall not exceed 20 mm, 130 mm and 130 mm and with minimum reflective area of 13 Sqcm on each side and the slope to the base shall be 35 +/- 5 degree. The body of the marker should having finger grip for easy and accurate placement and application with epoxy / bituminous Adhesive as recommended by the manufacturer of the marker. The color of the marker should be as per the IRC 35-2015 and as directed by Engineer-in-charge.**

**MORTH V<sup>th</sup> REVISION Cl. No. 804, Pg. no. 353**

**804 Reflective Pavement Markers (Road Studs) And Solar Powered Road Markers (Solar Studs)**

**Scope**

The work shall cover the providing and fixing of reflective pavement marker (RPM) or road stud, a device which is bonded to or anchored within the road surface, for lane marking and delineation for night-time visibility, as specified in the Contract.

**Material**

Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrile) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 4280.

Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methacrylate conforming to ASTM D 788 or equivalent.

**Design**

The slope or retro-reflecting surface shall preferably be  $35 \pm 5^\circ$  to base and the area of each retro-reflecting surface shall not be less than 13.0 sq.cm.

**Optical Performance****Unidirectional and Bi-directional Studs**

Each reflector or combination of reflectors on each face of the stud shall have a Coefficient of Luminous Intensity (CIL). not less than that given in Tables 800-13 or 800-14 as appropriate.

## Omni-directional Studs

Each Omni-directional stud shall have a C.I.L. of not less than 2 mcd/lx.

**Table 800-13 : Minimum C.I.L. Values for Category 'A' Studs**

| Entrance Angle | Observation Angle | C.I.L. in mcd/lx |       |     |
|----------------|-------------------|------------------|-------|-----|
|                |                   | White            | Amber | Red |
| 0° U 5° L & R  | 0.3°              | 220              | 110   | 44  |
| 0° U 10° L & R | 0.5°              | 120              | 60    | 24  |

**Table 800-14: Minimum C.I.L. Values for Category 'B' Studs**

| Entrance Angle<br>• | Observation Angle | C.I.L. in mcd/lx |       |     |
|---------------------|-------------------|------------------|-------|-----|
|                     |                   | White            | Amber | Red |
| 0° U 6° L & R       | 0.3°              | 20               | 10    | 4   |
| 0° U 10° L & R      | 0.5°              | 15               | 7.5   | 3   |

### Note :

- The entrance angle of 0° U corresponds to the normal aspect of the reflectors when the reflecting road stud is installed in horizontal road surface.
- The stud incorporating one or more corner cube reflectors shall be included in Category 'A'. The stud incorporating one or more bi-convex reflectors shall be included in Category 'B'.

## Tests

Co-efficient of luminance intensity can be measured by procedure described in ASTM E 809 "Practice for Measuring Photometric Characteristics" or as recommended in BS:873-Part 4: 1973.

Under test conditions, a stud shall not be considered to fail the photometric requirements if the measured C.I.L. at any one position of measurement is less than the values specified in Tables 800-13 or 800-14 provided that

the value is not less than 80 percent of the specified minimum, and the average of the left and right measurements for the specific angle is greater than the specified minimum.

## Solar Powered Road Markers (Solar Studs)

The solar studs shall be made of Aluminium alloy and poly carbonate material which shall be absolutely weather resistant and strong enough to support a load of 13,635 kg tested in accordance with ASTM D4280. Its colour may be white, red, yellow, green or blue or combination as directed by the Engineer. Its water resistance shall meet the requirements of

IP 65 in accordance with IS:12063:1987 Category 2, for protection against water ingress. The dimensions of solar studs shall not be less than 100 mm x 100 mm x 10 mm. It shall have super bright LEDs so as to provide long visibility from a distance of more than 800 m. Its flashing rate shall not be less than 1 Hz. It should be able to give the prescribed performance in the temperature range of -40°C to +55°C. Its life shall be not less than 3 years.

## **Fixing of Reflective Markers**

### **Requirements**

The enveloping profile of the head of the stud shall be smooth and the studs shall not present any sharp edges to traffic. The reflecting portions of the studs shall be free from crevices or ledges where dirt might accumulate. Marker height shall not be less than 10 mm and shall not exceed 20 mm, and its width shall not exceed 130 mm. The base of the marker shall be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from a flat surface. All road studs shall be legibly marked with the name, trade mark or other means of identification of the manufacturer.

### **Placement**

The reflective marker shall be fixed to the road surface using the adhesives and the procedure recommended by the manufacturer. No nails shall be used to affix the marker so that they do not pose safety hazard on the roads. Regardless of the type of adhesive used, the markers shall not be fixed if the pavement is not surface dry and on new asphalt concrete surfacing until the surfacing has been opened to traffic for a period of not less than 14 hours. The portions of the highway surface, to which the marker is to be bonded by the adhesive, shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed.

### **Warranty and Durability**

The contractor shall submit a two year warranty for satisfactory field performance including stipulated retro-reflectance of the reflecting panel, to the Engineer. In addition, a two year warranty for satisfactory infield performance of the finished road marker shall also be given by the contractor who carries out the work of fixing of reflective road markers. In case the markers are displaced, damaged, get worn out or lose their reflectivity compared to stipulated standards, the contractor would be required to replace all such markers within 15 days of the intimation from the Engineer, at his own cost.

#### **804.8 Measurement for Payment**

The measurement of reflective road markers/solar powered road studs shall be in **numbers** of different types of markers supplied and fixed.

#### **804.9 Rate**

The contract unit rate for reflective road markers/solar powered road studs shall be payment in full compensation for furnishing all labour, material, tools, equipment including incidental costs necessary for carrying out the work at site conforming to the specification complete as per approved drawings or as directed by the Engineer.

**Item No. 53**

Road marking with hot applied thermoplastic paints with reflectorising glass beads on bitumin surface providing and laying a hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250gms per sqm area, thickness of 2.5mm is excluding of surface applied glass beds as per IRC:35- 2015. The finished surface to be level, uniform and free from streaks and holes. zebra patta /bump patta lane/center line/ edge line/cut patta. The white color marking should provide liminance coefficinet on cemend road shall be min 130 mcd/m2/lux and Asphalt road shall be min 100 mcd/m2/lux during the service life during the day time. The marking should meet the performance criteria for night time reflectivity, wet reflectivity and skid resistance as mentioned in the section-15 of IRC 35-2015. Warranty for the Retro reflectivity should be two years.

MORTH V<sup>th</sup> REVISION Cl. No. 803, Pg. no. 338

**803 ROAD MARKINGS****Scope**

The work shall consist of providing road markings of specified width, layout and design using paint of the required specifications as given in the Contract and as per guidelines contained in from IRC:35-1997.

**Materials**

Road markings shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorised paint or cold applied reflective paint as specified in the item and the material shall meet the requirements as specified in these Specifications.

**Ordinary Road Marking Paint**

Ordinary paint used for road marking shall conform to Grade I as per IS:164.

The road marking shall preferably be laid with appropriate road marking machinery.

**Hot Applied Thermoplastic Road Marking****Thermoplastic Material****General**

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass refiectorizing beads. The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

**Requirements :**

**Composition:** The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 800-9,



**Table 800-9 : Proportions of Constituents of Marking Material (Percentage by Weight)**

| Component                           | White     | Yellow         |
|-------------------------------------|-----------|----------------|
| Binder                              | 18.0 min. | 18.0 min.      |
| Glass Beads                         | 30-30     | 30-30          |
| Titanium Dioxide                    | 10.0 min. | - -            |
| Calcium Carbonate and Inert Fillers | 42.0 max. | See Note below |
| Yellow Pigments                     | - -       | See Note below |

**Note :** Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

- i) **properties:** The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part I), shall be as below:
  - a) **luminance :**  
White: Daylight luminance at 45°-65 percent min. as per AASHTO M 249  
Yellow: Daylight luminance at 45°-45 percent min. as per AASHTO M 249
  - b) **drying time :** When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.
  - c) Skid resistance: not less than 45 as per BS:6044.
  - d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
  - e) Softening point: 102.5°C ± 9.5°C as per ASTM D 36.
  - f) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249
- ii) **storage life :** The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/ Contractor.
- iii) **Reflectorisation :** Shall be achieved by incorporation of beads, the

grading and other properties of the beads shall be as specified in Clause 803.4.2.

- iv) **Marking** : Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
  - 1) The name, trade mark or other means of identification of manufacturer
  - 2) Batch number
  - 3) Date of manufacture
  - 4) Colour (white or yellow)
  - 5) Maximum application temperature and maximum safe heating temperature.
- v) **sampling and testing** : The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

## **803.4.2 Reflectoring Glass Beads**

### **General**

This Specification covers two types of glass beads to be used for the production' of reflectorised pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-9 and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6.4.

The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions.

These shall conform to the requirements spelt out in

### **Specific Requirements**

**Gradation** The glass beads shall meet the gradation requirements for the two types as given in Table 800-10.

**Table 800-10: Gradation Requirements for Glass Beads**

| Sieve Size       | Percent Retained |          |
|------------------|------------------|----------|
|                  | Type '1          | Type 2   |
| 1.18 mm          | 0 to 3           |          |
| 850 micron       | 5 to 20          | 0 to 5   |
| 600 micron       | --               | 5 to 20  |
| 425 micron       | 65 to 95         |          |
| 300 micron       | --               | 30 to 75 |
| 180 micron       | 0-10             | 10 to 30 |
| Below 180 micron | - -              | 0 to 15  |

- a) **roundness:** The glass beads shall have a minimum of 70 percent true spheres.
- b) **refractive index:** The glass beads shall have a minimum refractive index of 1.50.
- c) **Free flowing properties:** The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

### Test Methods

The specific requirements shall be tested with the following methods:

- i) Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter dessicator which is filled within 25 mm of the top of a dessicator plate with sulphuric acid water solution (specific gravity 1.10). Cover the dessicator and let it stand for 4 hours at 20°C to 29°C. Remove sample from dessicator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.
- ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part I).
- iii) The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these Specifications.

However, if so required, these tests may be carried out as directed by the Engineer.

### **803.4.3            Application properties of thermoplastic Material**

The thermoplastic material shall readily get screeded/extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

The material upon heating to application temperatures shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

### **803.4.4            Preparation**

- i) The material shall be melted in accordance with the manufacturer's instructions in a heater with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.
- ii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

### **803.5    Reflectorised Paint**

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirements of Clause 803.4.2.

### **803.6    application**

Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

Where the compound is to be applied to cement concrete pavement, a sealing primer as

recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.

The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line. Such new material shall so bond itself to the old line that no splitting or separation takes place. Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed.

In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS:3262 (Part 3).

The markings shall be done to accuracy within the tolerances given below:

- i) Width of lines and other markings shall not deviate from the specified width by more than 5 percent.
- ii) The position of lines, letters, figures, arrows and other markings shall not deviate from the position specified by more than 20 mm
- iii) The alignment of any edge of a longitudinal line shall not deviate from the specified alignment by more than 10 mm in 15 m.
- iv) The length of segment of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

In broken lines, the length of segment and the gap between segments shall be as indicated on the drawings; if these lengths are altered by the Engineer, the ratio of the lengths of the painted sections shall remain the same

### **Properties of finished road Markings**

The finished lines shall be free from ruggedness on sides and ends and be parallel to the

general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

- a) The stripe shall not be slippery when wet.
- b) The marking shall not lift from the pavement in freezing weather.
- c) After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperatures upto 60°C.
- d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic.
- e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
- f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS:164

#### **803.6.1          Measurements for payment**

The painted markings shall be measured **in sq. metres** of actual area marked (excluding the gaps, if any).

In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

#### **803.6.2          Rate**

The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, including all incidental costs necessary for carrying out the work at the site conforming to these Specifications complete as per the approved drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work to these Specifications.

**Item No. 54**

**Cautionary Warning Sign :-** Providing and fixing sign boards made out of 2 mm aluminium sheet / 4 mm ACP (Aluminium Composite Panel); size 90 × 90 × 90 cms equilateral triangle as per design of IRC-67-2012, pre-treated with phosphating process and acid etching; coated with one coat of epoxy primer and two coats of best quality epoxy paint; reflectorised with Micro-Prismatic Grade retro-reflective sheeting of Type-XI as per ASTM D-4956 and latest MoRT&H specifications; 3.6 mtr long stand post of 75 × 75 × 6 mm / 65 NB circular MS pipe as required and frame fabricated from suitable size iron angle of 35 × 35 × 3 mm; painted with best quality epoxy coatings in black and white bands. The details of symbol for each board shall be as per the instructions of the Engineer-in-Charge. The fixing at site shall be in 1:2:4 cement concrete block of size 45 × 45 × 60 cms for each leg, including excavation, curing, etc., complete under the supervision of the Engineer-in-Charge. A warranty for 10 years for the retro-reflective sheeting from original manufacturer and a certified copy of 3-year outdoor exposure test report from third-party test laboratory for the product offered shall be submitted by the contractor. (A) Class-C Type-XI Retro-Reflective Sheeting

**Item No. 55**

**Regulatory / Mandatory Sign :-** Providing and fixing sign boards made out of 2 mm aluminium sheet / 4 mm ACP (Aluminium Composite Panel); size 60 cms dia circle as per design of IRC-67-2012, pre-treated with phosphating process and acid etching; coated with one coat of epoxy primer and two coats of best quality epoxy paint; reflectorised with Micro-Prismatic Grade retro-reflective sheeting of Type-XI as per ASTM D-4956 and latest MoRT&H specifications; 3.6 mtr long stand post of 75 × 75 × 6 mm / 65 NB circular MS pipe as required and frame fabricated from suitable size iron angle of 35 × 35 × 3 mm; painted with best quality epoxy coatings in black and white bands; the details of symbol for each board shall be as per the instruction of Engineer-in-Charge; the fixing at site shall be in 1:2:4 cement concrete block of size 45 × 45 × 60 cms for each leg including excavation, curing etc., complete under the supervision of Engineer-in-Charge; a warranty for 10 years for the retro-reflective sheeting from original manufacturer and a certified copy of 3-year outdoor exposure test report from third-party test laboratory for the product offered shall be submitted by the contractor. (A) Class-C Type-XI Retro-Reflective Sheeting

**Item No. 56**

**Providing and fixing STOP sign boards** made out of 2 mm aluminium sheet / 4 mm ACP (Aluminium Composite Panel), of size 900 mm octagonal, as per the design and specifications of IRC-67:2012. The board shall be pre-treated with phosphating process and acid etching, coated with one coat of epoxy primer and two coats of best quality epoxy paint, and reflectorised with Micro-Prismatic Grade retro-reflective sheeting, Class-C, Type-XI, conforming to ASTM D-4956 and latest MoRT&H specifications. The sign shall be fixed on a 3.6 m long support post made of 75 × 75 × 6 mm square MS section / 65 NB circular MS pipe, as required. The frame shall be fabricated from 35 × 35 × 3 mm MS angle and painted with best quality epoxy coatings in black and white bands. The symbols and lettering on the sign board shall be as per the instructions of the Engineer-in-Charge. The sign shall be fixed at site in a 1:2:4 cement concrete foundation block of size 450 × 450 × 600 mm for each leg, including excavation, concreting, curing, and all incidental works, complete under the supervision of the Engineer-in-Charge. The contractor shall provide a 10-year warranty for the retro-reflective sheeting from the original manufacturer and submit a certified copy of a 3-year outdoor exposure test report from a third-party test laboratory for the product offered. (A) Class-C Type-XI Retro-Reflective Sheeting

**Item No. 57**

**Facility Informatory Sign :-**Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 80 x 60 cms rectangular as per design of IRC-67-2012. Pre treated with phospheting process & acid etching; coated with one coat of epoxy primer and two coats of best quality epoxy paint ;reflectorised with Micro Prismatic Grade retro reflectivesheeting of Type-11 as per ASTM D-4956 and latest M.O.S.T.Specifications; 3.6mtr long stand post of 75 x 75 x 6mm / 65NB Circular MS Pipe as required and frame fabricated from suitable size iron angle of 35 x 35 x 3mm; painted with bestquality epoxy coatings in black and white bends. The details of symbol foreach board shall be as per theinstruction of engineer in charge. The fixing at site shall be in 1:2:4 CC blockof size 45 x 45 x 60 Cms. for each leg.including excavation, curing etc.complete under the supervision of engineer in charge. A warranty for 10 years for the Retro reflective sheeting from original manufacturer & a certified copy of 3 year outdoor exposure test report from third party test lab for the product offered shall be submitted by contractor. (A) Class-C Type-11 Retro Reflective sheeting

**Item No. 58**

**Direction (Junction) Sign :-**Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 244x122 cms. rectangular as per design of IRC-67-2012. Pre treated with phospheting process & acid etching; coated with one coat of epoxy primer and two coats of best quality epoxy paint ;reflectorised with Micro Prismatic Grade retro reflectivesheeting of Type-11 as per ASTM D-4956 and latest M.O.S.T.Specifications; 4.0mtr long (2 Nos.) stand post of 75 x 75 x 6mm / 65NB Circular MS Pipe as required and frame fabricated from suitable size iron angle of 50 x 50 x 5mm; painted with bestquality epoxy coatings in black and white bends. The details of symbol foreach board shall be as per theinstruction of engineer in charge. The fixing at site shall be in 1:2:4 CC blockof size 45 x 45 x 60 Cms. for each leg.including excavation, curing etc.complete under the supervision of engineer in charge. A warranty for 10 years for the Retro reflective sheeting from original manufacturer & a certified copy of 3 year outdoor exposure test report from third party test lab for the product offered shall be submitted by contractor. (A) Class-C Type-11 Retro Reflective sheeting

**MORTH V<sup>th</sup> REVISION Cl. No. 801, Pg. no. 325**

**801 Traffic signs****Scope**

The work shall consist of the fabrication, supply and installation of ground mounted traffic signs on roads. The details of the signs shall be as shown in the drawings and in conformity with the Code of Practice for Road Signs, IRC:67-2010.

**Materials**

The various materials and fabrication of the traffic signs shall conform to the following requirements:



## Concrete

Concrete for foundation shall be of M 15 Grade as per Section 1700 or the grade shown on the drawings or otherwise as directed by the Engineer.

## Reinforcing steel

Reinforcing steel shall conform to the requirement of IS:1786 unless otherwise shown on the drawing.

## Bolts, nuts, washers

High strength bolts shall conform to IS:1367 whereas precision bolts, nuts, etc., shall conform to IS:1364.

## Plates and supports

Plates and support sections for the sign posts shall conform to IS:226 and IS:2062 or any other relevant IS Specifications.

## Substrate

Sign panels shall be fabricated on aluminium sheet, aluminium composite panel, fibre glass sheeting, or sheet moulding compound. Aluminum sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS:736-Material Designation 24345 or 1900. Aluminium Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low Density Polyethylene (LDPE) between two thick skins/sheets of aluminium with overall thickness and 3 mm or 4 mm (as specified in the Contract), and aluminium skin of thickness 0.5 mm and 0.3 mm respectively on both sides.

The mechanical proportion of ACM and that of aluminium skin shall conform to the requirements given in Table 800-1, when tested in accordance with the test methods mentioned against each of them.

**Table 800-1 : Specifications for Aluminium Composite Material (ACM)**

| s. no.   | description   | Specification |                           |
|----------|---|---------------|---------------------------|
|          |   | standard test | acceptable Value          |
| <b>a</b> | <b>Mechanical properties of acM</b>                               |               |                           |
| 1)       | Peel off strength with retro reflective sheeting (Drum Peel Test) | ASTM D903     | Min. 4 N/mm               |
| 2)       | Tensile strength  | ASTM E8       | Min. 40 N/mm <sup>2</sup> |

|          |                                      |          |                               |
|----------|--------------------------------------|----------|-------------------------------|
| 3)       | 0.2% Proof Stress                    | ASTM E8  | Min. 34 N/mm <sup>2</sup>     |
| 4)       | Elongation                           | ASTM E8  | Min. 6%                       |
| 5)       | Flexural strength                    | ASTM 393 | Min. 130 N/mm <sup>2</sup>    |
| 6)       | Flexural modulus                     | ASTM 393 | Min. 44.00 N/mm <sup>2</sup>  |
| 7)       | Shear strength with Punch shear test | ASTM 732 | Min. 30 N/mm <sup>2</sup>     |
| <b>B</b> | <b>properties of aluminium skin</b>  |          |                               |
| 1)       | Tensile strength (Rm)                | ASTM E8  | Min. 65 N/mm <sup>2</sup>     |
| 2)       | Modulus of elasticity                | ASTM E8  | Min. 70.000 N/mm <sup>2</sup> |
| 3)       | Elongation                           | ASTM E8  | A50 Min. 2%                   |
| 4)       | 0.2% Proof Stress                    | ASTM E8  | Min. 10 N/mm <sup>2</sup>     |

### **Plate thickness**

Shoulder mounted ground signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick with Aluminium and 3 mm thick with Aluminium Composite Material. All other signs be at least 2 mm thick with Aluminium and 4 mm thick with Aluminium Composite Material. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under prevailing wind and other loads.

In respect of sign sizes not covered by IRC:67, the structural details (thickness, etc.) shall be as per the approved drawings or as directed by the Engineer.

## **801.3 Traffic Signs having Retro-Reflective Sheeting**

### **801.3.1 General requirements**

The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface.

It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for co-efficient of retro-reflection, day/night time colour luminous, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance and its having passed these tests shall be obtained from a Government Laboratory/Institute, by the manufacturer of the sheeting. The retro-reflective sheeting shall be either of Engineering Grade material with enclosed lens, High Intensity Grade with encapsulated lens or Micro-prismatic Grade retro-reflective element material as given in Clauses 801.3.2 to 801.3.7. Guidance on the recommended application of each class of sheeting may be taken from IRC:67.

### 801.3.2 High intensity grade sheeting

#### 801.3.2.1 High intensity grade (type iii)

This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic having a smooth surface or as an unmetallised micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in **table 800-2**.

**Table 800-2 : Acceptable Minimum Co-efficient of Retro-Reflection for High intensity grade sheeting (type iii) (encapsulated lens type) (candelas per lux per square Metre)**

| observation angle in degrees | entrance angle in degrees | white | yellow | orange | green | red | Blue | Brown |
|------------------------------|---------------------------|-------|--------|--------|-------|-----|------|-------|
| 0.1 <sup>0</sup> B           | -4 <sup>0</sup>           | 300   | 200    | 120    | 54    | 54  | 24   | 14    |
| 0.1 <sup>0</sup> B           | +30 <sup>0</sup>          | 180   | 120    | 72     | 32    | 32  | 14   | 10    |
| 0.2 <sup>0</sup>             | -4 <sup>0</sup>           | 250   | 170    | 100    | 45    | 45  | 20   | 12    |
| 0.2 <sup>0</sup>             | +30 <sup>0</sup>          | 150   | 100    | 60     | 25    | 25  | 11   | 8.5   |
| 0.5 <sup>0</sup>             | -4 <sup>0</sup>           | 95    | 62     | 30     | 15    | 15  | 7.5  | 5.0   |
| 0.5 <sup>0</sup>             | +30 <sup>0</sup>          | 65    | 45     | 25     | 10    | 10  | 5.0  | 3.5   |

A minimum of Coefficient of Retro-reflection (RA)  $\text{cd}/\text{fc}/\text{ft}^2$  ( $\text{cd}\cdot\text{lx}\cdot\text{m}^2$ ).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the Contract or order. When totally wet, the sheeting shall show not less than 90 percent, of the values of retro reflectance indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

#### 801.3.3 High intensity Micro-prismatic grade sheeting (Hip) (type iv)

This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in **table 800-3**.

**Table 800-3 : Acceptable Minimum Co-efficient of Retro-Reflection for High intensity Micro-prismatic grade sheeting (type iV)  
(candelas per lux per square Metre)**

| <b>observation</b> | <b>entrance</b> | <b>white</b> | <b>yellow</b> | <b>orange</b> | <b>green</b> | <b>red</b> | <b>Blue</b> | <b>Brown</b> |
|--------------------|-----------------|--------------|---------------|---------------|--------------|------------|-------------|--------------|
| 0.1° B             | -4°             | 500          | 380           | 200           | 70           | 90         | 42          | 25           |
| 0.1° B             | +30°            | 240          | 175           | 94            | 32           | 42         | 20          | 12           |
| 0.2°               | -4°             | 360          | 270           | 145           | 50           | 65         | 30          | 18           |
| 0.2°               | +30°            | 170          | 135           | 68            | 25           | 30         | 14          | 8.5          |
| 0.5°               | -4°             | 150          | 110           | 60            | 21           | 27         | 13          | 7.5          |
| 0.5°               | +30°            | 72           | 54            | 28            | 10           | 13         | 6           | 3.5          |

A Minimum Coefficient of Retro reflection (RA)  $\text{cd}/\text{fc}/\text{ft}^2$  ( $\text{cd}\cdot\text{lx}\cdot\text{m}^2$ ).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table . At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

#### **801.3.4 prismatic grade sheeting**

##### **801.3.4.1 prismatic grade sheeting (type Viii)**

The reflective sheeting shall be retro reflective sheeting made of micro prismatic retro reflective material. The retro reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro reflection (determined in accordance with ASTM E 810) as indicated in Table 800-4.

##### **801.3.4.2 prismatic grade sheeting (type ix)**

The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in Table 800-5.

**Table 800-4 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade sheeting (type Viii) (candelas per lux per square Metre)**

| observatio<br>n angle | entranc<br>e angle | white | yello<br>w | orang<br>e | gree<br>n | red | Blue | Brown | fluor-<br>escen<br>t<br>yellow | fluor-<br>esce<br>nt<br>yello | fluor-<br>escen<br>t<br>orang |
|-----------------------|--------------------|-------|------------|------------|-----------|-----|------|-------|--------------------------------|-------------------------------|-------------------------------|
| 0.1° B                | -4°                | 1000  | 750        | 375        | 100       | 150 | 45   | 30    | 800                            | 600                           | 300                           |
| 0.1° B                | +30°               | 460   | 345        | 175        | 46        | 69  | 21   | 14    | 370                            | 280                           | 135                           |
| 0.2°                  | -4°                | 700   | 525        | 265        | 70        | 105 | 32   | 21    | 560                            | 420                           | 210                           |
| 0.2°                  | +30°               | 325   | 245        | 120        | 33        | 49  | 15   | 10    | 260                            | 200                           | 95                            |
| 0.5°                  | -4°                | 250   | 190        | 94         | 25        | 38  | 11   | 7.5   | 200                            | 150                           | 75                            |
| 0.5°                  | +30°               | 115   | 86         | 43         | 12        | 17  | 5    | 3.5   | 92                             | 69                            | 35                            |

- A Minimum Coefficient of Retro reflection ( $R^A$ )  $\text{cd}/\text{fc}/\text{ft}^2$  ( $\text{cd-lx-lm}^2$ ).
- B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

**Table 800-5 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade sheeting (type ix) (candelas per lux per square Metre)**

| obser<br>-<br>vatio<br>n | entranc<br>e | white | yellow | orang<br>e | green | red | Blue | fluoresce<br>nt yellow/<br>green | fluore<br>-<br>scent<br>yello | fluore<br>-<br>scent<br>orang |
|--------------------------|--------------|-------|--------|------------|-------|-----|------|----------------------------------|-------------------------------|-------------------------------|
| 0.1° B                   | -4°          | 600   | 500    | 250        | 66    | 130 | 130  | 530                              | 400                           | 200                           |
| 0.1° B                   | +30°         | 370   | 280    | 140        | 37    | 74  | 17   | 300                              | 220                           | 110                           |
| 0.2°                     | -4°          | 380   | 285    | 145        | 38    | 76  | 17   | 300                              | 230                           | 115                           |
| 0.2°                     | +30°         | 215   | 162    | 82         | 22    | 43  | 10   | 170                              | 130                           | 65                            |
| 0.5°                     | -4°          | 240   | 180    | 90         | 24    | 48  | 11   | 190                              | 145                           | 72                            |
| 0.5°                     | +30°         | 135   | 100    | 50         | 14    | 27  | 6.0  | 110                              | 81                            | 41                            |
| 1.0°                     | -4°          | 80    | 60     | 30         | 8.0   | 16  | 3.6  | 64                               | 48                            | 24                            |
| 1.0°                     | +30°         | 45    | 34     | 17         | 4.5   | 9.0 | 2.0  | 36                               | 27                            | 14                            |

- A Minimum Coefficient of Retro reflection (RA)  $\text{cd}/\text{fc}/\text{ft}^2$  ( $\text{cd}\cdot\text{lx}\cdot\text{m}^2$ ).
- B Values for  $0.1^\circ$  observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

### 801.3.4.3 prismatic grade sheeting (type xi)

A Retro-reflective sheeting typically manufactured as a cube corner. The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in Table 800-6.

**Table 800-6 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade sheeting type a (type xi) (candelas per lux per square Metre)**

| obser<br>-<br>vatio<br>n | entranc<br>e<br>angle | white | yello<br>w | orang<br>e | gree<br>n | red | Blue | Brown | fluore<br>-<br>scent<br>yellow<br>/<br>green | fluore<br>-<br>scent<br>yello<br>w | fluore<br>-<br>scent<br>orang<br>e |
|--------------------------|-----------------------|-------|------------|------------|-----------|-----|------|-------|--|------------------------------------|------------------------------------|
| $0.1^\circ$              | $-4^\circ$            | 830   | 620        | 290        | 83        | 125 | 37   | 25    | 660  | 500                                | 250                                |
| $0.1^\circ$              | $+30^\circ$           | 325   | 245        | 115        | 33        | 50  | 15   | 10    | 260  | 200                                | 100                                |
| $0.2^\circ$              | $-4^\circ$            | 580   | 435        | 200        | 58        | 87  | 26   | 17    | 460  | 350                                | 175                                |
| $0.2^\circ$              | $+30^\circ$           | 220   | 165        | 77         | 22        | 33  | 10   | 7.0   | 180  | 130                                | 66                                 |
| $0.5^\circ$              | $-4^\circ$            | 420   | 315        | 150        | 42        | 63  | 19   | 13    | 340  | 250                                | 125                                |
| $0.5^\circ$              | $+30^\circ$           | 150   | 110        | 53         | 15        | 23  | 7.0  | 5.0   | 120  | 90                                 | 45                                 |
| $1.0^\circ$              | $-4^\circ$            | 120   | 90         | 42         | 12        | 18  | 5.0  | 4.0   | 96   | 72                                 | 36                                 |
| $1.0^\circ$              | $+30^\circ$           | 45    | 34         | 16         | 5.0       | 7.0 | 2.0  | 1.0   | 36   | 27                                 | 14                                 |

- A Minimum Coefficient of Retro-reflection (RA)  $\text{cd}/\text{fc}/\text{ft}^2$  ( $\text{cd}\cdot\text{lx}\cdot\text{m}^2$ ).
- B Values for  $0.1^\circ$  observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

### **801.3.5           Adhesives**

The sheeting shall have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent other preparation for adhesion to a smooth clean surface, in a manner recommended by the sheeting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. The sheeting shall be applied in accordance with the manufacturer's specifications.

### **801.3.6           Fabrication**

Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheeting. The aluminium sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheeting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheeting. Complete sheets of the material shall be used on the signs except where it is unavoidable. At splices, sheeting with pressure-sensitive adhesives shall be overlapped not less than 5 mm. Where screen printing with transparent colours is proposed, only butt joint 'shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

### **801.3.1           Messages/Borders**

The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut out from durable transparent overlay or cut out from the same type of reflective sheeting for the cautionary/mandatory sign boards. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. For the informative and other sign boards, the messages (legends, letters, numerals etc.) and borders shall be cut out from durable transparent overlay film or cut-out from the same reflective sheeting only. Cut-outs shall be from durable transparent overlay materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. For screen-printed transparent coloured areas on white sheeting, the coefficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in Tables 800-2 to 800-8 as applicable. Cut-out messages and borders, wherever

used, shall be either made out of retro-reflective sheeting or made out of durable transparent overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

### **801.3.2 Colour for signs**

**801.3.2.1** Signs shall be provided with retro-reflective sheeting and/or overlay film/screening ink. The reverse side of all signs shall be painted grey.

**801.3.2.2** Except in the case of railway level crossing signs the sign posts shall be painted in 250 mm side bands, alternately black and white. The lowest band next to be ground shall be in black.

**801.3.2.3** The colour of the material shall be located within the area defined by the chromaticity coordinates in Table 800-7 and comply with the luminance factor when measured as per ASTM D-4956.

**Table 800-7 : Colour Specified Limits (Daytime)**

| colour                   | 1     |       | 2     |       | 3     |       | 4     |       | daytime luminance factor (y%) |      |
|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------------------------------|------|
|                          | x     | y     | x     | y     | x     | y     | x     | y     | Min.                          | Max. |
| White                    | 0.303 | 0.300 | 0.368 | 0.366 | 0.340 | 0.393 | 0.274 | 0.329 | 15                            | --   |
| Yellow                   | 0.498 | 0.412 | 0.557 | 0.442 | 0.479 | 0.520 | 0.438 | 0.472 | 24                            | 45   |
| Green                    | 0.026 | 0.399 | 0.166 | 0.364 | 0.286 | 0.446 | 0.207 | 0.771 | 2.5                           | 11   |
| Red                      | 0.648 | 0.351 | 0.735 | 0.265 | 0.629 | 0.281 | 0.565 | 0.346 | 2.5                           | 11   |
| Blue                     | 0.140 | 0.035 | 0.244 | 0.210 | 0.190 | 0.255 | 0.065 | 0.216 | 1                             | 10   |
| Orange                   | 0.558 | 0.352 | 0.636 | 0.364 | 0.570 | 0.429 | 0.506 | 0.404 | 12                            | 30   |
| Brown                    | 0.430 | 0.340 | 0.610 | 0.390 | 0.550 | 0.450 | 0.430 | 0.390 | 1                             | 6    |
| Fluorescent Yellow-Green | 0.387 | 0.610 | 0.369 | 0.546 | 0.428 | 0.496 | 0.460 | 0.540 | 60                            | --   |
| Fluorescent Yellow       | 0.479 | 0.520 | 0.446 | 0.483 | 0.512 | 0.421 | 0.557 | 0.442 | 45                            | --   |
| Fluorescent Orange       | 0.583 | 0.416 | 0.535 | 0.400 | 0.595 | 0.351 | 0.645 | 0.355 | 25                            | --   |

The colours shall be durable and uniform in acceptable hue when viewed in day light or under normal headlights at night.



**801.3.6.1** The Regulatory/Prohibitory and warning signs shall be provided with white background and red border. The legend/ symbol for these signs shall be in black colour. The Mandatory sign shall be provided with Blue background and white Symbol/letter.

**801.3.6.2** The colours chosen for informatory or guide signs shall be distinct for different classes of roads. For National Highways and State Highways, these signs shall be of green background and for Expressways these signs shall be of blue background with white border, legends and word messages.

### **801.3.7 Refurbishment**

Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing or materials as per Clause 801.2.5, pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

### **801.3.8 Sizes of letters**

**801.3.8.1** Letter size should be chosen with due regard to the speed, classification and location of the road, so that the sign is of adequate size for legibility but without being too large or obtrusive. The size of the letter, in terms of x-height, to be chosen as per the design speed is given in Table 800-8.

**table 800-8 : acceptable limits for sizes of letters**

| <b>design speed<br/>(km./hr.)</b> | <b>Minimum 'x' Height<br/>of the letters<br/>(mm)</b> | <b>Minimum sight distance/<br/>clear Visibility distance<br/>(m)</b> | <b>Maximum distance<br/>from centre line<br/>(m)</b> |
|-----------------------------------|---|--|--|
| 40                                | 100   | 45   | 12   |
| 50                                | 125   | 50   | 14   |
| 65                                | 150   | 60   | 16   |
| 80                                | 250   | 80   | 21   |
| 100                               | 300   | 90   | 24   |
| 120                               | 400   | 115  | 32   |

The thickness of the letters and their relation to the x-height, the width, the heights are indicated in Table IV (a) of the Annexure-4 of IRC:67 to facilitate the design of the informatory signs and definition plates.

**801.3.8.2** For advance direction signs on non-urban roads, the letter size ('x' height) should be minimum of 150 mm for Expressway, National and State Highways and 100 mm for other roads. In case of overhead signs, the size ('X' height) of letters may be minimum 300 mm. Thickness of the letter could be varied from 1/6 to 1/5 of the letter 'x' size. The size of the initial uppercase letter shall be 1-1/3 times x-height. In urban areas, letter size shall

be 100 mm on all directional signs. For easy and better comprehension, the word messages shall be written in upper case letters only.

**801.3.8.3** Letter size on definition plates attached with normal sized signs should be 100 mm or 150 mm. In the case of small signs, it should be 100 mm. Where the message is long, as for instance in "NO PARKING" and "NO STOPPING" signs, the message may be broken into two lines and size of letters may be varied in the lines so that the definition plate is not too large. The lettering on definition plates will be all in upper case letters.

### **801.3.9 warranty and durability**

The Contractor shall obtain from the manufacturer a ten year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of micro-prismatic sheeting and a seven-year warranty for high intensity grade and submit the same to the Engineer. The warranty shall be inclusive of the screen printed or cut out letters/legends and their bonding to the retro-reflective sheeting. The Contractor/supplier shall also furnish the LOT numbers and certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty and that the contractor/supplier is the authorized converter of the particular sheeting.

All signs shall be dated during fabrication with indelible markings to indicate the start of warranty. The warranty shall also cover the replacement obligation by the sheeting manufacturer as well as contractor for replacement/repair/restoration of the retro-reflective efficiency.

A certificate in original shall be given by the sheeting manufacturer that its offered retro-reflective sheeting has been tested for various parameters such as co-efficient of retro-reflection, day/night time colour and luminance, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance; the tests shall be carried out by a Government Laboratory in accordance with various ASTM procedures and the results must show that the sheeting has passed the requirements for all the above mentioned parameters. A copy of the test reports shall be attached with the certificate.

### **801.4 Installation**

The traffic signs shall be mounted on support posts, which may be of GI pipes conforming to IS:1239, Rectangular Hollow Section conforming to IS:4923 or Square Hollow Section conforming to IS:3589. Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area up to 0.9 sq.m shall be mounted on a single post, and for greater area two or more supports shall be provided.

Post-end(s) shall be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

All components of signs (including its back side) and supports, other than the reflective portion and G.I. posts shall be thoroughly de-scaled, cleaned, primed and painted with two coats of epoxy/ fibre glass/ powder coated paint. Any part of support post below ground shall be painted with protective paint.

The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

#### **801.5                      Measurement for payment**

The measurement of standard cautionary, mandatory and information signs shall be in **numbers** of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured in Nos.

#### **801.6                      Rate**

The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site furnishing of necessary test certificates, warranty and incidentals to complete the work in accordance with these Specifications.