

Contract No.:

GOVERNMENT URBAN DEVELOPMENT COMPANY LIMITED

GANDHINAGAR

[A WHOLLY OWNED GOVERNMENT OF GUJARAT UNDERTAKING]



BIDDING DOCUMENT FOR

**PROPOSED 2-LANE RAILWAY OVER BRIDGE IN LIEU OF LC. NO. 48A BETWEEN RLY KM. 629/3 TO 629/4,
NEAR DHRANGADHRA RLY. STATION, DHRANGADHRA.**

VOLUME – II

PART-II (GENERAL TECHNICAL SPECIFICATION-CIVIL)

GOVERNMENT OF GUJARAT

By

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(Through e- Procurement Portal only - <https://gudctender.nprocure.com/>)

GENERAL TECHNICAL SPECIFICATION (CIVIL)

Item No. 1

Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth upto 3.0 M. and lead upto 100m for 10 Cum (For Railway Pier).

Relevant Specifications of MORT&H fifth revision Section – 304 shall apply to this item.

1 Excavation for Structures

1.1 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.

1.2 Classification of Excavation

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

1.3 Construction Operations

1.3.1 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.

1.3.2 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.

1.3.3 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.

1.3.4 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 upto 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 upto 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.

1.3.5 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.

1.3.6 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.

1.3.7 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.

1.3.8 Disposal of Surplus Excavated Materials

Clause 301.3.11 shall apply.

1.4 Measurements for Payment

Excavation for structures shall be measured in cum 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.

1.5 Rates

1.5.1 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.

1.5.2 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.

Item No. 2

Excavation in large boulders and soft rock by welding including shoring, strutting and dewatering as necessary and disposing of the excavated stuff as directed (For Railway Pier).

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 murrum, 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 murrum 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 200m 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

The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

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 Top soil

When so directed by the Engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths and stock piled 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 upto 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 murrum 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 re-laid 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 of with all leads 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 leads 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 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 1/3rd 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.

304 EXCAVATIONS 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 horizontals 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 upto 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 upto 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.

Item No. 3

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 (For Railway Pier).

1. The relevant specifications given for machine mixed plain cement concrete **M15** grade as per Section -1500, 1700 & 2100 of MORT&H fifth revision specification.
2. The measurement & payment shall be per **cum** basis.
3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.

Item No. 4

Providing and Casting in situ Controlled Cement Concrete M35 for R.C.C. Raft footing and cutt-off walls including necessary shuttering laying, vibrating, ramming and curing complete (For Railway Pier).

1. The relevant specifications given for machine mixed plain cement concrete **M35** grade as per Section - 1500, 1700 & 2100 of MORT&H fifth revision specification.
2. The measurement shall be per **cum** basis.

3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
4. The mode of payment shall be in per **cum**. Basis.

Item No. 5

Providing and placing in position FE 550D (With CRS) TMT bar reinforcement for following items including cutting bending hooking and tying complete as per detailed drawing. For RCC Railway Pier Raft & Open foundation.

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1009 & 1600 shall apply to this item.
2. The measurement shall be in **MT** basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **MT**. basis.

Item No. 6

Providing and filling trenches of Labour charges - Excavator in rocky strata with ordinary cement concrete M-15 (For Railway Pier).

1. The relevant specifications given for machine mixed plain cement concrete **M15** grade as per Section -1500, 1700 & 2100 of MORT&H fifth revision specification & as per relevant RDSO specification.
2. The measurement shall be per **Cum** basis.
3. The rate includes tamping, vibrating, levelling and curing complete with all formwork, dewatering wherever required including all materials, labours, plants, machineries & tools, all leads and lifts, etc. complete as per specification.
4. The mode of payment shall be in per **cum**. basis.

Item No. 7

Filling available excavated earth (excluding rock) in trenches. plinth, sides of foundations etc. in layers not exceeding 20 cm. in depth consolidating each deposited layer by ramming and watering (For Railway Pier).

1. Relevant Specifications of MORT&H fifth revision Section – 304 shall apply to this item.
2. The measurement & payment shall be in **Cum** basis.

Item No. 8

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 Upto 5.0 M."

(B) Height 5.0M to 10.0M

(C) Height 10.0M to 15.0M

1. The relevant specifications given for machine mixed plain cement concrete **M35** grade as per Section -1500, 1700 & 2200 of MORT&H fifth revision specification.
2. The measurement shall be per **cum** basis.

3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
4. The mode of payment shall be in per **cum**. Basis

Item No. 9

Providing and laying in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending, hooking and tying complete as per detailed drawings for the following. (A) Piers

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1600 & 1009 shall apply to this item.
2. The measurement shall be in **MT** basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **MT**. basis.

Item No. 10

Providing and laying in situ machine mixed controlled M-35 grade cement concrete for RCC caps, side walls, tie walls etc. including M:40 pedestals over piers and abutments including necessary scaffolding formwork, centering, transporting, placing, compacting by mechanical vibrators, finishing and curing and casting, finishing at any height or depth as per drawing etc. complete excluding reinforcement, as directed by Engineer and as per specification.

Pedestals in M:40

Seismic Restrainer in M:40

1. The relevant specifications given for machine mixed plain cement concrete **M35 & M40** grade as per Section -1500, 1700 & 2200 of MORT&H fifth revision specification.
2. The measurement shall be per **cum** basis.
3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
4. The mode of payment shall be in per **cum**. Basis.

Item No. 11

Providing & fixing in position (Thermo mechanically treated bars) FE 550D (With CRS) TMT bar steel bars of various diameters for all RCC works in Foundations, Pier, Abutment wall, box wall, Abt. cap, Dirt wall, side wall, Retaining wall, Pedestals as per detailed design & drawings and schedule including cutting, bending, hooking the bars, binding with 18 SWG GI wires and supporting as required with all lifts and leads etc. complete including cost of all labour, materials, tools, plants, equipments etc. all complete as directed by Engineer and as per specifications.

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1600 & 1009 shall apply to this item.
2. The measurement shall be in **MT** basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding,

- forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **MT**. basis.

Item No. 12

Providing and applying anti carbonation, anti fading, mold resistant, heat insulating, and 100% acrylic breathable decorative external waterproof coating of approved shade having Viscosity @ Room Temperature by Ford cup No. B-4 (dilute 2 parts of product with 1 part of water) 18 to 30 sec. pH of 7.00 to 10.00 and Sp. Gravity @ Room Temperature 1.30+0.1, tested for carbon dioxide diffusion resistance properties for coating materials and coating systems for open atmosphere surface of substructure as well as superstructure as per DIN EN 1062-6 (2002-2010) by a NBA Grade "A" accredited institution (For Railway Pier).

1. Relevant specifications shall apply as per item description and as directed by engineer in charge.
2. The measurement shall be on the basis of **Sqm**.
3. The mode of payment shall be in per **Sqm** basis.
4. The rate include labour, material, equipment required for complete this item.

Item No. 13

Design, supply, fitting and fixing in position true to line and level POT-PTFE bearing of 250 MT Capacity, consisting of a metal piston supported by a disc or un reinforced elastomer confined within a metal cylinder, sealing rings, dust seals, PTFE surface sliding against stainless steel mating surface, complete assembly to be of cast steel / fabricated structural steel, metal and elastomer elements complete as per IS:2062, IS:1030, AISI:304, AISI:316, IS:6911, BS:3784, IS:3400, IS:226, BS-5400, Bridge Code and as per approved drawing and Technical Specifications. The design of the bearings shall be submitted by the manufacturers / contractor and got approved from Railway before fixing. Test report after inspection of the bearings shall be submitted and got approved before the materials are lifted from the manufacturer premises.

POT-cum -PTFE Bearing (Free end)

POT Bearing-Fixed Type

POT-cum -PTFE Guided (L)Bearing

POT-cum -PTFE Guided (T)Bearing

1. The relevant specifications for POT cum PTFE bearings as per Section-2006 & 2000 of MORT&H fifth revision Specifications shall apply to this item.
2. The measurement shall be in each **MT** bearing basis.
3. The rate is for finished item complete and paid only after fixing in position below the girder.
4. The bearing shall be procured from the MORTH approved manufacturer only.

Item No. 14

Providing and fixing mild steel dowel bars of minimum 32 mm 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 (For Railway Portion).

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1600 shall apply to this item.
2. The measurement & payment shall be in **Rmt** basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.

Item No. 15

Providing and Casting in situ controlled cement concrete M 40 for R.C.C. Deck Slab including centering, scaffolding , curing and finishing complete (For Railway Portion).

1. The relevant specifications given for machine mixed plain cement concrete **M40** grade as per Section -1500, 1700 & 2300 of MORT&H fifth revision specification.
2. The measurement shall be per **cum** basis.
3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
4. The mode of payment shall be in per **cum**. Basis

Item No. 16

Supplying, fabrication, assembling of all types of steel girders of specified spans with structural steel conforming to Quality "B0" Grade Designation E250 conforming to IS:2062, erection / slewing / end launching of steel girders with cranes or any other approved launching methods as per site conditions (not requiring traffic block) on substructure including provision of trolley refuges etc., complete as per approved QAP and drawings conforming to IRS-B1-2001 and other relevant codes and specifications.

Note:

1. Detailed fabrication and erection drawings & launching methodology will be prepared by the contractor and got approved from Railway.
2. The rate is all inclusive including launching in position, complete in all respect except cost of (i) Painting / Metalising; (ii) Bearings & (iii) HSFG bolts which shall be paid extra under relevant item.
3. The payment shall be made on the theoretical weight of main components and gusset plates only.
4. **Payment Schedule:**
(i) Receipt of material at site: 40%
(ii) Fabrication of girders: 20%
(iii) Erection/Launching: 20%
(iv) Completion in all respects: 20%"

**Plate Girder/Semi Through Girder/Composite Girder (Steel Work)
(Composite steel girder of span length above 36.0m)"**

1. The relevant specifications as per relevant RDSO specification & as per relevant MORTH specification Section 1900.
2. The measurement and payment shall be in MT. basis.
3. The rate includes for supply, loading, unloading, transporting to site. Welding and supporting in position to ensure lines and levels including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.

Item No. 17

Extra for using steel conforming to Grade Designation E350 instead of Grade Designation E250 of Quality "B0" as per IS: 2062

1. The relevant specifications as per relevant RDSO specification & as per relevant MORTH specification Section 1900.
2. The measurement and payment shall be in MT. basis.
3. The rate includes for supply, loading, unloading, transporting to site. Welding and supporting in position to ensure lines and levels including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.

Item No. 18

Supplying and fixing HSFG bolts of any dia and any length with suitable nuts including DTI washers conforming to IRS-B1-2001 for bridges and steel structures with contractors labour, tools and plants and lead and lift etc., complete.

1. The relevant specifications as per relevant RDSO specification & as per relevant MORTH specification Section 1900.
2. The measurement and payment shall be in **KG.** basis.
3. The rate includes for supply, loading, unloading, transporting to site. Welding and supporting in position to ensure lines and levels including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.

Item No. 19

Metallizing of steel work of girders with sprayed aluminium after surface preparation by Sand/grit blasting, followed by one coat of etch primer (IS:5666) & one coat of Zinc Chrome primer (IS:104) and two coats of aluminium paint (IS:2339) with all labour, T&P and material as a complete job duly conforming to all relevant specifications and process given under Clause 39 of IRS-B1-2001. Note: Nominal Thickness of sprayed Aluminium coating shall be 150 microns. DFT of Zinc chrome primer shall be 25-30 microns and DFT of each coat of Aluminium paint shall be 12-14 microns.

1. The relevant specifications as per relevant RDSO specification & as per relevant MORTH specification Section 1900.
2. The measurement shall be in Sqm. basis.
3. The rate includes for supply, loading, unloading, transporting to site. Welding and supporting in position to ensure lines and levels including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **Sqm.** Basis

Item No. 20

Providing and placing in position FE 550D (With CRS) TMT. Bar reinforcement including, cutting, bending hooking and tying complete as per detailed drawings.(I) Solid Slab.(II) Deck Slab.

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1600 & 1009 shall apply to this item.
2. The measurement shall be in MT basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **MT.** basis.

Item No. 21

Providing and casting RCC in M-40 controlled concrete Crash Barriers as per detailed drawings including necessary scaffolding, centering, formwork, mixing in machine, transporting, placing, compacting, finishing, curing, etc. complete including providing and fixing of inserts if any with all leads and lifts as per drawing & specification and as directed by Engineer, excluding reinforcement (For Railway Portion).

1. The relevant specifications given for machine mixed plain cement concrete **M40** grade as per Section -1500, 1700 & 2700 of MORT&H fifth revision specification & as per relevant RDSO specification.
2. The measurement shall be per **Cum** basis.
3. 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, de shuttering 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. Note:- Rates in items shall include cost of providing grooves, chamfers, moulding, cut-out etc. in formwork. The work will include placing in position of necessary fixtures, sleeves for various purposes, etc. complete as per drawings, specifications and as directed by the Engineer in charge. The rate shall also include preparation of construction joints as per specifications and provide approved wire mesh/weld mesh at such location as approved by the Engineer-in-charge or as shown in drawings.
4. The mode of **payment shall be in per cum.** basis.

Item No. 22

Providing and laying precast RCC footpath slab in controlled cement concrete of M:20 grade (7 cm thickness including necessary reinf.) and providing and setting cement chequered tiles in C.M. 1:5 as per drawing including necessary formwork, cutting and finishing complete.

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:

- a) 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.
- b) 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.
- c) 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

410.3.1 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.

410.3.2 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.

410.3.3 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.

410.3A 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).

410.3.5 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.

410.3.6 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.

IS Sieve Size	Percent Passing
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

IS Sieve Size	Percent Passing
2.36 mm	100
1.18 mm	0-100
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 ± 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

Sub-Bases, Bases (Non-Bituminous) and Shoulders

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. 23

Providing and fixing post and pipe railing as per detailed drawing including 3 coats of painting to steel works complete.

1. The relevant specification for MorT&H Clause No. 810 shall apply to this item.
2. The measurement & payment shall be in **RMT** basis.

Item No. 24

Providing and fixing in position (Thermo mechanically Treted bars) FE 550D (With CRS) TMT bar reinforcing bars of various diameters for the Crash Barrier as per detailed designs and drawings and schedule including cutting, bending, hooking the bars, binding with 18 SWG GI wires with cost of all labour, materials, tools, plants, equipments, supporting as required with all lifts and leads etc. all complete as per specification and as directed by Engineer.

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section 1600 & 1009 shall apply to this item.
2. The measurement shall be in MT basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.
4. The mode of payment shall be in per **MT**. basis.

Item No. 25

Providing and laying Double Walled corrugated Pipes (DWC) of Polyethylene (conforming to IS:14930-II) of 50mm O.D. / 38mm I.D. with fittings and necessary connecting accessories of same material at required depth for laying cable below footpath slab etc. complete as per specification and as directed by Engineer (For Railway Portion).

1. The relevant specifications as per IS 4985 Specification
2. Relevant specifications given for above work as described shall be applicable to this item.
3. The measurement shall be in **Rmt**.
4. The rate for this item includes all materials, labour, and everything required to execute this item etc. complete and as directed by engineer in charge.
5. The mode of payment shall be in per **Rmt**. basis.

Item No. 26

Providing and fixing 100 mm dia. G.I. Drainage spouts, as per MOST Drg. No SD/303 including grating with suitable clean out fixtures including all leads and lifts etc. complete as per specification, design & drawings and as directed by Engineer (For Railway Portion).

1. The relevant specifications given for as per Section 2705 of MORT&H fifth revision specification.
2. Material for the drainage spout shall be as mentioned in the item and shall be got approved from the Engineer-in-charge.
3. Water spout shall be 100 mm internal dia. G.I. rating shall be provided at the entry and shall be fixed in the recess so as to be flush with the road surface. The quality and size of the grating shall be got approved for the Engineer-in-charge. The drainage spouts shall project at least 10 cm. outside the concrete and shall be rigidly fixed in it. The grating and C.I. pipes shall be painted with two coats of anticorrosive black bitumen paint.
4. Measurement & **payment shall be per number** of drainage spout fixed.
5. Unit rate includes necessary iron gratings as per drawings.

Item No. 27

Providing, laying and jointing in true line and level 110 diameter U.P.V.C (Type B) conforming to IS 13592-1992 with one end plain and other end socketed with rubber ring, & fittings conforming to ISI 14735-1999 of approved make for drainage system pipe line, pipe shall be jointed with each other with rubber lubricant, pipe shall be fixed on wall using of PVC clamp of the size 110 mm diameter x 149 mm length x 145 mm height at every 2000 mm center to center or shall be concealed in walls as directed including necessary fittings such as bends, shoes etc. including testing of pipes and joints and jointed with adhesive solvent cement including cost of all materials.(For Downtake / longitudinal runner pipe (For Railway Portion))

1. The relevant specification for MorT&H Clause No. 2700 shall apply to this item.
2. The measurement & payment shall be in **RMT** basis.

Item No. 28

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) - For inner face of crash barrier of Railway Portion

INTRODUCTION:

The objective of this work is to supply and application of a finish coat of Synthetic Enamel Paint on new concrete surface.

SCOPE OF WORK:

The contractor's scope of work shall comprise but not limited to the following:-

1. Preparation of all types of surfaces to be painted by removing all loose material / paint, dust, stain etc.
2. Supply & application of primer / putty wherever required.
3. Supply & application of one finish coat of Synthetic Enamel Paint of approved brand on concrete surface
4. Supply & application of Synthetic Enamel Paint of approved brand / make as per Annexure -1 on PPS fence & other as per specification and relevant item.

MATERIAL AND WORKMANSHIP:

1. All the materials, to be used in the work for the purpose of contract shall be as per standards / specifications and relevant test certificates showing requisite properties. The test certificates shall be submitted to the Engineer for his verification. Paints without test certificates or expired paints shall not be accepted.
2. All paints and paint constituents to be used for the work shall be delivered to the work area in

- original sealed containers, bearing manufacturer's labels, batch No., date of manufacture etc.
3. Constituent adhesives such as thinner, driers etc. shall be those recommended by the paint manufacturer.
 4. The workmanship shall be one of the best class achievable in the industry and acceptable to the Engineer. Rectification on account of poor workmanship shall be done by the contractor to the satisfaction of Engineer.

Materials Required For Painting First Coat Primer and Two Subsequent Coats

Application of primer on walls / Concrete surfaces:-

- Ø Cement primer
- Ø Turpentine
- Ø Putty
- Ø Polish paper
- Ø Wood primer
- Ø Emery polish paper
- Ø Water

DESCRIPTION OF ACTIVITIES TO BE CARRIED OUT AT SITE:

Preparation and cleaning of surface before painting:

- a. The existing painted surface should be cleaned thoroughly by using scrapers, wire brushes, emery paper, buffing wheels etc., thus making it free from all oil & grease, loose particles, rust, dust etc. to receive the finish coat.
- b. Surfaces shall be thoroughly cleaned to remove any dust, oil & grease with suitable cleaning agent followed by rinsing with clean water. Damaged painted areas shall be scrubbed thoroughly to achieve a clean surface. Pits / abrupt undulations shall be filled with compatible putty wherever required.

Walls, floors & ceiling and adjacent equipments and piping shall be satisfactorily protected by drop clothes.

Other precautionary measures should be taken during spray / brush painting to ensure that surrounding area /equipment is not affected.

Application of paint:

The application should be as per manufacturer's instructions / specifications. Before opening the packed drum, it should be rolled on the floor and after opening the drum paints shall be stirred well so that no material/ pigments remains settled at the bottom. Suitably the paint shall be checked as per requirement before opening.

The choice of method of application i.e. by brush or by spray gun will be decided by the Engineer. However, adjacent equipment / structures shall be suitably protected and care shall be taken to prevent intoxication of the surrounding area. The method of paint application depending upon the area shall be jointly discussed and decided with Engineer. Paint thickness (DFT) shall be as per the item scheduled. In case the dry film thickness of finish paint is observed less than the specified values, additional coat shall have to be applied free of charge.

Inspection & check:

All the work is subject to the inspection of the Engineer or his authorized representative which shall be carried out in a manner, satisfactory to the Engineer. The contractor shall rectify any short comings pointed out by the said representative. The general inspection requirements are as follows:-

- a) No paint shall be applied until the authorized inspection has ascertained that all prepared surfaces are satisfactorily cleaned and are in a condition to ensure the proper receipt of and adhesion of the coating.
- b) The contractor shall furnish all gauges, instruments and the necessary measuring equipments required for inspecting the work, test pieces, samples etc. at site and in the shop. The

Engineer's authorized representative is intended to ensure that the material and workmanship are in accordance with this specification, but it will not relieve the contractor for any of his responsibilities for the ultimate workmanship and performances.

EQUIPMENT TO BE USED IN PAINTING WORK:

- i) Drop cloth / polythene sheets:
Drop cloth and polythene sheets of suitable size & quality shall be used to protect other materials and surfaces.
- ii) Masking:
The masking material where-ever necessary shall be used in sufficient quantities to avoid falling of paint on unwanted surfaces.
- iii) Grinding / buffing wheels, wire brush & emery paper.
- iv) Electrical distribution panels switch boards & hand lamps.
- v) Kerosene, thinners, acetone etc. to remove oil / grease etc.
- vi) Painting brush:
Good quality brushes with long and flexible bristles free from any paint residue shall be used.
- vii) Neat, clean & painted scaffoldings of good quality.
- viii) Good quality ladders, platforms etc.
- ix) Safety gears to be used by personnel like respirator, face mask, hand gloves, protective clothing etc.

MAN POWER:

Experienced man power including Engineers, supervisors, inspectors and painters shall be deployed on the work. The painters shall have to be qualified by EIC before start of work. All other personnel shall be duly authorized by Site in-Charge before deploying them into work. A safety supervisor shall also be deployed for monitoring & instructing the safety aspects during the work.

INSPECTION REPORTS:

Inspection Reports in mutually agreed format shall be submitted along with completion of the work. Each RA Bill shall be submitted with inspection reports of the quantities billed for.

PROGRESS MONITORING:

The contractor shall submit a weekly report and a monthly report in mutually agreed format for monitoring the progress of work.

LIST OF APPROVED SYNTHETIC ENAMEL PAINTS

Approved Synthetic Enamel Paints Manufacturer

- i) Apcolite M/s Asian Paints
- ii) Luxol M/s Berger Paints
- iii) Neromin Synthetic Enamel M/s Kansai Nerolac Paints Ltd.
- iv) Tuffkote Chemical Resisting Enamel M/s Shalimar Paints

Application of paint:

Brushing operations are to be adjusted to the spreading capacity advised by the manufacture of particular paint. The paint shall be applied evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the -laying off is finished. The full process of crossing and laying off will constitute one coat.

Each coat shall be allowed to dry completely and lightly rubbed with very fine grade of sand-paper and loose particles brushed off before next coat is applied. Each coat shall vary slightly in shade and shall be got approved from Engineer-in-charge before next coat is started.

Each coat the last shall be lightly rubbed down with sand paper of fine pumice stone and cleaned of

dust before the next coat is applied. No hair marks from the brush or logging of paint puddles in the corners of panels, angles of moldings etc. shall be left on the work.

Special care shall be taken while painting over bolts, nuts, rivets, overlaps etc. Approved best quality brushes shall be used.

Scaffolding:

Where scaffolding is required, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be painted. A properly secured strong and well tied suspended platform (joola) may be used for painting. Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

MODE OF MEASUREMENT & PAYMENT:

The unit rate Painting two coats (including priming coat) on new R.C.C. shall include the cost of all materials, tools and plant required for mixing paint, placing & painting in position, all required specials and jointing adhesive compound, finishing as per direction of the Engineer-in-charge, and all other incidental expenses as shown on the drawings and according to these specifications. They shall also include the cost of making, fixing and removing of all scaffolding and forms required for the work.

The rate of Painting two coats (including priming coat) on new R.C.C. shall include the cost of all labour, materials tools and plant scaffolding and all incidental expenses as described herein above.

The Painting two coats (including priming coat) on new R.C.C. work shall be measured for its length and width or Height limiting dimensions to those specified on plan or as directed.

Item No. 29

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 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). (For Railway Portion).

CEMENT PAINT

Material

- The cement Paint shall be (conforming to IS 5410) of approved brand and manufacture.
- The cement Paint shall be brought to the site of work by the contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Engineer-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the Engineer-in-Charge.

Preparation of Surface

- For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly.

Preparation of Mix

- Cement Paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement Paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement Paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement

Paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

- The lids of cement Paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement Paint rapidly becomes air set due to its hygroscopic qualities.
- In case of cement Paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

Application

- The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement Paint shall be as per manufacturer's specification. The completed surface shall be watered after the day's work.
- The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.
- For new work, the surface shall be treated with three or more coats of water proof cement Paint as found necessary to get a uniform shade.
- For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

Precaution

- Water proof cement Paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, Paints etc. It shall not be applied on gypsums, wood and metal surfaces.
- If water proofing cement is required to be applied on existing surface, previously treated with white wash, colour wash etc., the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc. completely. Thereafter, a coat of cement primer shall be applied followed by two or more coat of water proof cement.

Scaffolding:

- Where scaffolding is required, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be painted. A properly secured strong and well tied suspended platform (joola) may be used for painting. Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

MODE OF MEASUREMENT & PAYMENT:

- The unit rate wall painting on concrete surface with water based cement paint shall include the cost of all materials, tools and plant required for mixing, cleaning brushing sand papering & painting with all required specials and Lapi compound, finishing as per direction of the Engineer-in-charge, and all other incidental expenses for producing pipe line work of specified diameter to complete the structure or its components as shown on the drawings and according to these specifications. They shall also include the cost of making, fixing and removing of all scaffolding and forms required for the work.
- The rate of Wall painting with water based cement paint shall include the cost of all labour, materials tools and plant scaffolding and all incidental expenses as described herein above.
- The Wall painting with water based cement paint shall be measured for its length and Height limiting dimensions to those specified on plan or as directed. The rate shall be for a unit of one square meter.

The payment will be made on **square Meter** basis of the finished work.

Item No. 30

Supplying, Fabricating and fixing access ladders, inspection platforms on bridges with structural steel conforming to IS:2062 including welding / bolting, priming painting with one coat of ready mixed paint of Zinc Chromate (IS:104) with DFT of 25-30 microns followed by one coat of Zinc Chrome Red Oxide (IS:2074) with DFT of 25 microns with all material, labour,

T&P as a complete job as directed by Engineer-in Charge.

1. The relevant specifications as per relevant RDSO specification & as per relevant MORTH specification Section 1900.
2. The measurement and payment shall be in **M.T.** basis.

Item No. 31

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 joints with bitumen complete.

1. The relevant specifications given for machine mixed plain cement concrete **M40** grade as per Section – 1000, 1500, 1700 & 2700 of MORTH fifth revision specification.
2. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
3. The measurement and payment shall be in **Cum** basis

Item No. 32

Providing and fixing in position FE 550D TMT (with CRS) bar reinforcement including cutting, bending and tying complete as per detailed drawings. (A) R.C.C. Wearing coat . (upto 10 ton)

1. The Relevant Specification of Item No. 5 shall apply to this item.
2. The measurement and Payment shall be per MT basis.

Item No. 33

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 @ 250 gms per sqm area, thickness of 2.5 mm is excluding of surface applied glass beads as per IRC: 35-2015. The finished surface to be leveled, uniform and free from streaks and holes. Zebra patta/bump patta lane/centre line/edge line/cut patta. The white colour marking should provide luminance coefficient on cemented road shall be 130 mcd / m² / lux and asphalt roads shall be minimum 100 130 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 (For Railway Portion).

1. The relevant specifications given in Section – 800 of MORTH fifth revision and latest GR of R&B Department as per SOR/ 1018/715/ C-1 part file specification shall apply to this item.
2. The measurement shall be in Sq.mt basis.
3. The rate includes of reflect rising glass beads at 250 gm/smt area. Thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC 35. The finished surface to be level uniform free from streaks and holes and as per direction of engineer in charge.
4. The mode of payment shall be in per **Sq.mt** basis.

Item No. 34

Cat Eye / Road Stud / RPM: Supplying of Molded Twin Shanks 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 strength of detachment of the integrated cylindrical shanks, (of diameter not

less than 19 +/- 2 mm and height not less than 30 +/- 2 mm) from the body is to be a minimum value of 500 Kgf. Fixing will be by drilling holes on the road for the shanks to go inside, without nails and using epoxy resin based adhesive as per manufacturer's recommendation and The color of the marker should be as per the IRC 35-2015 and as directed by Engineer-in-charge (For Railway Portion).

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

Item No. 35

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 (C) By mechanical means in area of light jungle.

Relevant Specifications of MORT&H fifth revision Section – 201 shall apply to this item.

1. CLEARING AND GRUBBING

1.1. Scope

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

1.2. Preservation of Property/Amenities

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

During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that effect vide Clause 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.

1-3. Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tier 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 foil within 500 mm 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. On areas beyond these limits, trees and stumps required to be removed as directed by the Engineer shall be cut down to 1 m below ground level so that these do not present an unsightly appearance.

All branches of trees extending above the 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.

1.4. Disposal of Materials

All materials arising from clearing and grubbing operations shall be the property of Government and shall be disposed of by the Contractor as hereinafter provided or directed by the Engineer.

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

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

1.5. Measurements for Payment

Clearing and grubbing for road embankment, drains and cross-drainage structures shall be measured on area basis in terms of hectares. 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. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the cleaning and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

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

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

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

1.6. Rates

- 1.6.1. The Contract unit rates for the various items of clearing and grubbing shall be payment in full-for carrying out, the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm ingirth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lifts to any lead. Unit rate based on Hectare basis.
- 1.6.2 The Contract unit rate for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and backfilling to required compaction, handling, salvaging, pilingand disposing of the clearedmaterials with all lifts and any lead.
- 1.6.3. Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the same shall be considered as including clearing and grubbing operations.
- 1.6.4 The mode of payment shall be in hectare basis.

Item No. 36

Demarkation of road alignment including marking out road line by providing and fixing wooden pegs or steel rod of required size at every 25 M to 50 M including excavating trenches ion both sides of 0.30 m x 0.30m including supplying of labours and all materials for every work etc complete.

1. Relevant Specifications of MORT&H fifth revision Section – 109 shall apply to this item.
2. The center line axis of the dual two-lane bridge is to be done for bridge and also for approaches / retaining walls in both ends shall be surveyed along their lengths. Center line pegs for each two-lane bridge, ramps including foundation pegs at each location and at suitable distance of 3.0 m c/c along the approach on each side shall be fixed.
3. All deviation angles of the central line axis for both the two-lane bridge including tangent distances shall be demarcated with pegs fixed in to the ground.
4. The rate on Lump sum basis shall include all equipment, survey instruments, necessary survey party, supply and fixing of pegs including, fixing of pillars for intermediate stations established GTS bench mark at every 200 m distance, labour, materials required in completing the job as required, as per direction of Engineer-in-charge.
5. Contractor has to carry out full topographical survey including working of center line with total station instrument.
6. The measurement and payment shall be paid per **Km**.

Item No. 37

Dismantling the existing structure including removing and stacking the dismantled materials as and where directed - RCC work & Rubble Masonary

(A) RCC work

(B) Rubble / brick masonry

(C) Structural steel work

Relevant Specifications of MORT&H fifth revision Section – 202 shall apply to this item.

202 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES / PAVEMENTS

202.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavements,

kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., from the right of way which in the opinion of the Engineer interfere with the construction of road or are not suitable to remain in place, disposing of the surplus/unsuitable materials and backfilling to after the required compaction as directed by the Engineer.

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

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

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

202.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the part of the structure to be retained and any other properties or structures nearby:

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed up to at least 600 mm below the sub-grade, slope face or original ground level whichever is the lowest or as necessary depending upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

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

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

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber having salvage value as is designated by the Engineer.

202.3 Dismantling Pavements and Other Structures

In removing pavements, kerbs, gutters, and other structures like guard-rails, fences, holes, catch basins, inlets, etc., where portions of the existing construction are to be left e finished work, the same shall be removed to an existing joint or cut and chipped to a line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to

provide for proper grades and connections with the new work as directed by the Engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for oval shall be broken to pieces whose volume shall not exceed 0.02 cum and used with approval of the Engineer or disposed of.

202.4 Back-filing

Holes and depressions caused by dismantling operations shall be backfilled with excavated her approved materials and compacted to required density as directed by the Engineer.

202.5 Disposal of Materials

All Surplus materials shall be taken over by the Contractor which may either be re-used with approval of the Engineer or disposed of with all leads and lifts.

202.6 Measurements for Payment

The work of dismantling shall be paid for in units indicated below by taking measurements re and after, as applicable:

i)	Dismantling brick/stone masonry/ concrete (plain and reinforced)	cu.m
ii)	Dismantling flexible and cement concrete pavement	cu.m
iii)	Dismantling steel structures	Kg.
iv)	Dismantling timber structures	cu.m
v)	Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m
vi)	Utility services	No.

202.7 Rates

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. The rates will include excavation and backfilling to the required compaction and for handling, giving credit towards salvage value disposing of dismantled materials with all lifts and leads.

Item No. 38

Dismantling of flexible pavements and disposal of dismantled materials with all leads and lifts, stacking serviceable and unserviceable materials. By Mechanical means.

Relevant Specifications of MORT&H fifth revision Section – 202 shall apply to this item.

1 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/ PAVEMENTS

1.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavements, kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., from the right of way which in the opinion of the Engineer interfere with the construction of road or are not suitable to remain in place, disposing of the surplus/unsuitable

materials and backfilling to after the required compaction as directed by the Engineer.

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

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

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

1.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the part of the structure to be retained and any other properties or structures nearby:

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed up to at least 600 mm below the sub-grade, slope face or original ground level whichever is the lowest or as necessary depending upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

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

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

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber having salvage value as is designated by the Engineer.

1.3 Dismantling Pavements and Other Structures

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

All concrete pavements, base courses in carriageway and shoulders etc., designated for oval shall be broken to pieces whose volume shall not exceed 0.02 cu.m and used with approval of

the Engineer or disposed of.

1.4 Back-filing

Holes and depressions caused by dismantling operations shall be backfilled with excavated her approved materials and compacted to required density as directed by the Engineer.

1.5 Disposal of Materials

All Surplus materials shall be taken over by the Contractor which may either be re-used with approval of the Engineer or disposed of with all leads and lifts.

1.6 Measurements for Payment

The work of dismantling shall be paid for in units indicated below by taking measurements re and after, as applicable:

i)	Dismantling brick/stone masonry/ concrete (plain and reinforced)	cu.m
ii)	Dismantling flexible and cement concrete pavement	cu.m
iii)	Dismantling steel structures	tonne
iv)	Dismantling timber structures	cu.m
v)	Dismantling pipes, guard rails, w-beam crash barrier, kerbs, gutters and fencing	linearm
vi)	Utility services	No.

Item No. 39

Dismantling of Cement Concrete Pavement (Dismantling of cement concrete pavement by mechanical means using pneumatic tools, breaking to pieces not exceeding 0.02 cum in volume and stock piling at designated locations and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately)

1. Relevant Specifications of MORT&H fifth revision Section – 202 shall apply to this item.
2. The measurement and payment shall be in Cum basis

Item No. 40

Providing and fixing pre-cast concrete kerb stone of gray cement based concrete block 30 cm length, 30 cm height and 15 cm thick of M250 grade concrete as per approved design & including excavation for fixing in proper line and level, filling the joint with C:M 1:3 (1 cement : 3 fine sand) etc complete. (In underspace portion & beside drain)

1. The Relevant Specification of Item No. 3 shall apply to this item.
2. The measurement and Payment shall be per cum basis.

Item No. 41

Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth upto 3.0 M. and lead upto 100m for 10 Cum (For Pier & Abutment Footing)

1. The Relevant Specification of Item No. 1 shall apply to this item.
2. The measurement shall be in Cu.m basis.
3. The rate includes shoring, Shuttering if required, dewatering, as necessary and disposing of the

excavated stuff as directed.

4. The mode of payment shall be in per **cum.** basis.

Item No. 42

Excavation in large boulders and soft rock by welding including shoring, strutting and dewatering as necessary and disposing of the excavated stuff as directed. (For Pier & Abutment Footing)

1. The Relevant Specification of Item No. 2 shall apply to this item.
2. The measurement shall be in Cu.m basis.
3. The mode of payment shall be in per **cum.** basis.

Item No. 43

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. (For Pier & Abutment Footing)

3. The Relevant Specification of Item No. 3 shall apply to this item.
4. The measurement and Payment shall be per **cum** basis.

Item No. 44

Providing and Casting in situ Controlled Cement Concrete M35 for R.C.C. Raft footing and cutt-off walls including necessary shuttering laying, vibrating, ramming and curing complete. (For Pier & Abutment Footing)

1. The Relevant Specification of Item No. 4 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 45

Providing and placing in position FE 550D (With CRS) TMT bar reinforcement for following items including cutting bending hooking and tying complete as per detailed drawing. For RCC Pier & Abutment Raft & Open foundation.

1. The Relevant Specification of Item No. 5 shall apply to this item.
2. The measurement and Payment shall be per **MT** basis.

Item No. 46

Providing and filling trenches of Labour charges - Excavator in rocky strata with ordinary cement concrete M-15. (For Pier & Abutment)

1. The Relevant Specification of Item No. 6 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 47

Filling available excavated earth (excluding rock) in trenches. plinth, sides of foundations etc. in layers not exceeding 20 cm. in depth consolidating each disposed layer by ramming and watering (For Pier & Abutment).

1. The Relevant Specification of Item No. 7 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 48

Carting of excavated material such as murrum, earth, kapachi, gravel, brickbats, kankar, debris, sand, dismantled material, including loading, unloading, stacking etc. complete at non objectional place as directed by engineer in charge (For Pier & Abutment).

Lead up to 3 Km**Additional rate for lead above 3 and upto 5 km****Additional rate for lead above 5 and upto 10 km**

1. The Relevant Specification of Item No. 41 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 49

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 (A) Height Upto 5.0 M.

(B) Height 5.0M to 10.0M

1. The Relevant Specification of Item No. 8 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 50

Providing and laying in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending, hooking and tying complete as per detailed drawings for the following. (A) Piers (B) Abutments

1. The Relevant Specification of Item No. 9 shall apply to this item.
2. The measurement and Payment shall be per **MT** basis.

Item No. 51

Providing and laying - Fitter Media 600mm thick directed at the back of abutments as per detailed specifications.

1. Well graded pebbles or metal of 40 mm to 63 mm size shall be used. The grading and tolerance of metal of pebbles should be as under.

Sr. No.	No. of Size range	Sieve designation	Percentage by weight passing through the sieve
1.	63 mm to 40 mm	90 mm	100-50
		63 mm	85-100
		50 mm	35-70
		40 mm	00-15
		20 mm	00-05

The size shall be 40 mm to 63 mm wherein, tolerance limit for oversize shall be upto 15% and that for lower size should be upto 15%. below 20 mm. It shall be tightly placed to a thickness not less than 600 mm and provided over the entire surface behind abutments wings or return walls to the full height.

2. Materials shall be first stacked in boxes of 2 m x 1.5 m x 0.5 m size on fairly level ground and measured.
3. The measurement & payment shall be made on square meter basis.
4. The unit rate includes the cost of materials, scaffolding, labour and tools to complete the work.

Item No. 52

Providing and filling sand behind abutments and between returns in layers as directed by Engineer In-charge (For Abutment).

1. The sand to be used for filling shall be coarse, granular, clean, free from dust and deleterious matters obtained from a source as approved by the Engineer-in-charge. Sand between returns shall confirm to I.S.: 383.

2. Sand between returns and below raft foundations shall be filled in suitable layers not exceeding 20 cms. at a time and each layer shall be well compacted.
3. Mode of measurement shall be the total cubical content (in cum) of the area covered by sand filling.
4. Unit rate includes the cost of material, labour and tools and plant to complete the work.

Item No. 53

Providing & laying weep hole in Abutments, and returns by using A.C. pipe of 100 mm including laying in proper grade and jointing the completed as per detailed specification (For Abutment).

1. **WEEP HOLE**

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall and return walls as shown on the drawing or directed by the Engineer to drive moisture from the back filling. Weep holes shall be provided with 100 mm dia using PVC/Polysil pipes structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be 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 horizontals towards the draining face. The spacing of weep holes shall generally be 1 m in either direction or as shown in the drawing with the lowest at about 150 mm above the low water level or ground level which is higher or as directed by the Engineer. Approved makes for PVC weep holes is Supreme and Finolex.

2. The Measurements & payment shall be given on number of weep holes provided.
3. The rate includes all materials, labors, equipments and plants etc. required for executing this item.

Item No. 54

Supplying and laying of bi-axial extruded high modulus polypropylene geogrid having minimum layer coefficient ratio as 1.3, junction efficiency not less than 90% and with 38 mm x 38 mm mesh opening. The roll size shall be 50.0 x 3.95 m, at easily accessible location including top and bottom, with all leads and lifts, manpower and machinery, materials, labour etc. complete and as directed by Engineer - in - charge (For Abutment).

703 GEOGRIDS

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 05035 (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 06637	kN/m	15% of Tutt.; both in machine and cross-machine direction
Tensile strength @5% strain	ASTM 06637	kN/m	20% of Tutt; both in machine and cross-machine direction
Junction Efficiency for extruded geogrids		GRI-GG2-87or	
ASTM-WK 14256	-	90% of rib ultimate tensile strength	
Ultraviolet stability	ASTM 04355	-	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. 55

Providing and laying in situ machine mixed controlled M-35 grade cement concrete for RCC caps, side walls, tie walls etc. including M:40 pedestals over piers and abutments including necessary scaffolding formwork, centering, transporting, placing, compacting by mechanical vibrators, finishing and curing and casting, finishing at any height or depth as per drawing etc. complete excluding reinforcement, as directed by Engineer and as per specification.

Pedestal in M40 grade conc.

Seismic Restrainer in M40 grade conc.

1. The Relevant Specification of Item No. 10 shall apply to this item.
2. The measurement and Payment shall be per **cum** basis.

Item No. 56

Providing and laying in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending, hooking and tying complete as per detailed for the following. (A) Abutment cap & Dirt wall. (B) Pier Cap.

1. The Relevant Specification of Item No. 11 shall apply to this item.
2. The measurement and Payment shall be per **MT** basis.

Item No. 57

Providing and applying anti carbonation, anti fading, mold resistant, heat insulating, and 100% acrylic breathable decorative external waterproof coating of approved shade having Viscosity @ Room Temperature by Ford cup No. B-4 (dilute 2 parts of product with 1 part of water) 18 to 30 sec. pH of 7.00 to 10.00 and Sp. Gravity @ Room Temperature 1.30+0.1, tested for carbon dioxide diffusion resistance properties for coating materials and coating systems for open atmosphere surface of substructure as well as superstructure as per DIN EN 1062-6 (2002-2010) by a NBA Grade "A" accredited institution (For Substructure).

1. The Relevant Specification of Item No. 12 shall apply to this item.
2. The measurement and Payment shall be per **Sqm** basis.

Item No. 58

Art painting work over various components of ROB / FOB / Underpass with three coat water coat putty of approved brand after duly rubbing the surface to make the surface even end smooth. The work includes one coat of exterior primer coat of approved brand and three or

more coat of exterior plastic emulsion paint of approved brand over the prepared surface. Over this art painting work to be done as per direction and design pattern approved by Engineer-in-charge. The work includes the cost centering, shuttering, scaffolding and clearing the site properly after completion of work. The work also includes the cost of all material, manpower, stencils etc. required for art painting.

(A) Pier / Abutment & Pier Cap / Abutment Cap

1. The Relevant specification shall be followed as per item description and as directed by engineer in charge.
2. The measurement & payment shall be in **Sqm.** basis.

Item No. 59

Providing and fixing in position fully moulded restrained elastomeric Bearings as per detailed drawings.

1. The relevant specifications for Elastomeric Bearing as per Section-2005, 2007 to 2010 of MORT&H fifth revision Specifications shall apply to this item.
2. The measurement and payment shall be in **Cum** basis
3. The rate is for finished item complete and paid only after fixing in position below the girder.
4. The bearing shall be procured from the MORTH approved manufacturer only."

Item No. 60

Providing and fixing mild steel dowel bars of minimum 32 mm 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.

1. The Relevant Specification of Item No. 14 shall apply to this item.
2. The measurement and Payment shall be per Rmt basis.

Item No. 61

Providing and casting in-situ or precast controlled cement concrete M 50 for prestressed concrete work in super structure including centering, shuttering, curing, scaffolding ramming, vibrating, finishing, launching or shifting complete. (II) Deck Slab. (III) Main Girders. (IV) Diaphragm or cross girder.

1. The relevant specifications given for machine mixed plain cement concrete M50 grade as per Section – 1500, 1700 & 2300 of MORT&H fifth revision specification.
2. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
3. The measurement and payment shall be in **Cum** basis.

Item No. 62

Providing and placing in position FE 550D (With CRS) TMT. Bar reinforcement including, cutting, bending hooking and tying complete as per detailed drawings.(I) Solid Slab.(II) Deck Slab.

1. The Relevant Specification of Item No. 20 shall apply to this item.
2. The measurement and Payment shall be per **MT** basis.

Item No. 63

Providing and placing in position FE 550D (With CRS) TMT Bar reinforcement including,

cutting, bending hooking and tying complete as per detailed drawings.(I) Main Girders.(II) Diaphragm or cross girder.

1. The Relevant Specification of Item No. 62 shall apply to this item.
2. The measurement and Payment shall be per **MT** basis.

Item No. 64

Providing and fixing in position to exact profile High tensile steel wires 12.7/15.2mm dia of required ultimate strength conforming to low Relaxation Prestressing steel strands including bending, cutting, tying providing necessary standards as per IS 14268 and anchorages, sheathing (HDPE), stressing, grouting, ducts as per detailed drawing including necessary plant and machinery complete.

1. The relevant specifications as per IS 1786 Specification & as per relevant MORT&H fifth revision section-1800 specification shall apply to this item.
2. The measurement and payment shall be in **MT**. basis.
3. The rate includes for supply, loading, unloading, transporting to site, cutting, bending, hooking, placing, tying in position with contractor's own GI annealed binding wire, welding, forming the cage and lowering it in position in pile bore etc. Welding and supporting in position to ensure lines and levels during concreting, maintaining proper cover / spacing, all leads & lifts, etc. including contractor's own equipment, labour, supervisor, taxes, machineries, etc. complete as per drawings and specification.

Note: - Weight will be calculated considering length of strands between faces of Anchorages plus grip length multiplied by unit weight of strand. Dummy cable as required will be measured under this item.

Item No. 65

Providing and carrying out load test on bridge deck with simulated loading including provision, placing and removal of loading, supplying, fixing and removing deflection measuring instruments etc. complete with platforms for fixing the instruments etc. complete as per the details supplied and specification and as directed by Engineer and including submission of required results in triplicate after satisfactory completion of the load test.

1. The Engineer –in-charge shall instruct that a load test be made on any part of the super structure if in his opinion such a test is deemed necessary for one or more of reasons specified below:-
 - (a) The work test cubes failing to attain the specified strength.
 - (b) The shuttering being prematurely removed.
 - (c) Over loading during construction of the structure or part thereof.
 - (d) Concrete improperly cured.
 - (e) Any other circumstances attributable to negligence on the part of the contractor which, in the opinion of the Engineer-in-charge, results in the reduction of required strength of the structure or part thereof.
 - (f) Any reason other than the foregoing.
2. If the load test be ordered to be made solely or in part for the reasons (a) to (e) the test shall be carried out for contractor's own cost. If the test is required to be carried out for the reasons specified at (f) here in before, the contractor shall make the test and shall be paid for the same.
3. The test load shall not be applied earlier than 28 days of the completion of placing of the concrete in the part of the structure to be tested and the latter shall not be supported during the test by the shuttering or other non-permanent support. Necessary care shall, however, be taken to ensure that in the event of failure under the test temporary support of the loaded member shall be immediately available.
4. If the result of the load test for the reasons mentioned at (a) to (e) is not satisfactory in the opinion of the Engineer-in-charge he shall instruct that the part of the structure concerned shall be taken down or cut out and reconstructed to his satisfaction or that other remedial measures shall be taken to make the structure secure and strong as per requirement at the contractor's own

risk and cost or the work may be accepted as sub-standard work and paid at reduced rate as may be decided by the Engineer-in-charge and his decision in the matter shall be binding, on the contractor. The contractor shall provide necessary materials, instruments, equipments observations platforms, plant and labour needed for carrying out the test as required. The load in general shall be in the form of sand bags. However, the contractor may apply the test load in any other suitable manner as may be approved by the Engineer-in-charge. The contractor shall make all necessary arrangements for observation platforms, centering, taking deflection by deflectometers etc. to the entire satisfaction of the Engineer-in-charge. The test load shall be kept at least 24 hours or as directed before removal.

Test load of superstructure shall be 1.5 times the equivalent load including maximum stresses at sections of maximum stresses at sections of maximum bending moment and or shear force for which the superstructure is designed.

5. The item for the purpose of payment shall be measured per M.T of load placed on the superstructure and the payment of the same made on completion of the test.
6. Unit rate shall include all materials, labour, measuring instruments, tools and plant necessary to carry out the load test.

Item No. 66

Providing and applying anti carbonation, anti fading, mold resistant, heat insulating, and 100% acrylic breathable decorative external waterproof coating of approved shade having Viscosity @ Room Temperature by Ford cup No. B-4 (dilute 2 parts of product with 1 part of water) 18 to 30 sec. pH of 7.00 to 10.00 and Sp. Gravity @ Room Temperature 1.30+0.1, tested for carbon dioxide diffusion resistance properties for coating materials and coating systems for open atmosphere surface of substructure as well as superstructure as per DIN EN 1062-6 (2002-2010) by a NBA Grade "A" accredited institution (For Superstructure).

1. The Relevant Specification of Item No. 57 shall apply to this item.
2. The measurement and Payment shall be per **Sqm** basis.

Item No. 67

Art painting work over various components of ROB / FOB / Underpass with three coat water coat putty of approved brand after duly rubbing the surface to make the surface even and smooth. The work includes one coat of exterior primer coat of approved brand and three or more coat of exterior plastic emulsion paint of approved brand over the prepared surface. Over this art painting work to be done as per direction and design pattern approved by Engineer-in-charge. The work includes the cost centering, shuttering, scaffolding and clearing the site properly after completion of work. The work also includes the cost of all material, manpower, stencils etc. required for art painting.

(A) Outer Face of Crash Barrier

1. The Relevant Specification of Item No. 58 shall apply to this item.
2. The measurement and Payment shall be per **Sqm** basis.

Item No. 68

Providing and casting RCC in M-40 controlled concrete Crash Barriers as per detailed drawings including necessary scaffolding, centering, formwork, mixing in machine, transporting, placing, compacting, finishing, curing, etc. complete including providing and fixing of inserts if any with all leads and lifts as per drawing & specification and as directed by Engineer, excluding reinforcement. (For Approach Viaduct Portion)

1. The Relevant Specification of Item No. 21 shall apply to this item.
2. The measurement and Payment shall be per **Cum** basis.

Item No. 69

Providing and fixing RCC M:25 architectural pylons at end of approach structures including

all materials, labour, reinforcement laying, ramming, curing etc. complete as per detailed working drawing.

1. Relevant specifications of plain and reinforced cement concrete as per Section -1500 & 1700 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in **cubic meter** of concrete done.

Item No. 70

Providing and fixing marble slab including engraving and painting complete. (i) Size 75cm x 60cm x 4cm.

1. 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.
2. Measurement shall be per number of marble plate fixed.
3. Unit rates includes cost of all material labour and tools to complete the work

Item No. 71

Providing and fixing in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending and tying complete as per detailed drawings.(A) Crash Barrier, (B) Wearing Coat, (C)Architectural pylons

1. The relevant specification for MORT&H specifications as in section 1600 & 1009 (5th revision) shall be apply to this itme.
2. The mode of payment shall be in per **MT.** basis.

Item No. 72

Providing and laying Double Walled corrugated Pipes (DWC) of Polyethylene (conforming to IS:14930-II) of 50mm O.D. / 38mm I.D. with fittings and necessary connecting accessories of same material at required depth for laying cable below footpath slab etc. complete as per specification and as directed by Engineer. (For Approach Viaduct Portion)

1. The Relevant Specification of Item No. 25 shall apply to this item.
2. The measurement and Payment shall be per Rmt basis.

Item No. 73

Providing, laying and jointing in true line and level 110 diameter U.P.V.C (Type B) conforming to IS 13592-1992 with one end plain and other end socketed with rubber ring, & fittings conforming to ISI 14735-1999 of approved make for drainage system pipe line, pipe shall be jointed with each other with rubber lubricant, pipe shall be fixed on wall using of PVC clamp of the size 110 mm diameter x 149 mm length x 145 mm heigh at every 2000 mm center to center or shall be concealed in walls as directed including necessary fittings such as bends, shoes etc. including testing of pipes and joints and jointed with adhesive solvent cement including cost of all materials.(For Downtake / longitudinal runner pipe for approach viaduct portion)

1. The Relevant Specification of Item No. 27 shall apply to this item.
2. The measurement and Payment shall be per Rmt basis.

Item No. 74

Providing and fixing 100 mm dia. G.I. Drainage spouts, as per MOST Drg. No. SD/303 including grating with suitable clean out fixtures including all leads and lifts etc. complete as per specification, design & drawings and as directed by Engineer (For approach viaduct

portion).

1. The Relevant Specification of Item No. 26 shall apply to this item.
2. The measurement and Payment shall be per Nos basis.

Item No. 75

Strip seal expansion joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement up to 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.)

1. The relevant specifications as per clause 2600 of MORT&H (5th revision) and as per relevant RDSO specification shall apply to this item.
2. The measurement shall be in Rmt. basis.
3. The rate is inclusive of supplying, fixing with contractor's own materials, equipments, machineries, labour, transport, testing, bolts, socket tubes, neoprene sheet/cap etc. complete. The rate is finished item complete and will be paid after fixing in all respect. The Contractor shall procure Expansion Joint, confirming to relevant MORTH specification from approved MORTH vendor with prior approval of Engineer in- charge/
4. The mode of payment shall be in per **Rmt.** basis.

Item No. 76

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) - For inner face of crash barrier of approach viaduct portion

1. The relevant specification for item no. 28 shall apply to this item.
2. The measurement and payment shall be in **Sqmt** basis.

Item No. 77

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.

1. The relevant specification for item no. 31 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 78

Providing and fixing in position FE 550D TMT (with CRS) bar reinforcement including cutting, bending and tying complete as per detailed drawings. (A) R.C.C. Wearing coat . (upto 10 ton)

1. The relevant specification for item no. 32 shall apply to this item.
2. The measurement and payment shall be in **MT** basis.

Item No. 79

Road marking with hot applied thermoplastic paints with reflectorizing glass beads on bitumen surface providing and laying a hot applied thermoplastic compound 2.5 mm thick including reflectorizing glass beads @ 250 gms per sqm area, thickness of 2.5 mm is excluding of surface applied glass beads as per IRC: 35-2015. The finished surface to be leveled, uniform and free from streaks and holes. Zebra patta/bump patta lane/center line/edge line/cut patta. The white color marking should provide luminance coefficient on cemented road shall be 130 mcd / m² / lux and asphalt roads shall be minimum 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

retro reflectivity shall be two years. (For Approach viaduct Portion)

1. The relevant specification for item no. 33 shall apply to this item.
2. The measurement and payment shall be in **Sqm** basis.

Item No. 80

Cat Eye / Road Stud / RPM: Supplying of Molded Twin Shanks 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 strength of detachment of the integrated cylindrical shanks, (of diameter not less than 19 +/- 2 mm and height not less than 30 +/- 2 mm) from the body is to be a minimum value of 500 Kgf. Fixing will be by drilling holes on the road for the shanks to go inside, without nails and using epoxy resin based adhesive as per manufacturer's recommendation and The color of the marker should be as per the IRC 35-2015 and as directed by Engineer-in-charge. (For Approach viaduct Portion)

1. The relevant specification for item no. 34 shall apply to this item.
2. The measurement and payment shall be in **Nos** basis.

Item No. 81

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.

1. The relevant specifications are as per item for continuity arrangement in deck slab as per the detailed drawing shown in the tender shall apply to this item.
2. The measurement and payment shall be in **Rmt** basis.
3. The rate includes labour, material, fixtures, components filler etc. complete as directed by engineer in charge.

Item No. 82

Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth upto 3.0 M. and lead upto 100m for 10 Cum (For Retaining wall & Toe Wall).

1. The relevant specification for item no. 1 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 83

Excavation in large boulders and soft rock by welding including shoring, strutting and dewatering as necessary and disposing of the excavated stuff as directed. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 2 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 84

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. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 3 shall apply to this item.

2. The measurement and payment shall be in **Cum** basis.

Item No. 85

Providing and Casting in situ Controlled Cement Concrete M35 for R.C.C. Raft footing and cutt-off walls including necessary shuttering laying, vibrating, ramming and curing complete. (For Retaining wall)

1. The relevant specification for item no. 4 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 86

Providing and placing in position FE 550D (With CRS) TMT bar reinforcement for following items including cutting bending hooking and tying complete as per detailed drawing. For RCC Retaining wall Open foundation.

1. The relevant specification for item no. 5 shall apply to this item.
2. The measurement and payment shall be in **MT** basis.

Item No. 87

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) RCC Retaining wall Stem (A) Height Upto 5.0 M. (B) Height 5.0M to 10.0M

1. The relevant specification for item no. 8 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 88

Providing and laying in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending, hooking and tying complete as per detailed drawings for the following. (A) RCC Retaining wall Stem

1. The relevant specification for item no. 9 shall apply to this item.
2. The measurement and payment shall be in **MT** basis.

Item No. 89

Providing and applying anti carbonation, anti fading, mold resistant, heat insulating, and 100% acrylic breathable decorative external waterproof coating of approved shade having Viscosity @ Room Temperature by Ford cup No. B-4 (dilute 2 parts of product with 1 part of water) 18 to 30 sec. pH of 7.00 to 10.00 and Sp. Gravity @ Room Temperature 1.30+0.1, tested for carbon dioxide diffusion resistance properties for coating materials and coating systems for open atmosphere surface of substructure as well as superstructure as per DIN EN 1062-6 (2002-2010) by a NBA Grade "A" accredited institution.

1. The Relevant Specification of Item No. 57 shall apply to this item.
2. The measurement and Payment shall be per **Sqm** basis.

Item No. 90

Art painting work over various components of ROB / FOB / Underpass with three coat water coat putty of approved brand after duly rubbing the surface to make the surface even and smooth. The work includes one coat of exterior primer coat of approved brand and three or more coat of exterior plastic emulsion paint of approved brand over the prepared surface. Over this art painting work to be done as per direction and design pattern approved by Engineer-in-charge. The work includes the cost centering, shuttering, scaffolding and clearing the site properly after completion of work. The work also includes the cost of all material, manpower,

stencils etc. required for art painting.

(A) Outer Face of Crash Barrier

1. The Relevant Specification of Item No. 58 shall apply to this item.
2. The measurement and Payment shall be per **Sqm** basis.

Item No. 91

Providing and laying - Filter Media 600mm thick directed at the back of abutments as per detailed specifications. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 51 shall apply to this item.
2. The measurement and payment shall be in **Sqm** basis.

Item No. 92

Providing and filling sand behind abutments and between returns in layers as directed by Engineer In-charge. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 52 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 93

Providing & laying weep hole in Aburtments, and returns by using A.C. pipe of 100 mm including laying in proper grade and jointing the completed as per detailed specification. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 53 shall apply to this item.
2. The measurement and payment shall be in **Nos** basis.

Item No. 94

Providing and casting in-situ controlled cement concrete M 30 for approach slab including formwork curing and finishing complete

1. The relevant specifications given for machine mixed controlled cement concrete **M30** grade as per Section -1500, 1700 & 2700 of MORT&H fifth revision specification.
2. The measurement shall be per **cum** basis.
3. The rate is inclusive of all materials, including necessary dewatering, mixing in fully automatic batch mix plant, transport, curing, vibrating, placing in position, shuttering, formworks, de-shuttering 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.
4. The mode of **payment shall be in per cum**. Basis.

Item No. 95

Providing and casting in-situ controlled cement concrete M 20 For Raft and cutoff walls including necessary formwork, vibrating curing, and finishing complete (Toe Wall)

1. The Relevant specification of MoRT&H Fifth revision as given in section – 1500, 1700 & 2100 shall apply to this item and as directed by engineer in-charge.
2. The measurement and payment shall be in **Cum** basis.

Item No. 96

Providing and casting RCC in M-40 controlled concrete crash barrier as per detailed drawings including necessary scaffolding, centering, formwork, mixing in machine, transporting, placing, compacting, finishing, curing, etc. complete including providing and fixing of inserts if any with all leads and lifts as per drawing & specification and as directed by Engineer, excluding reinforcement. (For Retaining wall & Toe Wall)

1. The relevant specification for item no. 21 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 97

Providing and fixing in position FE 550D (With CRS) TMT bar reinforcement including cutting, bending and tying complete as per detailed drawings. (A) R.C.C. Approach slab, (B) Toe Wall, (C) Crash Barrier

1. The relevant specification for item no. 24 shall apply to this item.
2. The measurement and payment shall be in **MT** basis.

Item No. 98

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) - For inner face of crash barrier

1. The relevant specification for item no. 28 shall apply to this item.
2. The measurement and payment shall be in **Sqmt** basis.

Item No. 99

Providing and laying Double Walled corrugated Pipes (DWC) of Polyethylene (conforming to IS:14930-II) of 50mm O.D. / 38mm I.D. with fittings and necessary connecting accessories of same material at required depth for laying cable below footpath slab etc. complete as per specification and as directed by Engineer.

1. The Relevant Specification of Item No. 25 shall apply to this item.
2. The measurement and Payment shall be per **Rmt** basis.

Item No. 100

Box cutting the road surface to proper slope and camber for making a base for road work including removing the excavated stuff and depositing on the road side slope as directed upto 50m lead (For Service Road).

1.0 Workmanship:

- 1.1 The land width required for road way, gutter side slope and catch water gutter shall be cleared off all trees, having a girth of 30 cm. and less. The loose stones, vegetation, bushes, stumps, and other objectionable materials shall also be removed. The roots of the trees and stumps shall be removed up to 30 cm. below the grade formation. All the materials cleared will be the property of the Client. Useful material shall be arranged in convenient stacks, along the road boundary or as directed, at places within any lead and handed over to the Client, in convenient sections. Unsuitable materials shall be burnt or otherwise disposed off by the Contractor, at his own cost without causing any nuisance, inconvenience or damage to the work, property or the people in the neighborhood. If the material is disposed off outside the road length, necessary permission of private land owner shall be taken by the Contractor and royalty etc. if any, shall be paid by him, without claiming any compensation. All the material shall be disposed off in neat manner.
- 1.2 After clearing the site, the alignment of the road shall be properly set out, true to lines, curves, grades and sections shown on the plan or as directed by the Architect and Engineer-in-charge. The Contractor shall provide all labours and materials such as lime, string, pegs, nails, bamboos, stones, mortar, concrete etc. required for setting out, establishing bench mark and giving profiles. The Contractor shall be responsible for maintaining bench mark's profile, alignments and other stacks and marks, as long as they are required for the work, in the opinion of the Engineer-in charge. If the Contractor defaults in this respect even after the

direction of the Engineer-in-charge, within the specified time, they may be restored by the Engineer-in-charge, at the cost of the Contractor. Levels and the sections of the ground shall be taken and recorded in the presence of the Contractor or his authorised representative before the excavation is started, so as to serve as the basis of measurement. The Contractor or his representative shall sign the field book in token of his acceptance of the levels, etc. If there is any disagreement, the Contractor shall inform it in writing to the officer concerned, with specific representation before starting further work. Once the work is started, no cognisance of any complain shall be taken. Merely not signing shall not be deemed as a disagreement.

- 1.3** Profile of sections including the road side gutters to be excavated, shall be line marked at the interval of 10 m. to 15 m. or as directed by the Architect & Engineer-in-charge, to conform the curved or straight alignments, sections, grade, and side slopes. The center line shall clearly be marked and profile of embankment shall be set-up with the line marked on each side. The roadway section shall first be excavated with vertical side for each lift and the side slope for that lift shall be excavated in steps. The steps shall be smoothened to the required slope, when the excavation reaches the road formation. Contractor shall on no account excavate beyond the slope or below the specified grade unless so directed by the Architect & Engineer-in-charge. If the excavation is done below the specified level or outside the specified sections, it shall not be paid for and the Contractor shall be required to fill up at his own cost such extra excavation in the road portion, with approved materials of the embankment grade in layers, watered and fully compacted, so as to obtain the maximum density laid down for the embankment. The Contractor may require to keep the measurement, ridges and dead man to be left, at specified intervals or places and kept intact, till ordered by the Engineer-in-charge to remove, for the purpose of checking the measurements. The excavation shall be finished neatly, smoothly and evenly to the correct lines, curves, grades, sections and side slopes as shown on the plans or directed by the Engineer-in-charge. The subgrade if loose, shall be scarified, watered and compacted to the same density as that of embankment. The section, side slopes and catch water gutter shall be maintained by the Contractor at his own cost in such a way that the formation of the gutter will be well drained by providing necessary diversion, etc. Necessary passages shall be provided for leading away seepage, springs, surface flow or rain water safely without damaging the work. If any damage occurs due to default of the Contractor in this respect, he shall make good the damage at his own cost. If it is necessary in the excavation of the work to interrupt existing surface drain, sewer or under drainage, temporary arrangements shall be provided till such time as and when necessary or as directed. The Contractor, at his own cost shall make the interrupted drainage and sewer etc. unless separately specified in the tender. Any damage to the existing work or work in hand caused as a result of his operations or negligence shall be made good by the Contractor at his own cost. Road side gutters shall be excavated to the specified sections and shall be measured along with the main cutting in m³.
- 1.4** Care shall be taken to see that excavation is carried out in a safe manner so that, there will not be any risk to the work or workman, by landslides or falling material, boulders and collapsing sides, etc.
- 1.5** If a landslide occurs in the cutting, it shall be removed as directed by the Engineer-in-charge. If the finished slopes, slides into the roadway before final acceptance of the work, such slide shall be removed by the Contractor and shall be paid extra for, at the contract rate for the class of excavation involved, provided the slides are not due to any negligence of the Contractor. The classification of the material in slides shall conform to its condition, at the time of removal and payment shall be made accordingly regardless of its prior condition.
- 1.6** If there is traffic nearby or if there are villages or towns in the neighborhood barricades, the traffic signals shall be provided for day as well as night for the duration of the work, in such a way to prevent accidents. Warning signals shall be displayed on both sides, 7.0 m. away from the point of danger, giving sufficient warning. Necessary signalers shall be stationed at each end to regulate traffic wherever necessary or as directed. Measure shall be taken to see that the excavation does not affect to the adjoining structures or properties. If there is any damage

to the adjoining property, injury to workers, the public, animals, etc. due to the negligence of the Contractor, he will be responsible and liable to all the consequences, including compensation.

- 1.7 All the excavated materials shall be the property of the Client. When the useful excavated materials shall be reused in the embankment, within any lead, it shall be directly deposited in the required location, in specified layers. No handling or conveyance charges shall be paid, if material is temporarily deposited elsewhere and subsequently conveyed to the site of deposition. The sequence of the operation shall be arranged properly. Material required for the item other than the bank shall be arranged in neat stacks at convenient places without interfering with the drainage, in any way. If no area of land is available on site and the excavated useful stuff is to be stacked temporarily before being reused under the same agreement, the Contractor shall make his own arrangement for stacking of these materials temporarily on private land by paying rents, etc., without claiming any compensation. Surplus materials not required for reuse may be used of his own, to uniformly widened the embankment, to flatten the slope and to fill lower places in the road land, if so permitted by the Engineer-in-charge. Materials not required for the reuse, whatsoever, may be disposed off by the Contractor, at his own cost in manner approved by the Engineer-in charge.
- 1.8 If the Contractor does not wish to utilize the quantity of cutting within the any lead for any reason, then he may do the embankment work with the earth brought from the other sources. But in that case, the full or the part of acceptable quantity of stuff for which payment is made or to be made will be deducted from net quantity of the earth work in embankment arrived at within chain age measured as above.
- 1.9 **The Measurement of the item shall be in Cum basis.** Excavation shall be measured in its original position by taking cross section before the work starts and after its completion. The quantity shall be worked out by the average area method. When the classification of the strata changes, the Contractor shall bring this to the notice of the Engineer-in-charge, who will then verify and if necessary, take levels for the changed strata for the purpose of the measurement.

Item No. 101

Earthwork for embankment including breaking clods, dressing with all lead and lift and including watering rolling and consolidation of subgrade in layers at O.M.C. to required dry density including filling the depression which occur during the process using vibratory roller 8t to 10t. (A) From borrow pits within land width (For Service Road).

1. MORT&H specifications as in section 305 & 900 (**5th revision**) shall be followed in connection with this item. All relevant provisions as have been included in the respective IRC and IS specifications are also applicable.
2. The land width on which the earthwork is to be done shall be cleared of all trees having a girth of 30 cm and less, loose stones, vegetation, bushes, stumps, and all other objectionable materials. All the materials cleared will be the property of Government. Useful material shall be arranged in convenient stacks along the road boundary or as directed at places within all lead & Lift and handed over to the department in convenient section. Unsuitable material shall be burnt or otherwise disposed off by the contractor at his own cost without causing any nuisance, inconvenience or damage to the works property or people in the neighborhood. In all cases the materials shall be disposed off in a neat manner.
3. After clearing the site, the alignment of the road shall be properly set out true to line, curves, slopes, grades, and sections as shown on the plan or directed by the engineer in charge. The contractor shall provide all labours and materials such as lime, strings, pegs, nails, bamboos, stone, mortar, concrete, etc. required for setting out, establishing bench marks and giving profiles. The contractor shall be responsible for maintaining the BMs profile alignments and other marks as long as they are required for the work in the opinion of the engineer in charge. If the

contractor defaults in this respect they may be restored by the department at the cost of the contractor.

4. When an existing embankment is to be widened, continuous, horizontal benches, each at least 0.30 meter wide shall be cut into the existing slope for ensuring adequate bond with the fresh embankment of the embankment. The 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 type of hauling equipment.
5. The soil to be used for embankment shall be free from trees, stumps, roots, rubbish or any other objectionable materials. Only material considered suitable by the engineer-in-charge shall be used for the construction and that considered unsuitable other disposed off as directed by him. The selection of the materials to be used in the construction of embankment shall be made after soil surveys and investigations carried out by the department. The embankment shall consist of earth available from road side borrow pits on either side with all lead and all lifts.
6. Location, shape and size of borrow pits shall be as indicated by the engineer in charge. Pits shall not be dug continuously. Ridges of not less than 8 metres width should be left at interval not exceeding 300 metres. Small drain shall be cut through the ridges to facilitate drainage. The outer edge of borrow pits shall be so regulated that the bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontals projected from the edge of final section of the bank, the maximum depth in any case being limited to 1.5 metres. Also, no pits shall be dug within 5 metres of the toe of the final section of the road embankment.
 - 1.1. No borrow pits shall be allowed at the following sites along the road.
 - i.) Up to 30 metres on either side of CD works.
 - ii.) Up to 15 metres on either side of cart track crossing for which approaches are to be constructed.
 - 1.2. If there is top layer of black cotton or other objectionable soils, the same shall be removed and disposed off elsewhere and usable material found at lower level will only be used in the embankment.
7. The embankment shall be constructed in uniform layers not exceeding 250 mm in loose thickness. The soil shall be spread uniformly over the entire width of the embankment, unless otherwise directed by the engineer in charge. The consolidation including watering and rolling of earthwork shall be carried out by the department. The operation of laying the successive layer of earth shall have to be suitably. All clods of hard lumps of earth shall be broken to have maximum size of 15 cm when being placed in the embankment and a maximum size of 5 cm when being placed in the top 45 cms of the embankment. The work of next layer shall be allowed only after the first layer below it has been thoroughly compacted.
8. Where an embankment is to be placed on sloping ground, the surface of the ground shall be benched in the steps of trenches or broken up in such a manner that the new material shall have perfect bond with the existing surface. Where the embankment is to be placed over an existing road surface, the surface shall be scarified to minimum depth of a 5 cm so as to provide ample bond between the old and new material. However, when the embankment is to be placed over an old concrete pavement and lies within 1 meter of new sub grade level the pavement shall be broken up in pieces not to exceed 0.1 m and may be left under the new embankment. If the existing road surface is of granulate or bituminous type and lies within 1 mt. of the new sub grade level, the same shall be scarified to a depth of minimum 50 mm, so as to provide ample bond between the old and the new material.
9. To avoid interference with the construction of abutment, wing walls or return walls of culverts/bridge structure, the contractor shall at point to be determined by the engineer in charge, suspend work on embankments 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 interference or damage to the bridge work. Unless directed otherwise, the filling ground culverts, bridges and other structures up to a distance twice the height of embankment. The fill material shall not be placed against any abutment or wing wall unless permission has been given for 14 days, the embankment 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 in charge. Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneous with the laying of fill material. The material used for the filter shall conform to the requirements for filter medium and will be aid extra in the relevant item.

10. The embankment shall be finished in conformity with the alignment, levels, cross sections and dimension shown on the plans or as directed by engineer in charge. Where the alignment of the road is in a curve, the top of the embankment shall be formed with the super elevation and the increased width shown on the drawings or as the engineer in charge may direct. Finishing operations shall include the work of shaping and dressing the shoulders, road bed and the side slopes to conform the cross section.
11. The earthwork measurements shall be paid on cross sectional measurements and computing the volumes of earthwork in cubic metres by average area method. The contractor shall sign day-to-day levelling work and also original cross section, longitudinal section, etc. in token of his acceptance. The working sections both longitudinal and cross of the ground shall be taken by the engineer in charge before the actual work is started. The contractor or his authorized representative shall attend day to day levelling work and sign with date the field book daily in token of his acceptance. If there is any disagreement the contractor shall inform of it in writing to the officer concerned with specific reference to the sections before starting further work. Once the work is started, no cognizance of any complaint will be taken. Merely not signing of level book shall not be deemed as disagreement. The executive engineer shall also verify levelling work to the extent of 5% before commencement of earthwork and on finalization. The contractor shall maintain the embankment by filling in ruts, rain cuts, depression due to shrinkage, etc. to proper formation and grade till this item is finally measured and accepted by the department. The measurements shall be taken on compacted earthwork. If the compaction as stipulated in Para above is not done by the department in that case shrinkage from such earthwork quantity shall be deducted as per norms i.e. 10% after monsoon and 15% before monsoon. However, the contractor shall have to bear loss of quantity due to all settlements as well as other types of deformations etc., if any, that might have taken place at the time of taking the final measurement of this item.
12. The rate of earthwork includes, clearing jungles, dog-belling, fixing profiles, erecting necessary pillars for stones for bench marks for leveling purpose, excavating earth from borrow areas, breaking clods, conveying, and spreading earth in layers with all lead and lift, finishing the entire embankment and incidentals necessary to complete the work to the specifications. The cutting stuff of cutting in ordinary soil, soft murrum, soft rock, hard murrum and hard rock shall be utilized in embankment construction under this item within the lead specified in the particular item. No payment shall be made under this item for the cutting stuff used in the embankment but labour for cutting will be paid as per specifications in the particular item, and only balance quantity of earthwork brought from borrow areas will be paid in this item.
13. The measurement will be in **cum** of actual completed volume.

Item No. 102

Construction of granular sub-base (Grade - V) 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 MoRTH clause 401 (For Approach Retaining wall + Toe wall & Service Road).

401 GRANULAR SUB-BASE

401.1 Scope

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid 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.

401.2 Materials

401.2.1 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.

401.2.2 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 Designation	Percent by Weight Passing the IS Sieve					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75.0mm	100	-	-	-	100	-
53.0mm	80-100	100	100	100	80-100	100
26.5mm	55-90	70-100	55-75	50-80	55-90	75-100
9.50mm	35-65	50-80	-	-	35-65	55-75
4.75mm	25-55	40-65	10-30	15-35	25-50	30-55
2.36mm	20-40	30-50	-	-	10-20	10-25
0.85mm	-	-	-	-	2-10	-
0.425mm	10-15	10-15	-	-	0-5	0-8
0.075mm	<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) Or IS:5640	40 maximum
Liquid limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
Cb rate 98% dry density (at IS:2720-Part 8)	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the contract

401.3 Construction Operations

401.3.1 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.

401.3.2 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.

401.4 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. 103

Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be maintain during construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver compacting with 8-10 tonnes vibratory roller, finishing and curing as per MoRTH clause 601.

601 DRY LEAN CEMENT CONCRETE SUB-BASE

601.1 Scope

- 601.1.1 The work shall consist of construction of (zero slump) dry lean concrete sub-base for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.
- 601.1.2 The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the drawings.

601.2 Materials

601.2.1 Sources of Materials

The Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the dry lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor later proposes to obtain the 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.

60.2.2 Cement

Any of the following types of cement may be used with prior approval of the Engineer:

Sr. No.	Type	Conforming to
i)	Ordinary Portland Cement 43 Grade	IS:8112
ii)	Portland Slag Cement	IS:455
iii)	Portland Pozzolana Cement	IS:1489-Part I

If the subgrade soil contains soluble sulphates in a concentration more than 0.5 percent, sulphate resistant cement conforming to IS:6909 shall be used.

Cement to be used may preferably be obtained in bulk form. It shall be stored in accordance with stipulations contained in Clause 1014 and shall be subjected to acceptance test prior to its immediate use.

601.2.3 Fly-ash

Fly-ash upto 20 percent by weight of cementitious material (cement + fly ash) may be used along with 43/53 grade cement may be used to replace OPC cement grade 43 upto 30 percent by weight of cement. Fly-ash shall conform to IS:3812 (Part 1) and its use shall be permitted only after ensuring that facilities exist for uniform blending through a proper mechanical facility with automated process control like batch mix plant conforming to 18:4925 and 18:4926.

601.2.4 Aggregates

601.2.4.1 Aggregates for lean concrete shall be natural material complying with 18:383. The aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set forth in Table 600-2. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching, or as directed by the Engineer.

601.2.4.2 Coarse Aggregates

Coarse aggregates shall comply with clause 602.2.6.2, except that the maximum size of the coarse aggregate shall be 26.5 mm, and aggregate gradation shall comply with Table 600-1.

601.2.4.3 Fine Aggregates

The fine aggregate shall comply with Clause 602.2.6.3.

601.2.4.4 The material after blending shall conform to the grading as indicated in Table 600-1.

Table 600-1 : Aggregate Gradation for Dry Lean Concrete

Sieve Designation	Percentage by Weight Passing the Sieve
26.50 mm	100
19.0 mm	75-95
9.50 mm	50-70
4.75 mm	30-55

2.36mm	17-42
600 micron	8-22
300 micron	7-17
150 micron	2-12
75 micron	0-10

601.2.5 Water

Water used for mixing and curing of concrete shall comply with Clause 602.2.7.

601.2.6 Storage of Materials

All materials shall be stored in accordance with the provisions of Clauses 602.2.12 of these Specifications and other relevant IS Specifications.

601.3 Proportioning of Materials for the Mix

601.3.1 The mix shall be proportioned with a maximum aggregate cementitious material ratio of 15:1. The water content shall be adjusted to the optimum as per Clause 601.3.2 for facilitating compaction by rolling. The strength and density requirements of concrete shall be determined in accordance with Clauses 601.7 and 601.8 by making trial mixes. Care should be taken to prevent one size of aggregate falling into the other size of the hopper of the feeding bin while loading the individual size of aggregates into the bins.

601.3.2 Moisture Content

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from Engineer. While laying in the main work, the lean concrete shall have moisture content between the optimum and optimum +2 percent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

601.3.3 Cement Content

The cement content in the dry lean concrete shall be such that the strength specified in Clause 601.3.4 is achieved. The minimum cement content shall be 150 kg/cu.m of concrete. In case fly ash is blended at site as part replacement of cement, the quantity of fly ash shall not be more than 20 percent by weight of cementitious material and the content of OPC shall not be less than 120 kg/cu.m.

If this minimum is not sufficient to produce dry lean concrete of the specified strength, it shall be increased as necessary by the Contractor at his own cost.

601.3.4 Concrete Strength

The average compressive strength of each consecutive group of 5 cubes made in accordance with Clause 903.5.1.1 shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5

MPa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer and demonstrated in the trial length construction.

601.4 Sub-grade

The sub-grade shall conform to the grades and cross-sections shown on the drawings and shall be laid and compacted in accordance with Clause 305. The subgrade strength shall correspond to the design strength specified in the Contract. As far as possible, the construction traffic shall be avoided on the prepared sub-grade.

601.5 Drainage Layer

A drainage layer conforming to Clause 401 shall be laid above the subgrade before laying the Dry Lean Concrete sub-base, as specified in the drawings and the Contract.

601.6 Construction

601.6.1 General

The Dry Lean Concrete shall be laid on the prepared_ granular drainage layer. The pace and programme of the Dry Lean Concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The Dry Lean Concrete sub-base shall be overlaid with concrete pavement only after 7 days of sub-base construction.

601.6.2 Batching and Mixing

The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with Clauses 602.9.2, 602.9.3.1 and 602.9.3.2. The design features of Batching Plant should be such that the plant can be shifted quickly.

601.6.3 Transporting

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tipping trucks with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to paving site shall be such that the travel time available from mixing to paving as specified in Clause 601.6.5.2 will be adhered to. Tipping truck shall not have old concrete sticking to it. Each tipping truck shall be washed with water jet before next loading as and when required after inspection.

601.6.4 Placing

Lean concrete shall be placed by a paver with electronic sensor on the drainage layer or as specified in the Contract. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the _sub-base. One day before placing of the dry lean cement concrete sub base, the surface of the granular sub-base/drainage layer

shall be given a fine spray of water and rolled with a smooth wheeled roller.

Preferably the lean concrete shall be placed and compacted across the full width of the two lane carriageway, by constructing it in one go. In roads with carriageway more than 2 lanes a longitudinal joint shall be provided. Transverse butt type joint shall be provided at the end of the construction in a day. Transverse joints in the concrete pavement shall not be coterminous with the transverse construction joint of the Dry Lean Concrete.

The Dry Lean Concrete shall be laid in such a way that it is at least 750 mm wider on each side than the proposed width including paved shoulders of the concrete pavement. The actual widening shall be decided based on the specifications of the paver, such that the crawler moves on the Dry Lean Concrete, and the cost of extra width shall be borne by the Contractor.

601.6.5 Compaction

601.6.5.1 The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is well closed. The minimum dry density obtained shall not be less than 98 percent of that achieved. During the trial length construction in accordance with Clause 601.7. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 96 percent of that achieved during the trial construction.

601.6.5.2 The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the temperature of concrete is between 25°C and 30°C, and 120 minutes if less than 25°C. This period may be reviewed by the Engineer in the light of the results of the trial run but in no case shall it exceed 120 minutes. Work shall not proceed when the temperature of the concrete exceeds 30°C. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35°C. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.

601.6.5.3 Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 kN static weight are suitable for rolling dry lean concrete. In case any other roller is proposed, the same shall be got approved from the Engineer, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the dry lean concrete, the compatibility of the mix and the weight and type of the roller and the same as well as the total requirement of rollers for the jobs shall be determined during trial run by measuring in-situ density and the scale of the work to be undertaken.

Except on super elevated portions where rolling shall proceed from the inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre.

First, the edge/edges shall be compacted with a roller running forward and backward. The roller shall then move inward parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half widths.

- 601.6.5.4 A preliminary pass without vibration to bed the Dry Lean Concrete down shall be given followed by the required number of passes to achieve the desired density and, a final pass without vibration to remove roller with vibration marks and to smoothen the surface.

Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these locations, use of plate vibrators shall be made, if so directed by the Engineer.

- 601.6.5.5 The final lean concrete surface on completion of compaction shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material, laid and compacted. For repairing honeycombed/hungry surface, concrete with aggregates of size 10 mm and below shall be spread and compacted as per Specifications. It is necessary to check the level of the rolled surface for compliance. Any level/thickness deficiency shall be corrected after applying concrete with aggregates of size 10 mm and below after roughening the surface. Surface regularity also shall be checked with 3m straight edge. Strength tests shall be carried out, and if deficiency in strength is noticed, at least three (evenly spread) cores of minimum 100 mm dia per km shall be cut to check deficiency in strength. The holes resulting from cores shall be restored by filling with concrete of the specified strength and compacted by adequate rodding.

- 601.6.5.6 Segregation of concrete in the tipping trucks shall be controlled by moving the dumper back and forth while discharging the mix into the same or by any appropriate means. Paving operation shall be such that the mix does not segregate.

601.6.6 Joints

Construction and longitudinal joints shall be provided as per the drawings.

Transverse butt type joint shall be provided at the end of the construction in a day. Longitudinal construction joint shall be provided only when full width paving is not possible. Transverse joints in Dry Lean concrete shall be staggered from the construction butt type joint in Concrete pavement by 800-1000 mm.

Longitudinal joint in Dry Lean Concrete shall be staggered by 300-400 mm from the longitudinal joint of concrete pavement.

At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical plane where the correct thickness of the properly compacted material has been obtained.

601.6.7 Curing

As soon as the lean concrete surface is compacted, curing shall commence. One of the following methods shall be adopted:

- a) Curing may be done by covering the surface by gunny bags/hessian, which shall be kept wet continuously for 7 days by sprinkling water.
- b) The curing shall be done by spraying with approved resin based' aluminized reflective curing compound conforming to ASTM-C 309-81 in accordance with Clause 602.9.12. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days. The rate of application shall be as recommended by the supplier.
- c) Wax-based white pigmented curing compound with water retention index of not less than 90 percent shall be used to cure the dry lean concrete. The curing compound shall conform to 88:7542. The compound shall be applied uniformly with a mechanical sprayer and with a hood to protect the spray from the wind. The curing compound shall be applied over the entire exposed surface of the Dry Lean Concrete, including sides and edges, at the rate of 0.2 litres/sq.m, or as recommended by the supplier.

The first application, referred to as curing application shall be applied immediately after the final rolling of Dry Lean Concrete is completed. As soon as the curing compound loses tackiness, the surface shall be covered with wet hessian for three days. The second application of curing compound also referred to as the debonding application, shall be applied 24 to 48 hours prior to the placement of the concrete pavement. Any damaged Dry Lean Concrete shall be corrected prior to the second application. Normally, the manufacturer's instructions shall be followed for its application.

601.7 Trial Mixes

The Contractor shall make trial mixes of dry lean concrete with moisture contents like 5.0, 5.5, 6.0, 6.5 and 7.0 percent using specified cement content, specified aggregate grading and aggregate-cement ratio specified in Clause 601.3.1. Optimum moisture and density shall be established by preparing cubes with varying. Moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot as described in Clause 903.5.1.1. After establishing the optimum moisture, a set of six cubes shall be cast at optimum moisture for the determination of compressive strength on the third and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory by increasing cement content. After the mix design is approved, the Contractor shall construct a trial section in accordance with Clause 601.8.

If during the construction of the trial length, the optimum moisture content determined as above is found to be unsatisfactory, the Contractor may make suitable changes in the moisture content to achieve the satisfactory mix. The cube specimens prepared with the changed mix content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be

determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in raveling of surface.

601.8 Trial Length

601.8.1 The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a "Method Statement" giving detailed description of the proposed materials, plant, equipment, mix proportions, and procedure for batching, mixing; laying, compaction and other construction procedures. The Engineer shall also approve the location and length of trial construction which shall be a minimum of 100 m length laid in two days and for full width of the pavement. The trial length shall be outside the main works. The trial length shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid Dry Lean Concrete sub-base. The construction of trial length shall be repeated till the Contractor proves his ability to satisfactorily construct the Dry Lean Concrete sub-base.

601.8.2 After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length and average of these densities shall be determined. The density holes shall not be made in the strip 500 mm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 percent. The field density of regular work will be compared with this reference density in accordance with Clauses 601.6.5.1 and 903.5.1.2.

601.8.3 The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. The lower surface shall not have honey; combing and the aggregates shall not be held loosely at the edges.

601.8.4 The main work shall not start until the trial length has been approved by the Engineer. After approval has been given, the materials, mix proportions, moisture content, mixing, laying, compaction plant and construction procedures shall not be changed without the approval of the Engineer.

601.9 Tolerances for Surface Regularity, Level, Thickness, Density and Strength Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

601.10 Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the dry lean concrete sub-base. Construction vehicles at slow speed may be permitted after 7 days of its construction with the prior approval of the Engineer.

601.11 Measurement for Payment

The unit of measurement for dry lean concrete pavement shall be in cubic metre of concrete placed, based on the net plan area for the accepted thickness shown on the drawings or as directed by the Engineer.

601.12 Rate

The Contract unit rate payable for dry lean concrete sub-base shall be for carrying out the required operations including full compensation for all labour, materials and equipment, mixing, transport, placing, compacting, finishing, curing, rectification of defective surface testing and incidentals such as trial length to complete the work as per Specifications, all royalties, fees, storage and rents where necessary and all leads and lifts.

Item No. 104

Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with in M -40 grade of concrete with 53 grade cement , coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site and mechanically laid with a fixed form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing as per MoRTH clause 602

1. The relevant specification for MORT&H Cl no. 602 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 105

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 (For Underspace).

1. The Relevant specification shall be followed as per item description and as directed by engineer in charge.
2. The measurement & payment shall be in **Sqm.** basis.

Item No. 106

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 @ 250 gms per sqm area, thickness of 2.5 mm is excluding of surface applied glass beads as per IRC: 35-2015. The finished surface to be leveled, uniform and free from streaks and holes. Zebra patta/bump patta lane/centre line/edge line/cut patta. The white colour marking should provide liminance coefficient on cemented road shall be 130 mcd / m2 / lux and asphalt roads shall be minimum 100 130 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 (For Approach Retaining wall + Toe wall & Service Road)..

3. The relevant specification for item no. 33 shall apply to this item.

4. The measurement and payment shall be in **Sqm** basis.

Item No. 107

Cat Eye / Road Stud / RPM: Supplying of Molded Twin Shanks 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 strength of detachment of the integrated cylindrical shanks, (of diameter not less than 19 +/- 2 mm and height not less than 30 +/- 2 mm) from the body is to be a minimum value of 500 Kgf. Fixing will be by drilling holes on the road for the shanks to go inside, without nails and using epoxy resin based adhesive as per manufacturer's recommendation and The color of the marker should be as per the IRC 35-2015 and as directed by Engineer-in-charge (For Approach Retaining wall + Toe wall & Service Road).

1. The relevant specification for item no. 34 shall apply to this item.
2. The measurement and payment shall be in **Nos** basis.

Item No. 108

Retro-Reflective road signs.

- a) **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.**

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in **Nos.** basis

- b) **Regulatory / Mandatory Sign :-Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 60 cms Dia Circle 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

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

- c) **Hazard Marker Sign :-**Providing and fixing sign boards made out of 1.5mm aluminium sheet / 3mm ACP (Aluminum composite Panel); size 90x30 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; 1.8mtr 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**

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

- d) **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**

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

- e) **Men at work (2' x 2') sign :-**Providing and fixing sign boards made out of 2.0 mm aluminium sheet / 4 mm ACP(Aluminum composite Panel); size 60cm x 60cm square 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; 3.3 mtr long 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 or inscription / numerals for each board shall be as per the instruction of engineer in

charge. The fixing at site shall be in 1:2:4 CC block of 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

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

f) Danger Plate :- Providing & fixing sign board made out of 2.0 mm aluminium sheet / 4 mm ACP (aluminum Composite Panel), size 30cms diameter circle, pretreated with phosphating process and acid etching, painted with one coat of epoxy primer and two coats of best quality epoxy paint reflectorised with retro reflective sheeting as per latest M.O.S.T. specifications. 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

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

g) Cautionary Warning Sign :- Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 90 x 90 x 90 cms. equilateral triangle as per design of IRC-67-2012. Pre treated with phosphating 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 best quality epoxy coatings in black and white bends. 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 CC block of 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

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

h) Distance Informatory / Destination Sign :- Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 180x120 cms. rectangular as per design of IRC-67-2012. Pre treated with phosphating 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 best quality epoxy coatings in black and white bends. 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 CC block of 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

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

i) **Village Name Sign :-Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminum composite Panel); size 90x60 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; 3.3mtr 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 or inscription/letters / numerals for each board shall be as per the instruction 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**

1. The relevant specifications given in Section – 800 of MORT&H fifth revision specification shall apply to this item.
2. The measurement & payment shall be in Nos. basis

Item No. 109

Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth upto 3.0 M. and lead upto 100m for 10 Cum (For Box Drain & Pipe Culvert).

1. The relevant specification for item no. 1 shall apply to this item.
2. The measurement and payment shall be in Cum basis.

Item No. 110

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 (For Box Drain & Pipe Culvert).

1. The relevant specification for item no. 3 shall apply to this item.
2. The measurement and payment shall be in Cum basis.

Item No. 111

Dismantling the existing structure including removing and stacking the dismantled materials as and where directed - RCC work & PCC Work

**RCC
PCC**

1. The relevant specification for item no. 37 shall apply to this item.
2. The measurement and payment shall be in Cum basis.

Item No. 112

Providing and Casting in situ Controlled Cement Concrete M25 for Box Drain and Head walls including necessary shuttering laying, vibrating, ramming and curing complete (For Box Drain & Pipe Culvert).

1. The relevant specification of MORT&H Section no. 1700, 2100, & 2200 shall apply to this item.
2. The mode of measurement & payment shall be done in **Cum** basis.

Item No. 113

Providing and placing in position FE 550D (With CRS) TMT bar reinforcement for following items including cutting bending hooking and tying complete as per detailed drawing. For RCC Raft & Open foundation (For Box Drain & Pipe Culvert Head Wall).

1. The relevant specification for MORT&H specifications as in section 1600 & 1009 (5th revision) shall be apply to this item.
2. The mode of measurement & payment shall be in per **MT.** basis.

Item No. 114

Earthwork for embankment including breaking clods, dressing with all lead and lift and including watering rolling and consolidation of subgrade in layers at O.M.C. to required dry density including filling the depression which occur during the process using vibratory roller 8t to 10t. (A) From borrow pits within land width.

1. The relevant specification for item no. 101 shall apply to this item.
2. The measurement and payment shall be in **Cum** basis.

Item No. 115

Supplying and fixing reinforced concrete heavy duty non-pressure pipes with collars for culverts including setting and joining the pipes in C.M. 1:2 watering and laying (To level of slops of I.S. 458 / 1971 Class NP4 casted by vertically vibrated technology of following internal diameter. 900mm dia Pipe Culvert.

1. The relevant specifications given as per Section - 1013 & 2900 of MORT&H fifth revision specification.

1013. REINFORCED CONCRETE PIPES

Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS:458.

The measurement and mode of payment shall be in **Running meter** basis.

Item No. 116

Providing and laying rubble for apron (Each stone weighting not less than 40 kg.) including and packing and filling in the interestices with quarry spalls. (More than 10 ton)

1. The relevant specifications given in Section – 2503 of MORT&H fifth revision shall apply to this item.
2. The measurement & Payment shall be in **Cum** basis

Item No. 117

Planting of Trees and their Maintenance (Planting of trees by the central verge / Road side and maintaining the plants)

1. Relevant specifications shall apply as per item description and as directed by engineer in charge.
2. The measurement shall be on the basis of **km.**
3. The mode of payment shall be in per **km** basis.

200
SITE CLEARANCE

201 CLEARING AND GRUBBING

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 require 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, undergrowth, 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:-

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

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:-

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

For 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 metre from the ground.

201.6 Rates

- 201.6.1 The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm 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.

- 201.6.2 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.
- 201.6.3 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.
- 201.6.4 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.
- 201.6.5 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.

202 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/ PAVEMENTS

202.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavements, kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., from the right of way which in the opinion of the Engineer interfere with the construction of road or are not suitable to remain in place, disposing of the surplus/unsuitable materials and backfilling to after the required compaction as directed by the Engineer.

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

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

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

202.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the part of the structure to be retained and any other properties or structures nearby:

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed up to at least 600 mm below the sub-grade, slope face or original ground level whichever is the lowest or as necessary depending

upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

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

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

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber having salvage value as is designated by the Engineer.

202.3 Dismantling Pavements and Other Structures

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

All concrete pavements, base courses in carriageway and shoulders etc., designated for oval shall be broken to pieces whose volume shall not exceed 0.02 cu.m and used with approval of the Engineer or disposed of.

202.4 Back-filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated her approved materials and compacted to required density as directed by the Engineer.

202.5 Disposal of Materials

All Surplus materials shall be taken over by the Contractor which may either be re-used with approval of the Engineer or disposed of with all leads and lifts.

202.6 Measurements for Payment

The work of dismantling shall be paid for in units indicated below by taking measurements re and after, as applicable:

i)	Dismantling brick/stone masonry/ concrete (plain and reinforced)	cu.m
ii)	Dismantling flexible and cement concrete pavement	cu.m
iii)	Dismantling steel structures	tonne
iv)	Dismantling timber structures	cu.m
v)	Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m
vi)	Utility services	No.

202.7

Rates

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. The rates will include excavation and backfilling to the required compaction and for handling, giving credit towards salvage value disposing of dismantled materials with all lifts and leads.

400

SUB-BASES, BASES (NON-BITUMINOUS)
AND SHOULDERS

401 GRANULAR SUB-BASE

401.1 Scope

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid 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.

401.2 Materials

401.2.1 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.

401.2.2 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 Designation	Percent by Weight Passing the IS Sieve					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75.0mm	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
2.36mm	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) or 15:5640	40 maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
·cBR at 98% dry density (at 15:2720-Part 8)	IS:2720 (Part 5)\	Minimum 30 unless otherwise specified in the Contract

401.3 Construction Operations**401.3.1 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 wheeld roller.

401.3.2 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 15:2720 (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.

401.4 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.

402 LIME TREATED SOIL FOR IMPROVED SUB-GRADE/SUB-BASE

402.1 Scope

This work shall consist of laying and compacting an improved sub-grade/lower sub-base of soil treated with lime on prepared sub-grade 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. Lime treatment is generally effective for soils which contain a relatively high percentage of clay and silty clay.

402.2 Materials

402.2.1 Soil

Except when otherwise specified, the soil used for stabilization shall be the local

clayey soil having a plasticity index greater than 8.

402.2.2 Lime

Lime for lime-soil stabilization work shall be commercial dry lime slaked at site or pre-slaked lime delivered to the site in suitable packing. Unless otherwise permitted by the Engineer, the lime shall have purity of not less than 70 percent by weight of Quick-lime (CaO) when tested in accordance with IS:1514. Lime shall be properly stored to avoid prolonged exposure to the atmosphere and consequent carbonation which would reduce its binding properties.

IS Sieve designation	Minimum percent by weight passing the IS Sieve
26.5 mm	100
5.6mm	80

402.3.3 Equipment for Construction

Stabilised soil sub-bases shall be constructed by mix-in-place method of construction or as otherwise approved by the Engineer. Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs.

The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of pulverizing and mixing the soil with additive and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work.

The thickness of any layer to be stabilized shall be not less than 100mm when compacted. The maximum thickness can be 200 mm, provided the plant used is accepted by the Engineer.

402.3.4 Mix-in-place Method of Construction

Before deploying the equipment, the soil after it is made free of undesirable vegetation or other deleterious matter shall be spread uniformly on the prepared subgrade in a quantity sufficient to achieve the desired compacted thickness of the stabilised layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled as directed by the Engineer.

The equipment used shall either be of single-pass or multiple pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

With single-pass equipment the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing, pulverisation and depth of processing is obtained. In multiple-pass processing, the prepared sub-grade shall be pulverised to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits mentioned hereinafter. The

lime shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

The mixing equipment shall be so set that it cuts slightly into the edge of the adjoining lane processed previously so as to ensure that all the material forming a layer has been properly processed for the full width.

402.3.5 Construction with Manual Means

Where manual mixing is permitted, the soil from borrow areas shall first be freed of all vegetation and other deleterious mate (and placed on the prepared subgrade. The soil shall then be pulverized by means of crow-bars, pick axes or other means approved by the Engineer.

Water in requisite quantities may be sprinkled on the soil for aiding pulverisation. On the pulverized soil, the lime in requisite quantities shall be spread uniformly and mixed thoroughly by working with spades or other similar implements till the whole mass is uniform. After adjusting the moisture content to be within the limits mentioned later, the mixed material shaft be leveled up to the required thickness so that it is ready to be rolled.

402.3.6 Addition of Lime

Lime may be mixed with the prepared material either in slurry form or dry state at the option of the Contractor with the approval of the Engineer.

Dry lime shall be prevented from blowing by adding water to the lime or other suitable means selected by the Contractor, with the approval of the Engineer.

The tops of windrowed material may be flattened or slightly trenched to receive the lime.

The distance to which lime may be spread upon the prepared material ahead of the-mixing operation shall be determined by the Engineer.

No traffic other than the mixing equipment shall be allowed to pass over the spread lime until after completion of mixing.

Mixing or remixing operations, regardless of equipment used, shall continue until the material is free of any white streaks or pockets of lime and the mixture is uniform.

Non-uniformity of colour reaction, when the treated material is tested with the standard phenolphthalein alcohol indicator, will be considered evidence of inadequate mixing.

402.3.7 Moisture Content for Compaction

The moisture content at compaction checked vide IS:2720 (Part 2)• shall neither be less than the optimum moisture content corresponding to IS:2720 (Part 8) nor more than 2 percent above it.

402.3.8 Rolling

Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with approved equipment preceded by a few passes of lighter rollers if necessary. Rolling shall commence at edges and progress towards the centre, except at super elevated portions or for carriageway with unidirectional cross-fall where it shall commence at the inner edge and progress towards the outer edge. During rolling, the surface shall be frequently checked for grade and crossfall (camber) and any irregularities corrected by loosening the material and removing/adding fresh material. Compaction shall continue until the density achieved is at least 98 percent of the maximum dry density for the material determined in accordance with IS:2720 (Part 8).

Care shall be taken to see that the compaction of lime stabilised material is completed within three hours of its mixing or such shorter period as may be found necessary in dry weather.

During rolling it shall be ensured that roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

402.3.9 Curing

The sub-base course shall be suitably cured for a minimum period of 7 days after which subsequent pavement courses shall be laid to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer.

402.4 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.

402.5 Strength

When lime is used for improving the subgrade, the soil-lime mix shall be tested for its CBR value. When lime stabilized soil is used in a sub-base, it shall be tested for unconfined compressive strength (UCS) at 7 days. In case of variation from the design CBRIUCS, in situ value being lower, the pavement design shall be reviewed based on the actual CBR/UCS values. The extra pavement thickness needed on account of lower CBRIUCS value shall be constructed by the Contractor at his own cost.

402.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Clause 112.

402.7 Measurements for Payment

Stabilised soil sub-graded sub-base shall be measured as finished work in position in cubic metres.

402.8 Rate

The Contract unit rate for lime stabilised soil sub graded/ sub-base 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).

403 CEMENT TREATED SOIL AND CEMENT-FLYASH TREATED SUB-BASE/BASE**403.1 Scope**

This work shall consist of laying and compacting a sub-base/base course of soil treated with cement or cement-flyash on- prepared subgrade/sub-base, in accordance with the requirements of these

Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or directed by the Engineer.

403.2 Materials**403.2.1 Material to be Treated**

The material used for cement or cement-flyash treatment shall be soil including sand and gravel, laterite, kankar, brick aggregate, crushed rock or slag or any combination of these. For use in a sub-base course, the material shall have a grading shown in Table 400-4. It shall have a uniformity coefficient not less than 5, capable of producing a well-closed surface finish. For use in a base course, the material shall be sufficiently well graded to ensure a well- closed surface finish and have a grading within the range given in Table 400-4. If the material passing 425 micron sieve is plastic, it shall have a liquid limit not greater than 45 percent and a plasticity index not greater than 20 percent determined in accordance with IS:2720 (Part 5). The physical requirements for the material to be treated with cement for use- in a base course shall be same as for Grading I Granular Sub-base, Clause 401.2.2.

403.2.2 Cement

Cement for stabilization shall either be ordinary Portland Cement, Portland Slag Cement or Portland Pozzolana Cement and shall comply with the requirements of IS:269, 455 or 1489 respectively.

Table 400-4 : Grading Limits of Material for Stabilisation with Cement

IS sieve size .	Percentage by mass passing Sub-Base/Base within the range
53.00 mm	100
37.5 mm	95-100
19.0 mm	45-100
9.5mm	35-100
4.75 mm	25-100
600micron	8-65
300micron	5-40

75 micron	O-10
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403.2.3 Lime

If needed for pre-treatment of highly clayey soils, Clause 402.2.2 shall apply.

403.2.4 Flyash

Flyash may be from anthracitic coal or lignitic coal. Flyash to be used for cement-flyash treatment shall conform to the requirement given in Tables 400-5 and 400-6.

Table 400-5 : Chemical Requirements for Fly Ash as Pozzolana

Sl. No.	Characteristics	Requirements for Fly Ash		Method of Test
		Anthracitic Flyash	Lignitic Flyash	
1)	SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃ in percent by mass, Min	70	50	IS:1727
2)	SiO ₂ in percent by mass, Min	35	25	18:1727
3)	MgO in percent by mass, Max	25	5.0	18:1727
4)	SO ₃ in percent by mass, Max	2.75	3.5	18:1727
5)	Available alkalies as Na ₂ O/K ₂ O in percent by mass, Max,	1.5	1.5	18:4032
6)	Total chlorides in percent by mass, Max	0.05	0.05	18:1727
7)	Loss on ignition in percent by mass, Max	5.0	5.0	18:1727

Table 400,6 : Physical Requirement for Fly Ash as a Pozzolona

Sl. No.	Characteristics	Requirement
1)	Fineness-specific surface in m ² /Kg by Blaine's permeability test, Min	250
2)	Particles retained on 45 micron IS sieve, Max	40
3)	Lime reactivity in N/mm ² , Min	3.5
4)	Soundness by autoclave test expansion of specimen in percent, Max	0.8
5)	Soundness by Lechatelier method-expansion in mm, Max	10

Pond ash or bottom ash, which does not meet the requirements of Tables 400-5 and 400-6 can also be used for cement-flyash treatment. However, in all cases of cement stabilised fly-ash/ bottom ash/ pond ash, mix should develop adequate strength.

403.2.5 Quantity of Cement in Cement-Soil Stabilised Mix

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The quantity of cement to be added as percent by weight of the dry soil shall be specified in the Contract. Also if lime is used as pretreatment for highly clayey soils, the quantity as percent by weight of dry soil shall be specified in the Contract. The mix design shall be done on the basis of 7 day unconfined compressive strength (UCS) and/or durability test under 12 cycles of wet-dry conditions. The laboratory strength values shall be at least 1.5 times the minimum field UCS value stipulated in the Contract.

403.2.6 Quantity of Cement in Cement/Fly Ash Treated Sub-base/Base

The quantity of cement shall be more than 2 percent by weight of cement fly-ash mix. The mix design shall be done to achieve a strength of 1.75 MPa when tested on cylindrical specimens compacted to the density at optimum moisture content, tested in accordance with IS:2720 (Part 8 as specified in the contract) after 7 days moist curing. The design mix shall indicate the proportions of cement and fly ash and the quantity of water to be mixed.

403.2.7 Water

The water to be used for cement stabilization shall be clean and free from injurious substances. Potable water shall be used.

403.3 Construction Operations

403.3.1 Weather Limitations

Stabilisation shall not be done when the air temperature in the shade is less than 10°C.

403.3.2 Degree of Pulverisation

For stabilisation, the soil before addition of cement shall be pulverised, where necessary, to the extent that it passes the requirements as set out in Table 400-7 when tested in accordance with the method described in Appendix-3.

Table 400-7: Soil Pulverisation Requirements for Cement Stabilisation

IS sieve Designation	Minimum percent by weight passing the IS sieve
26.5 mm	100
5.6mm	80

403.3.3 Clauses 402.3.3 to 402.3.5 shall apply as regards spreading and mixing the stabilizer except that cement or lime plus cement as the case may be, shall be used as the stabilizing material in place of lime.

403.3.4 Moisture Content for Compaction

The moisture content at compaction checked vide IS:2720 (Part 2) shall not be less than the optimum moisture content corresponding to IS:2720 (Part 8) nor more than 2 percent above it.

403.3.5 Rolling

Clause 402.3.8 shall apply except that care shall be taken to see that the compaction of cement stabilised material is completed within two hours of its mixing or such shorter period as may be found necessary in dry weather.

403.3.6 Curing

The sub-base/base course shall be suitably cured for 7 days. Subsequent pavement course shall be laid soon after to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer.

403.4 Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902.

403.5 Strength and Quality Control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900

Cement treated soil sub-base/base and cement/fly ash treated sub-base/base shall be tested for the unconfined compressive strength (UCS) value at 7 days, actually obtained in-situ. In case of variation from the design UCS, in-situ value being on lower side, prior to proceeding with laying of base/surface course on it, the pavement design shall be reviewed for actual UCS value. The extra pavement thickness needed on account of lower UCS shall be constructed by the Contractor at his own cost.

403.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Clause 112.

403.7 Measurements for Payment

Stabilised soil sub-base/base shall be measured as finished work in position in cubic metres.

403.8 Rate

The Contract unit rate for cement treated soil sub-base/base with pretreatment with lime if required and cement/fly ash treated sub-base/base shall be payment in full for carrying out required operations including full compensation for all components listed in Clause 401.7 (i) to (v).

404 WATER BOUND MACADAM SUB-BASE/BASE

404.1 Scope

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

thickness as per approved plans or as directed by the Engineer.

404.2 Materials

404.2.1 Coarse Aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag, over burnt (Jhama) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Materials other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed •gravel/shingle is used, not less than 90 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. The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part 5).

Table 400-8 : Physical Requirements of Coarse Aggregates for Water Bound Macadam for Sub-base/Base Courses

S.No.	Test	Test Method	Requirements
1) ***	Los Angeles Abrasion value or Aggregate Impact value	IS: 2386(Part4)	40 percent (Max)
		IS: 2386 (Part-4) or 15:5640*	30 percent (Max)
2)	Combined Flakiness and Elongation Indices (Total) **	IS:2386 (Part-1)	35 percent (Max)

* Aggregates which get softened in presence of water shall be tested for Impact value under wet conditions in accordance with 18:5640.

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

*** In case water bound macadam is used for sub-base, the requirements in respect of Los Angeles Value and Aggregate Impact Value shall be relaxed to 50 percent and 40 percent maximum respectively.

404.2.2 Crushed or Broken Stone

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

404.2.3 Crushed Slag

Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11:2 kN per m³ and the percentage of glossy material shall not be more than 20. It should also comply with the following requirements:

- i) Chemical stability To comply with requirements of appendix of BS:1047

- | | | |
|------|------------------|--------------------|
| ii) | Sulphur content | Maximum 2 percent |
| iii) | Water absorption | Maximum 10 percent |

404.2.4 Overburnt (Jhama) Brick Aggregates .

Jhama brick aggregates shall be made from overburnt bricks or brick bats and be free from dust and other objectionable and deleterious materials. This shall be used only for road stretch when traffic is low.

404.2.5 Grading Requirement of Coarse Aggregates

The coarse aggregates shall conform to one of the Gradings given in Table 400-9 as specified.

404.2.6 Screenings

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

Table 400-9 : Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS Sieve Designation	Percent by weight Passing
1)	63 mm to 45 mm	75mm	100
		63mm	90-100
		53mm	25-75
		45mm	0-1.5
		22.4 mm	0-5
2)	53 mm to 22.4 mm	63mm	100
		53mm	95-100
		45mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note: The compacted thickness for a layer shall be 75 mm.

Screenings shall conform to the grading set forth in Table 400-10. The quantity of screenings required for various grades of stone aggregates are given in Table 400-11. The Table also gives the quantities of materials (loose) required for 10 m² for sub-base/base compacted thickness of 75 mm.

The use of screenings shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc. as they are likely to get crushed to a certain extent under rollers.

404.2.7 Binding Material

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

The quantity of binding material where it is to be used will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m³ per 10m².

Table 400-10: Grading For Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by Weight Passing the sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95-100
		5.6mm	15-35
		180 micron	0-10
B	11.2 mm	11.2 mm	100
		9.5mm	80-100
		5.6mm	50-70
		180 micron	5-25

Table 400-11 : Approximate Quantities of Coarse Aggregates and Screenings Required for 75 mm Compacted Thickness of Water Bound Macadam (WBM) Sub-Base/Base Course for 10 m² Area

Classification	Size Range	Compacted Thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type Such as Moorum or Gravel	
				Grading Classification & Size	For WBM Sub-base/ Base Course (Loose Quantity)	Grading Classification & Size	Loose Qty.
Grading 1	63mm to 45 mm	75mm	0.91 to 1.07 m ³	Type A 13.2 mm	0.12 to 0.15 m ³	Not uniform	0.22 to 0.24 m ³
-do-	-do-	-do-	-do-	Type B 11.2 mm	0.20 to 0.22 m ³	-do-	-do-
Grading 2	53mm to 22.4 mm	75mm	-do-	-do-	0.18 to 0.21 m ³	-do-	-do-

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

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

404.3 Construction Operations

404.3.1 Preparation of Base

The surface of the sub-grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified grade and camber and cleaned of dust, dirt and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained.

Where the WBM is to be laid on an existing metalled road, damaged area including depressions and potholes shall be repaired and made good with the suitable material. The existing surface shall be scarified and re-shaped to the required grade and camber before spreading the coarse aggregate for WBM.

As far as possible, laying water bound macadam course over existing bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it.

404.3.2 Inverted Choke/Sub-surface Drainage Layer

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

404.3.3 lateral Confinement of Aggregates

For construction of WBM, arrangement shall be made for the lateral confinement of aggregates. This shall be done by building adjoining shoulders along with WBM layers. The practice of constructing WBM in a trench section excavated in the finished formation must be completely avoided.

Where the WBM course is to be constructed in narrow widths for widening of an existing pavement, the existing shoulders should be excavated to their full depth and width up to the sub-grade level except where widening specifications envisages laying of a stabilised sub-base using in-situ operations in which case the same should be removed only up to the sub-base level.

404.3.4 Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly and evenly upon the prepared sub-grade/ sub-base in the required quantities from the stockpiles to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 75 mm. 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 base be permitted. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimize the need for manual rectification afterwards.

No segregation of coarse aggregates shall be allowed and the coarse aggregates as spread shall be of uniform gradation with no pockets of fine material.

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

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

404.3.5 Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

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

Rolling shall be carried out on courses where coarse aggregates of crushed/ broken stone are used, till the road metal is partially compacted. This will be followed by application of screenings and binding material where required in Clauses 404.3.6 and 404.3.7.

However, where screenings are not to be applied as in the case of aggregates like brick metal, laterite and Kankar for sub-base construction, the compaction shall be continued until the aggregates are thoroughly keyed. Rolling shall be continued and light sprinkling of water shall be done till the surface is well compacted. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely with templates and longitudinally with 3 m straight edge. Any irregularities, exceeding 12 mm, shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.

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

404.3.6 Application of Screenings

After the coarse aggregates have been rolled to Clause 404.3.5, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be equipped with pneumatic tyres and operated so as not to disturb the coarse aggregates.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregates. These operations shall continue until no more screenings can be forced into voids of the coarse aggregates. The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

404.3.7 Sprinkling of Water and Grouting

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

In case of lime treated soil sub-base, construction of water bound macadam on top of it shall be taken up after curing as per Clause 402.3.9 and as directed by the Engineer.

Application of binding material : After the application of screenings in accordance with Clauses 404.3.6 and 404.3.7, the binding material where it is required to be used (Clause 404.2.7) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them; These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

404.3.8 Setting and Drying

After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings

or binding material as directed,' lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

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

404.4 Surface Finish and Quality Control of Work

404.4.1 The surface finish of construction shall conform to the requirements of Clause 902.

404.4.2 Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

404.4.3 The water bound macadam work shall not be carried out when the atmospheric temperature is less than 10°C in the shade.

404.4.4 Reconstruction of Defective Macadam

The finished surface of water bound macadam shall conform to the tolerances of surface/ regularity as prescribed in Clause 902. However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to sub-grade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and re-compacted. The area treated shall not be less than 10 sq.m. In no case shall depressions be filled up with screenings or binding material.

404.5 Arrangements for Traffic

During the period of construction, the arrangements for traffic shall be done as per Clause 112.

404.6 Measurements for Payment

Water bound macadam shall be measured as finished work in position in cubic metres.

404.7 Rate

The Contract unit rate for water bound macadam sub-base/base course shall be payable in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v), including arrangement of water used in the work as approved by the Engineer.

405 CRUSHED CEMENT CONCRETE SUB-BASE

405.1 Scope

This work shall consist of breaking and crushing the damaged cement concrete slabs and re-compacting the same as sub-base/base course in one or more layers. The work shall be performed on such widths and lengths as may be specified, in accordance

with the requirements of these Specifications and in conformity with the lines, grades and cross- sections shown on the drawings or as otherwise directed by the Engineer.

405.2 Materials

405.2.1 Coarse Aggregates

Coarse aggregates for this work shall be broken cement concrete slabs crushed to a size not exceeding 75 mm and as far as possible, conforming to one of the gradings given in Table 400-9.

405.3 Construction Operations

405.3.1 General

Crushed cement concrete sub-base course may be constructed in one or two layers, depending upon thickness of the concrete slabs dismantled and crushed. The thickness of each layer shall not exceed 75 mm compacted thickness.

405.3.2 Preparation of Surface

The surface of the subgrade shall be prepared in accordance with Clause 404.3.1.

405.3.3 Spreading of Aggregates

The sub-base material of grading specified in the Contract 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.

405.3.4 Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

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

Rolling shall be continued and light sprinkling of water shall be done till the surface is well compacted.

The rolled surface shall be checked transversely with templates and longitudinally with 3 m straight edge. Any irregularities, exceeding 12 mm, shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to the desired camber and grade.

405.4 Surface Finish and Quality Control of Work

The surface finish and control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

405.5 Arrangements for Traffic

During the period of construction, arrangement for traffic shall be done as per Clause 112.

405.6 Measurements for Payment

Breaking the existing cement concrete pavement slabs, crushing and recompacting the slab material as sub-base course shall be measured as a single item in terms of the volume of sub-base laid in position in cubic metres.

405.7 Rate

The Contract unit rate for crushed cement concrete sub-base course 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) . breaking the cement concrete slabs, crushing, sieving and recompacting the slab material as sub-base course;
- 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.

406 WET MIX MACADAM SUB-BASE/BASE

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 18:2386 (Part-5).

Table 400-12: Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/Base Courses

S.No.	Test	Test Method	Requirements
1)	Los Angeles Abrasion value or Aggregate Impact value	IS:2386 (Part-4)	40 percent (Max.)
		18:2386 (Part-4) or 18:5640.	30 percent (Max.)
2)	Combined Flakiness and Elongation 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/super elevation, 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 wave like motion in the sub-base/base course or subgrade. 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 recompact.

406.3.6 Setting and Drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

406.4 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 recompact 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.

407 CRUSHER-RUN MACADAM BASE

407.1 Scope

This work shall consist of furnishing, placing and compacting crushed stone aggregate sub-base and base courses constructed in accordance with the requirements set forth in these Specifications and in conformity with the lines, grades, thickness and cross-sections shown on the drawings or as directed by the Engineer.

407.2 Materials

The material to be used for the work shall be crushed rock. 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. It shall be free from any organic matter and other deleterious substances and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base. The aggregates shall conform to the grading and quality requirements given in Tables 400-14 and 400-15.

The grading to be adopted shall be as indicated in the Contract.

407.3 Construction Operations

407.3.1 Preparation of Sub-grade

The surface of the sub-grade shall be prepared in accordance with Clause 404.3.1. Any ruts, deformations or soft yielding places which occur in the sub-base or sub-grade shall be corrected and compacted to the required density before the aggregate base course is placed thereon.

407.3.2 Spreading, Watering, Mixing and Compaction

The aggregate shall be uniformly deposited on the approved subgrade by means of hauling vehicle with or without spreading devices. Aggregate will be distributed over the surface to the depth specified on the drawings or as directed by the Engineer.

Table 400-14: Aggregate Grading Requirements

Sieve Size	Percent passing by weight	
	53 mm max.size	37.5 mm max. size
63mm	100	
45mm	87-100	100
22.4 mm	50-85	90-100
5.6mm	25-45	35-55
710mm	10-25	10-30
90mm	2-5	2-5

Table 400-15 : Physical Requirements of Coarse Aggregates for Crusher-Run Macadam Base

	Test	Test Method	Requirements
1)	Los Angeles Abrasion value or Aggregate Impact value	18:2386 (Part 4) 18:2386 (Part 4) or 18:5640	40 maximum 30 maximum
2) /	Combined Flakiness and Elongation Indices (Total)	18:2386 (Part 1)	35 maximum** .
3)	*Water absorption	18:2386 (Part 3)	2 percent maximum
4)	Liquid Limit of material passing 425 micron	18:2720 (Part 5)	25 maximum
5)	Plasticity Index of material passing 425 micron	18:2720 (Part 5)	6 maximum

* If the water absorption is more than 2 percent, soundness test shall be carried out as per 18:2386 (Part-5)

** 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 value of flakiness index and elongation index so found are added up.

After the base course material has been deposited, it shall be thoroughly blade-mixed to full depth of the layer by alternately blading the entire layer to the center and back to the edges of the road. It shall then be spread and finished to the required cross-section by means of a motor grader.

Water shall be applied prior to and during all blading and processing operations to moisten the material sufficiently to prevent segregation of the fine and coarse particles. Water shall be applied in sufficient amounts during construction to assist in compaction.

Compaction shall commence immediately after the spreading operation. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity. The speed of the roller shall not exceed 5 km/h. Each layer of material shall be compacted to not less than 98 percent of the maximum density as determined by 18:2720 (Part-8).

407.4 Opening to Traffic

No vehicular traffic shall be allowed on the finished crusher-run macadam surface. Construction equipment may be allowed with the approval of the Engineer.

407.5 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 work shall be exercised by the Engineer in

accordance with Section 900.

407.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be done in accordance with Clause 112.

407.7 Measurements for Payment

Crusher-run macadam base shall be measured as finished work in position in cubic metres.

407.8 Rate

The Contract unit rate for crusher run macadam base shall be payment in full for carrying out the required operations including full compensation for all components as in Clause 401.7 (i) to (v).

408 SHOULDERS, ISLANDS AND MEDIANS

408.1 Scope

The work shall consist of constructing shoulder (hard/paved/earthen with brick or stone block edging) on either side of the pavement, median in the road dividing the carriageway into separate lanes and islands for channelising the traffic at junctions 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.

408.2 Materials

Shoulder on either side of the road may be of selected earth/granular material/paved conforming to the requirements of Clause 305/401 and the median may be of selected earth conforming to the requirements of Clause 305.

Median/Traffic islands shall be raised and kerbed at the perimeter and the enclosed area filled with earth and suitably covered with grass turf/shrubs as per Clause 307 and/or paved as per Clauses 410.3.4 or 410.3.5.

Paved shoulders shall consist of sub-base, base and surfacing courses, as shown in the drawings and materials for the same shall conform to relevant Specifications of the corresponding items. Where paved or hard shoulders are not provided, the pavement shall be provided with brick/stone block edgings as shown in the drawings. The brick shall conform to Clause 1003 of these Specifications. Stone blocks shall conform to Clause 1004 of these Specifications and shall be of size 225 mm x 110 mm x 75 mm.

408.3 Size of Shoulders/Medians/Islands

Shoulder (earthen/hard/paved)/median/traffic island dimensions shall be as shown on the drawings or as directed by the Engineer.

408.4 Construction Operations

408.4.1 Shoulders

The sequence of operations shall be such that the construction of paved shoulder is done in layers each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in paved and earth shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The corresponding layer in paved shoulder portion shall be compacted thereafter, which shall be followed by compaction of each shoulder layer. The adjacent layers having same material shall be laid and compacted together.

In all cases where paved shoulders have to be provided along side of existing carriageway, the existing shoulders shall be excavated in full width and to the required depth as per Clause 301.3.7. Under no circumstances, box cutting shall be done for construction of shoulders

Compaction requirement of earthen shoulder shall be as per Table 300-3. In the case of bituminous courses and concrete pavement, work on shoulder shall start only after the pavement course has been laid and compacted.

During all stages of shoulder construction, the required crossfall shall be maintained to drain off surface water.

Regardless of the method of laying all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed, without damage to the pavement, and the area so affected thoroughly cleaned.

408.4.2 Median and Islands

Median and islands shall be constructed in a manner similar to shoulder up to the road level. Thereafter, the median and islands, if raised, shall be raised at least 300 mm by using kerb stones of approved material and dimensions. and suitably finished and painted as directed by the Engineer. If not raised, the median and islands shall be differentiated from the shoulder/ pavement as the case may be, as directed by the Engineer. The confined area of the median and islands shall be filled with local earth or granular material or any other approved material and compacted by plate compactor/power rammer. The confined area after filling with earth shall be turfed with grass or planted with shrubs, or finished with tiles/slabs as provided in the drawings.

408.4.3 Brick/Stone Block Edging

The brick/stone blocks shall be laid on edge, with the length parallel to the transverse direction of the road. They shall be laid on a bed of 25 mm sand, set carefully rolled into position by a light roller and made flush with the finished level of the pavement.

408.5 Surface Finish and Quality Control of Works

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.

408.6 Measurements for Payment

Shoulder (earthen/hard/paved), island and median construction shall be measured as finished work in position as below:

- i) For excavation in cu.m.
- ii) For earthwork/granular fill in cu.m.
- iii) For sub-base, base, surfacing courses in units as for respective items
- iv) For kerb in running metre; length of kerb for median shall be measured for each side separately.
- v) For turfing, shrubs and tile/slab finish in sq.m.
- vi) For brick/stone block edging in running metre, the length for brick/ stone block edging for median edging shall be measured for each side separately.

408.7 Rate

The Contract unit rate for shoulder (hard/paved/earthen with brick or stone block edging), island and median construction 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) as applicable. The rate for brick/stone block edging shall include the cost of sand cushion.

409 CEMENT CONCRETE KERB AND KERB WITH CHANNEL

409.1 Scope

This work shall consist of constructing cement concrete kerbs and kerbs with channel in the central median and/or along the footpaths or separators in conformity with the lines, levels and dimensions as specified in the drawings or as directed by the Engineer.

409.2 Materials

Kerbs and kerb with channel shall be provided in cement concrete of Grade M 20 in accordance with Section 1700 of these Specifications.

409.3 Type of Construction

These shall be cast-in-situ construction with suitable kerb casting machine in all situations except at locations where continuous casting with equipment is not practicable. In those locations precast concrete blocks shall be used.

409.4 Equipment

A continuous kerb casting equipment of adequate capacity and controls, capable of laying the kerbs in required cross-sections and producing a well-compacted mass of concrete free of voids and honeycombs, shall be used.

409.5 Construction Operations

- 409.5.1 Kerb shall be laid on firm foundation of minimum 150 mm thickness of cement concrete of M 15 grade cast in-situ or on extended width of pavement. The foundation shall have a projection of 50 mm beyond the kerb stone. Before laying the foundation of lean, concrete, the base shall be leveled and slightly watered to make it damp.

409.5.2 In the median portions in the straight reaches, the kerb shall be cast in continuous lengths. In the portions where footpath is provided and/or the slope of the carriageway is towards median (as in case of superelevated portion), there shall be sufficient gap/recess left in the kerb to facilitate drainage openings.

409.5.3 After laying the kerbs and just prior to hardening of the concrete, saw cut grooves shall be provided at 5 m intervals up to finished road level or as specified by the Engineer.

409.5.4 Kerbs on the drainage ends such as along the footpath or the median in superelevated portions shall be cast with monolithic concrete channels as indicated in drawings. The slope of the channel towards drainage pipes shall be ensured for efficient drainage of the road surface.

409.6 Measurements for Payment

Cement concrete kerb/kerb with channel including foundation shall be measured in linear metre for the complete item of work.

409.7 Rate

The Contract unit rates for cement concrete kerb/kerb with channel including foundation for kerb shall be payment in full compensation for furnishing all materials, labour, tools, equipment for construction and other incidental cost necessary to complete the work.

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:

- a) 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.
- b) 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.
- c) 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

410.3.1 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.

410.3.2 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.

410.3.3 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.

410.3A 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).

410.3.5 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.

410.3.6 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.

IS Sieve Size	Percent Passing
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

IS Sieve Size	Percent Passing
2.36 mm	100

1.18 mm	0-100
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 ± 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

Sub-Bases, Bases (Non-Bituminous) and Shoulders

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.

500

Bases and Surface Courses (Bituminous)

501 GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

501.1 General

Bituminous pavement courses shall be made using the materials described in the Specifications.

The use of machinery and equipment mentioned in various Clauses of these Specifications is mandatory. Details of the machinery and equipment are available in the Manual for Construction and Supervision of Bituminous Works. The equipment mandatory for any particular project shall be in accordance with the Contract Specifications for that project.

501.2 Materials

501.2.1 Binder

The binder shall be an appropriate type of bituminous material complying with the relevant Indian Standard, as defined in the appropriate Clauses of these Specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the Contract or by the Engineer. Where viscosity grades of bitumen are specified, they are referred to by a designation in accordance with IS:73. Where modified bitumen is specified, it shall conform to the requirements of IRC:SP:53 and IS:15462; and the following provision of this Specification shall apply.

- i) Modified bitumen from refinery sources or blended at approved central plant or at site using appropriate industrial process and plant with high shear mill, and testing facilities to achieve stable and homogenous mix shall be used. The use of high shear mixer or any other device capable of producing a homogeneous blend is essential when the modifier is in powder form.
- ii) Transportation tanks and storage tanks shall be insulated and equipped with effective heating system and circulation/ agitating device to maintain the specified temperature, homogeneity and viscosity of the bitumen during transit and storage.
- iii) Separation, difference in softening point (R&B), shall not be more than 3°C for any type of specified modified bitumen when tested as per Annex B of IS:15462.

Selection criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site, are given in Table 500-1.

Selection criteria for modified bitumen shall be in accordance with IRC:SP:53.

**Table 500-1 : Selection Criteria for Viscosity-Graded (VG) Paving Bitumens
Based on Climatic Conditions**

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Tables 500-5 and 500-6 can be obtained for the weather station nearest to the project site from the Indian Meteorological Organization (IMO). This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day in May or June) is used in Tables 500-5 and

500-6. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMO. Since these are mean temperatures based on the average of 30-40 years data, these temperatures are significantly lower than the absolute maximum temperatures, which may have occurred in a specific year.

501.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall demonstrate through 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 approved anti-stripping agents, as per the manufacturer's recommendations, at the cost of the Contractor.

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, except that in the case of bituminous concrete the requirement in this regard shall be 95 percent.

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

5.01.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder and wearing courses. However, natural sand up to 50 percent of the fine aggregates may be allowed in base courses. 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). The plasticity index of the fraction passing 0.425 mm shall not exceed 4 when tested in accordance with IS:2720 (Part 5). The fine aggregates shall satisfy the physical requirements set forth in the individual relevant-clause for the material in question.

501.2.4 Sources of Material

The sources of materials proposed to be used by the Contractor shall per tested to the satisfaction of the Engineer who shall give the necessary approval. The Engineer may from time to time withdraw approval .of a specific source, or attach conditions to the existing approval. Any change in aggregate source for bituminous mixes shall require a new mix design, and laying trials, where the mix is based on a job mix design. Stockpiles from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain material sufficient for at least 5 days' work.

501.3 Mixing

Pre-mixed bituminous materials shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures are given in Table 500-2 of these Specifications. The difference in temperature between the binder and aggregate shall at no time exceed 14°C. In order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in Annex A of IRC:27.

Table 500-2 :Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celcius)

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	*Rolling Temperature
VG-40	160-170	160-175	160-170	150 Min	100 Min
VG-30	150-165	150-170	150 ·165	140 Min	90Min
VG-20	145-165	145-170	145-165	135 Min	· 85Min
VG-10	140-160	140-165	140-160	130 Min	BOMin

Rolling must be completed before the mat cools to these minimum temperatures.

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

501.4 Transporting

Bituminous materials shall be transported in clean insulated and covered vehicles. An asphalt release agent, such as soap or lime water, may be applied to the interior of the vehicle to prevent sticking and tc;> facilitate discharge of the material.

501.5 Laying

501.5.1 Weather and Seasonal Limitations

Laying shall be suspended:

- i) In presence of standing water on the surface;
- ii) When rain is imminent, and during rains, fog or dust storm;

- iii) When the base/binder course is damp;
- iv) When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen;
- v) When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

501.5.2 Cleaning of Surface

The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom and air jet. The equipment for applying a high pressure air jet from a compressor to remove dust or loose matter shall be available full time at the site.

501.5.3 Spreading

Prior to spreading the mix, the base shall be prepared by carrying out the required operations as per Clause 501.8 depending upon the site conditions. Except in areas where paver cannot get access, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine equipped with an electronic sensing device. The essential features of the paver finisher shall conform to Annex A of IRC:27. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space (such as confined space, foot ways, of irregular shape and varying thickness, approaches to expansion joints, etc.) where paver cannot be used, the material shall be spread, raked and levelled with suitable hand tools by trained staff.

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

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

501.5.4 Cleanliness and Overlaying

Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be sealed or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated, the Contractor shall make it good to the satisfaction of the Engineer, in compliance with Clause 501.8.

Binder course material shall be covered by either the wearing course or surface treatment, whichever is specified in the Contract.

501.6 Compaction

Bituminous materials shall be laid and compacted in layers, which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these Specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the center longitudinally except that on super-elevated and unidirectionally cambered portions, it shall progress from lower to the upper edge parallel to the center line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8-10 tonne static weight smooth-wheel rollers. The intermediate rolling shall be done with 8-10 tonne static weight or vibratory roller or with a pneumatic tyre roller of 12 to 15 tonne weight, with a tyre pressure of at least 0.56 MPa. The Contractor shall demonstrate the efficiency of the equipment proposed to be used by carrying compaction trials. The procedure for site trials shall be submitted to the Engineer for approval. The finish rolling shall be done with 6 to 8 tonne smooth wheel tandem rollers. Rolling shall continue until the specified compaction is achieved.

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

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

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

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol/ diesel or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of roller machine shall be in good working order, to prevent the mix from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mix should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

501.7 Joints

501.7.1 Where joints are made, the material shall be fully compacted and the joint made flush in one of the following ways:

- a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face coated with a suitable viscosity grade hot bitumen, or cold applied emulsified bitumen. While

spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix shall be dragged back to the hot Jane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.

- b) By using two or more pavers operating in echelon, where this is practicable and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling.

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

501.7.3 For transverse joints method a) above shall apply. Transverse joints in the successive and adjoining layers shall have a minimum offset of 2 m.

501.8 Preparation of Surface

501.8.1 Scope

This work shall consist of preparing an existing granular or black-topped surface for laying bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by the Engineer. The existing surface shall be firm and clean, and treated with Prime or Tack coat where specified in the Contract.

501.8.2 Materials

501.8.2.1 For Scarifying and Re-laying the Granular Surface

The material used shall be coarse aggregates salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregates and screenings so that aggregates and screenings thus supplemented correspond to Clauses 404 or 406.

501.8.2.2 For Patching Potholes and Sealing Cracks

Where the existing surface to be overlaid is bituminous, material required for patching and sealing cracks shall be in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.2.3 For Profile Corrective Course

The type of material for use as profile corrective course shall be as shown on the drawings or as directed by the Engineer. Where it is to be laid as part of the overlay/strengthening course, the profile corrective course material shall be of the same specification as that of the overlay/ strengthening course. However, if provided as a separate layer, it shall be of the specification and details given in the Contract.

501.8.3 Construction Operations

501.8.3.1 Preparing Existing Granular Surface

Where the existing surface is granular, all loose materials shall be removed, and the

surface lightly watered where the profile corrective course to be provided as a separate layer is also granular. Where the profile corrective course of bituminous material is to be laid over the existing granular surface, the latter shall, after removal of all loose material, be primed in accordance with Clause 502 and a tack coat applied in accordance with Clause 503.

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

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

501.8.3.2 Scarifying Existing Bituminous Surface

Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying layer, by a suitable method approved by the Engineer. After removal of all loose and disintegrated material, the underlying layers which might have been disturbed shall be suitably reworked supplementing the base material as necessary with suitable fresh stone aggregates and compacted to line and level. The compacted finished surface shall be primed in accordance with Clause 502. Reusable materials shall be stacked as directed by the Engineer with all leads and lifts.

501.8.3.3 Patching of Potholes and Sealing of Cracks

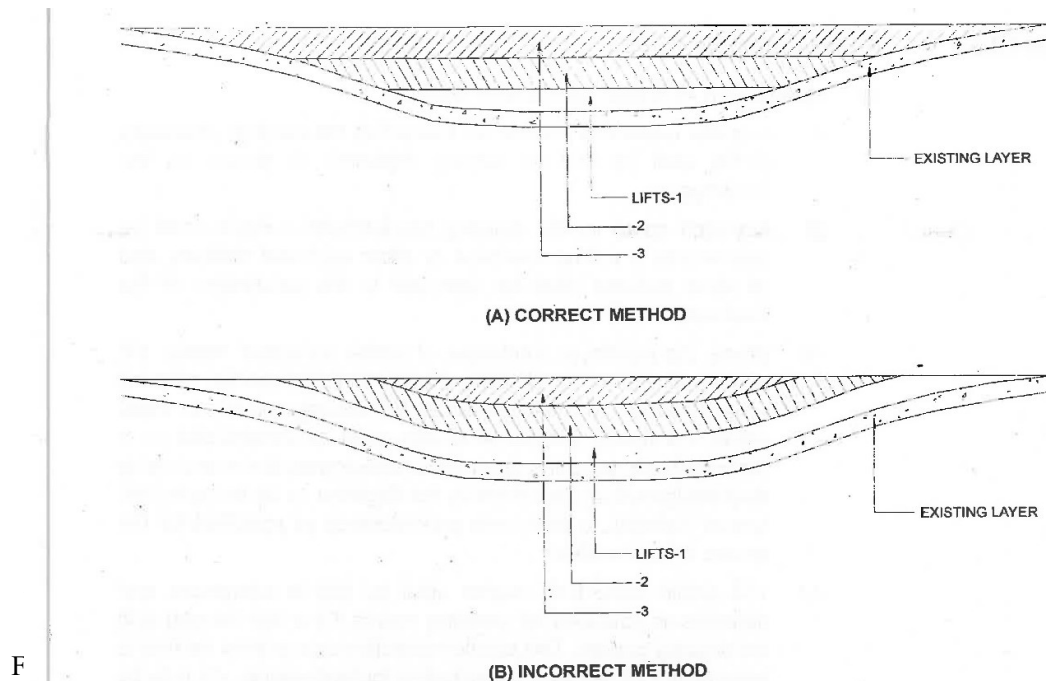
Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer,

501.8.3.4 Profile Corrective Course

a) Application of Profile Corrective Course

- i) A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings.
- ii) Any high spots in the existing black-topped surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the Engineer;
- iii) Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer, adopting such construction procedures and using such equipment as approved by the Engineer, to lay the specified type of material, to thickness and tolerance as specified for the course to be provided.
- iv) The profile corrective course shall be laid to tolerances and densities as specified for wearing course if it is laid integral with the wearing course. The profile corrective course shall be laid to tolerances and densities as specified for base course, if it is to be covered with a wearing course layer.

- b) Laying on Granular Base : After preparing the granular surface in accordance with Clauses 501.8.3.1 and 501.8.3.2, the profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4 (a), or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.
- c) Laying on Existing Bituminous Surface : The existing bituminous surface shall be prepared in accordance with Clause 501.8.3.3, and after applying a tack coat conforming to Clause 503, the bituminous profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4(a) and compacted to the requirements of the Specification.
- d) Correction of Local Depressions, Camber and Super-Elevation : Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the Engineer, which should be laid in accordance with Fig. 500-1. Normally, the maximum layer thickness at any point should not exceed 100 mm. In placing multiple lifts, they should be arranged according to the correct method as illustrated.



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

501.8.3.5 Covering the Profile Corrective Courses

Profile corrective course shall be so planned that the layer shall be covered by the designed base/wearing course at the earliest opportunity, before opening to regular traffic.

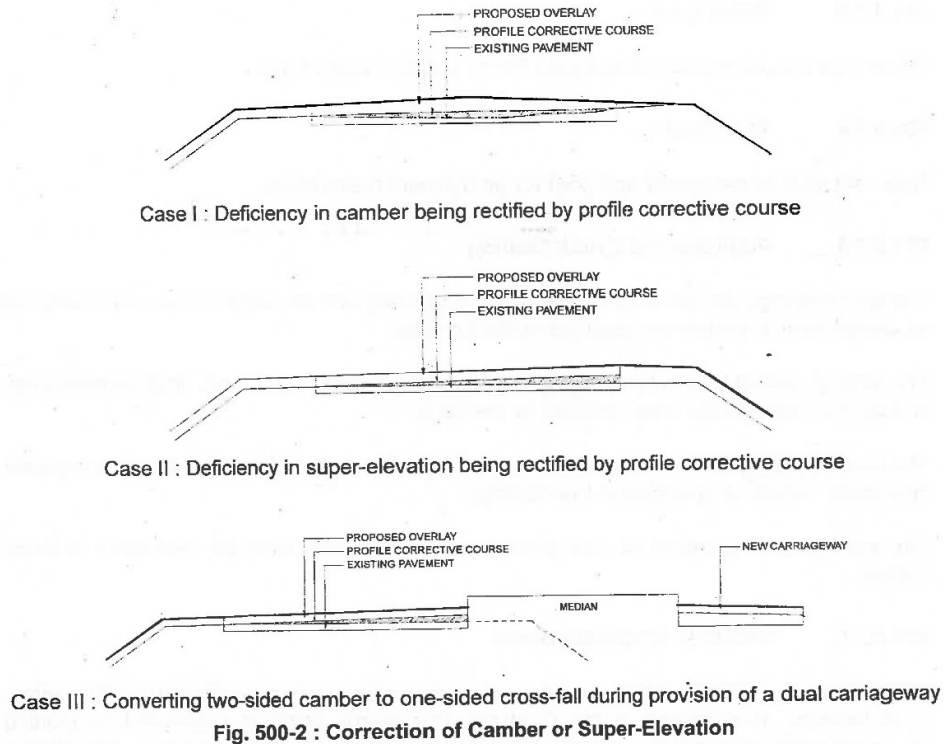
501.8.4 Surface Finish and Quality Control of Work

The relevant provisions of Section 900 shall apply.

501.8.5 Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

501.8.



501.8.7 Measurement for Payment

501.8.7.1 Cleaning of the Surface

The work of cleaning of the surface using mechanical broom and air-jet shall be incidental to the work of preparation of surface.

501.8.7.2 Scarifying

Scarifying the existing bituminous surface shall be measured and paid for on a square metre basis.

501.8.7.3 Prime Coat

Prime coat shall be measured and paid for on a square metre basis.

501.8.7.4 Tack Coat

Tack coat shall be measured and paid for on a square metre basis.

501.8.7.5 Potholes and Crack Sealing

The work of filling potholes shall be measured separately and be paid for in square metres or on weight basis in tonnes as specified in the Contract.

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

The work of sealing cracks of size 3 mm to 6 mm in width shall be measured in square metres or in linear meters as specified in the Contract.

The work of sealing cracks of size greater than 6 mm width shall be measured in linear metres..

501.8.7.6 Profile Corrective Course

Profile corrective course shall be measured as the volume laid in position in cubic metres, or in tonnage, as stipulated in the Contract. The volume shall be calculated by plotting the exact profile of corrective course as required, and laid, superimposed on the existing pavement profile. Cross-sectional areas of the profile corrective course shall be measured at intervals of 10 m centre to centre on straight sections and at 5 m center to centre on curves longitudinally and at seven locations transversely, for two lane carriageway, and at three locatinos transversely for single lane and the volume shall be calculated using the method of end areas.

501.8.7.7 Filling of Local Depressions

The work of filling depressions where instructed to be carried out separately shall be measured by the weight of the bituminous material placed in position.

501.8.8 Rates

501.8.8.1 Rate for Scarifying

The contract unit rate for scarifying existing bituminous surfaces, including repairing/reworking disturbed underlying layers and removing and stacking reusable and unusable materials, shall include but not necessarily be limited to, the cost of all labour, supply of materials needed for repair/reworking, hire charges of tools and plant, and transportation of scarified materials with all leads and lifts..

501.8.8.2 Rate for Premixed Bituminous Material

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

- i) Making arrangements for traffic to Clause 112 except for initial treatment to verge, shoulders and construction of diversions;
- ii) Cleaning of the surface;
- iii) Providing all materials to be incorporated in the work including arrangement for stock yards, all royalties, fees, rents where necessary and all leads and lifts;
- iv) Mixing, transporting, laying and compacting the mix, as specified including all wastage in cutting joints;
- v) All labour, tools, equipment, plant including installation of hot mix plant, power supply units and all machinery, incidental to complete the work to these Specifications;
- vi) Carrying out the work in part widths of the road where directed;
- vii) Carrying out all tests for control of quality;
- viii) The rate shall cover the provision of bitumen at the application rate specified in the contract, with the provision that the variation in actual percentage of bitumen used shall be assessed and the payment adjusted accordingly as per Contract;

- ix) The rates include for all testing, mix design, transporting and testing of samples, and cores and tests as directed by the Engineer; and
- x) The cost of all plant and laying trials as specified to prove the mixing and laying methods shall be deemed to be included in the Contractor's rates.

501.8.8.3 Rate for Potholes and Crack Sealing

The rate for patching potholes shall be as per Clause 3004.2.6.

The rate for sealing cracks by applying fog spray shall be as per Clause 513.9.

The rate for sealing of cracks of width 3 mm or more shall be as per Clause 3004.3.3.5.

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

501.8.8.4 Rate for Prime Coat

The Contract unit rate for prime coat shall be as per Clause 502.8.

501.8.8.5 Rate for Tack Coat

The Contract unit rate for tack coat shall be as per Clause 503.8.

501.8.8.6 Rate for Filling of Local Depressions

The Contract unit rate for filling of local depressions shall be payment in full for (i) furnishing all materials, (ii) all works involved including trimming, cleaning, backfilling, priming, application of tack coat, filling with bituminous material in layers and compacting each layer (iii) all labour, tools, equipment and incidentals to complete the works in accordance with the Specifications.

501.8.8.7 Rate for Profile Corrective Course

The Contract unit rate for profile corrective course when laid separately shall be payment in full for carrying out the required operations as specified, and shall include all components listed in Clause 501.8.8.2.

Annex 'A'
PROTECTION OF THE ENVIRONMENT

1 GENERAL

- 1.1 This Appendix sets out limitations on the Contractor's activities specifically intended to protect the environment.
- 1.2 The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on or off site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in these specifications.
- 1.3 The Contractor shall take all measures and precautions to avoid any nuisance or disturbance arising from the execution of the Works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.
- 1.4 In the event of any spoil, debris, waste or any deleterious substance from the site being deposited on any adjacent land, the Contractor shall immediately remove all such material and restore the affected area to its original state to the satisfaction of the Engineer.

2 WATER QUALITY

- 2.1 The Contractor shall prevent any interference with the supply to or abstraction from, and prevent any pollution of, water resources (including underground percolating water) as a result of the execution of the Works.
- 2.2 Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be reused for dust suppression and rinsing.
- 2.3 All water and other liquid waste products arising on the site shall be collected and disposed of at a location on or off the site and in a manner that shall not cause nuisance or pollution.
- 2.4 The Contractor shall not discharge or deposit any matter arising from the execution of the Works into any waters except with the permission of the Engineer and the regulatory authorities concerned.
- 2.5 The Contractor shall at all times ensure that all existing stream courses and drains within, and adjacent to, the site are kept safe and free from any debris and any materials arising from the Works.
- 2.6 The Contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution as a result of the execution of the Works.

3 AIR QUALITY

- 3.1 The Contractor shall devise and arrange methods of working to minimize dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimize adverse impacts on air quality.
- 3.2 The Contractor shall utilize effective water sprays during delivery, manufacture,

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

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

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

4 NOISE

4.1 The Contractor shall consider noise abatement measures in his planning and execution of the Works.

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

5 CONTROL OF WASTES

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

6 EMERGENCY RESPONSE

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

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

7. MEASUREMENT

7.1 No separate measurement shall be made in respect of compliance by the Contractor with these provisions. The Contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bill of Quantities and full compensation for such compliance will be

deemed to be covered by them.

502 PRIME COAT OVER GRANULAR BASE

502.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular/ stabilized surface to Clause 501.8.

502.2 Materials

502.2.1 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.

502.2.2 Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in Table 5003.

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

502.2.3 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 in Table 500-4.

Table 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)
WMMIWBW	MC30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC70	0.9-1.2

502.2.4 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.

502 3 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 1DOC. 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.

502.4 Construction

502.4.1 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.

502.4.2 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.

502.4.3 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 SS1 bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively though the jets of the spray and to cover the surface uniformly.

502.4.4 Curing of Primer and Opening to Traffic

A primed surface shall be allowed to cure for at least 24 hours or such other 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'.

502.5 Quality Control of Work

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

502.6 Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

502.7 Measurement for Payment

Prime coat shall be measured in terms of surface area of application in square metres.

502.8 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.

503 TACK COAT

503.1 Scope

The work shall consist of the application of a single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or as instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with Clause 501.8.

503.2 Materials

The binder used for tack coat shall be either Cationic bitumen emulsion (RS 1) complying with IS:8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per IS:217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the Contract or as directed by the Engineer.

503.3 Weather and Seasonal Limitations

Bituminous material 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. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

503.4 Construction

503.4.1 Equipment

The tack coat shall be applied by a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying shall not be permitted except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

503.4.2 Preparation of Base

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clause 501.8. The granular or stabilized surfaces shall be primed as per Clause 502. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

503.4.3 Application of Tack Coat

The application of tack coat shall be at the rate specified in Table 500-5, and it shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract, then it shall be the rate specified in Table 500 5. No dilution or heating at site of RS1 bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for cutback, 50°C to 80°C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed or 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.

Table 500-5 : Rate of Application of Tack Coat

Type of Surface	Rate of Spray of Binder in Kg per sq.m
Bituminous surfaces	0.20-0.30
Granular surfaces treated with primer	0.25-0.30
Cement concrete pavement	0.30-0.35

503.4.4 Curing of Tack Coat

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

503.5 Quality Control of Work

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

503.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

503.7 Measurement for Payment

Tack coat shall be measured in terms of surface area of application in square metres.

503.8 Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in Clause 401.8 (i) to (v) and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat, at 0.2 kg per square metre or at the rate specified in the Contract, with the provision that the variation between this quantity and actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

504 BITUMINOUS MACADAM

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	Max. 40%	IS:2386 Part IV
	Aggregate Impact Value	Max. 30%	IS:2386 Part IV
Durability	Soundness (Sodium or Magnesium)	scycles	
	Sodium Sulphate	Max. 12%	IS:2386 Part V
	Magnesium Sulphate	Ma)(.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%	AASHTO283

If the minimum retained tensile strength falls below 80percent; 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 Proportion-ing 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 ± 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 Limitation

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	19mm
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
132	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content ** 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 cubic metres, or by weight in metric tonnes, where used as regulating course, or square metres at the specified thickness as indicated in the Contract or shown on the drawings, or as otherwise directed by the Engineer.

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.

505 DENSE BITUMINOUS MACADAM

505.1 Scope

The specification describes the design and construction procedure for Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

505.2 Materials

505.2.1 Bitumen

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification 15:73, modified bitumen complying with Clause 501.2.1 or as otherwise specified in the Contract.

The type and grade of bitumen to be used shall be specified in the Contract

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

0.425 mm sieve shall not exceed 4, when tested in accordance with IS:2720 (Part 5).

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 limits indicated in Table 500-9.

The filler shall be free from organic impurities and have a plasticity Index not greater

than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

505.2.5 Aggregate Grading and Binder Content

505.2.5.1 When tested in accordance with JS: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 0.075 mm sieve	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 35% Max 27%	IS:2386 Part IV
Durability	Soundness either : Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile 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
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Table 500-10 : Composition of Dense Graded Bituminous Macadam

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5mm
Layer thickness	75-100 mm	50-75mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
45	100	..
37.5	95-100	100
26.5	63-93.	90-100
19	–	71-95
13.2	55-75	56-80
9.5	–	–
4.75	38-54	38-54
2.36	28-42	28-42
1.18	–	–
0.6	–	–
0.3	7-21	7-21
0.15	–	–
0.075	2-8	2-8
Bitumen content% by mass of total mix	Min 4.0**	Min 4.5**

* 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 Table 500-10 is -the minimum quantity. The quantity shall be determined in accordance with Clause 505.3.

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 500-11.

Table 500-11 :Requirements for Dense Graded Bituminous Macadam

Properties	Viscosity Grade Paving Bitumen	Modified bitumen		Test Method
		Hot climate	Cold climate	
Compaction level	75 blows on each face of the specimen			
Minimum stability (kN at 600C)	9.0	12.0 .	10.0	AASHTOT245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTOT245
Marshall Quotient $\left(\frac{\text{Stability}}{\text{Flow}} \right)$	2 – 5	2.5 – 5		MS-2 and ASTM 02041
%air voids	3-5			
% Voids Filled with Bitumen (VFB)	65-75			
Coating of aggregate particle	95% minimum			IS:6241
Tensile Strength ratio	80% Minimum			AASHTOT283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 500-13			

505.3.2 Binder Content

The binder content shall be optimized to achieve the requirements of the mix set out in Table 500-11. 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 Table 500-12 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 ¹ (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 air voids values between those listed.

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 inix;
 - 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 a mregate 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 susc.eptibility test;
- vi) Where the mixer is a batch mixer, the individualweights 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 Plant Trials - Permissible Variation in Job Mix Formula

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in• the actual mix from the job mix formula to be used shall be within the limits as specified in Table 509-13 and shall remain within the gradation .band. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

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 132 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 Trials

Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid 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 Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 901 and 902 as appropriate, or 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.

505.4.4S Tress 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 bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of Clause 502, 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 accordance with the provisions of Clause 503, 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 without the approval of the Engineer in writing, 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 9.00 of these Specifications.

505.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

505.8 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.

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.

506 SAND. ASPHALT BASE COURSE

506.1 Scope

This work shall consist of a base course composed of a mixture of sand, mineral filler where required and bituminous binder, placed and compacted upon a prepared and accepted sub- base in accordance with these Specifications and the Jines, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

Note: Sand Asphalt Base course is used in special situations like quality coarse aggregates not being available within economical leads and/or water needed for conventional base course not being readily available, as in desert areas.

506.2 Materials

506.2.1 Bitumen

The bitumen shall be paving bitumen of viscosity grade VG 30 or VG 20, as specified in the Contract, conforming to IS:73.

506.2.2 Sand

The sand shall be clean, naturally occurring or blended material free from any deleterious substances, dry and well graded within the limits given in Table 500-14 and with other physical properties conforming to the requirements of this Table.

Table 500-14: Sand Grading and Physical Requirements

Sieve Size (mm)	Cumulative Percentage by Weight of Total Aggregate Passing
9.5	100
4.75	85-100
2.36	80-100
1.18	70-98
0.60	55-95

0.30	30-75
0.15	10-40
0.075	4-10
Plasticity Index(%)	6max.
Sand equivalent (IS:2720 Part 37)	30 min.
Los Angeles Abrasion Value (IS:2386, Part 4)	40 max.

Note : Maximum thickness for sand asphalt is 80 mm.

506.2.3 Filler

When required, filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer. The filler shall conform to. Clause 505.2.4.

506.3 Mix Design

506.3.1 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 500-15.

506.3.2 Binder Content

The binder content shall be optimized to achieve the requirements of the mix set out in Table 500-15. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Table 500-15: Requirements for Sand Asphalt Base Course

Parameter	Requirement
Minimum stability (kN at 60°C)	2.0
Minimum flow(mm)	2
Compaction level (Number of blows)	2x 75
Percent air voids	3-5
Percent voids in mineral aggregate (VMA)	16 min.
Percent voids filled with bitumen (VFB)	65-75

506.3.3 Job Mix Formula

The Contractor shall develop the job mix formula proposed for use in the works and submit it to the Engineer for approval together with the following details :

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows where each is applicable:
 - a) Binder, as percentage by weight of total mixture;
 - b) Sand/Mineral filler as percentage by weight of total aggregate including mineral filler; •
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The results of tests enumerated in Table 500-15 as obtained by the Contractor;
- v) Test results of physical characteristics of aggregates to be used;
- vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the

work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which joint samples of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established by the Contractor and approved by the Engineer before actually using the materials.

506.3.4 Permissible Variation from Job Mix Formula

The Contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-12, with the condition that the gradation after the variation remains within the gradation envelop. These variations are intended to apply to individual specimens taken for quality control tests-in accordance with Section 900.

506.4 Construction Operations

506.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

506.4.2 Preparation of Base

The surface on which Sand Asphalt Base' course Material is to be laid shall be prepared, shaped and graded in the profile required for the particular layer in accordance with Clauses 501 and 902 as appropriate or as directed by the Engineer. The surface shall be thoroughly swept clean free from dust and foreign matter using a mechanical brush, and the dust blown off by compressed air. In confined locations where mechanical plant cannot get access, other methods shall be used as approved by the Engineer. A prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

506.4.3 Tack Coat

A tack coat over the base shall be applied in accordance with Clause 503, or otherwise as directed by the Engineer.

506.4.4 Preparation and Transportation of the Mixture

The provisions of Clauses 501.3 and 501.4 shall apply.

506.4.5 Spreading

The provisions of Clauses 501.5.2 to 501.5.4 shall apply. Laying must be accomplished at a suitable temperature to ensure proper compaction. Guidance for mixing and compaction temperature for the particular bitumen may be taken from Table 500-3 and

shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 poise (0.3 Pa.s) respectively, based on the original (unaged) bitumen properties.

506.4.6 Rolling

Clause 501.6 shall apply. Generally the initial or breakdown rolling shall be done with 8-10 tonne static weight smooth-wheeled rollers. The intermediate rolling shall be done with 8-10 tonne static weight or vibratory rollers or with a pneumatic tired roller of 12-15 tonne weight having a tyre pressure of at least 0.56 MPa. The finish rolling shall be done with 8-10 tonne deadweight smooth wheeled tandem rollers. The exact pattern of rolling shall be established at the laying trials.

506.5 Opening to Traffic

It shall be ensured that the traffic is not allowed without the express approval of the Engineer in writing, on the surface until the paved mat has cooled below 60°C in its entire depth.

506.6 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.

506.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

506.8 Measurement for Payment

Sand Asphalt Base course materials shall be measured as finished work, for the area covered, in cubic metres, metric tonnes, or in square metres, at a specified thickness, as stated in the Contract.

506.9 Rate

The Contract unit rate for Sand Asphalt Base course materials shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2 (i) to (x). The rate shall cover provision of 5 percent of bitumen by weight of the total mixture.

The variation in the actual percentage of bitumen used will be assessed and the rate, adjusted plus or minus as applicable.

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 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 0.075 mm sieve	18:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max 35%	18:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	18:2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	18:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Absorption	Water Absorption	Max 2%	18:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	18:6241
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 18:2386 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*	19mm	13.2 mm
Layer thickness	50mm	30-40 mm

Grading	1	2
Nominal aggregate size*	19mm	13.2 mm
Layer thickness	50mm	30-40 mm
IS Sieve ¹ (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

Description	Permissible Variation
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_{mm}} obtained on the day of compaction in accordance with ASTM 02041.

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 103.

507.4A 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 50j.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

The measurement shall be as specified in Clause 505.8.

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.

508 CLOSE-GRADED PREMIX SURFACING/MIXED SEAL SURFACING

508.1 Scope

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

508.1.2 Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents. Type A grading is recommended• for use in areas having rainfall more than 150 em per year. In other areas Type 8 grading may be used.

508.2 Materials

508.2.1 Binder

The provisions of Clause 510.1.2.1 shall apply.

508.2.2 Corse Aggregates

The provisions of Clause 511.1.2.2 shall apply.

508.2.3 Fine Aggregates

The fine aggregates shall consist of crushed rock, or natural sand or a mix use of both. These shall be clean, hard, durable, un-coated, mineral particles, dry; and free from injurious, soft or flaky particles and organic or deleterious substances.

508.2.4 Aggregate Gradation

The coarse and fine aggregates shall be so graded or combined as to conform to one or the other gradings given in Table 500-19, as specified in the contract.

Table 500-19: Aggregate Gradation

IS Sieve Designation (mm)	Cumulative Percent by Weight of Total Aggregate Passing	
	Type A	Type B
13.2 mm	–	100
11.2 mm	100	88-100
5.6mm	52-88	31-52
2.8mm	14-38	5-25
0.090 mm	0-5	0-5

508.2.5 Proportioning of Materials

The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic metre per square metre area. The quantity of binder used for premixing shall be 22.0 kg and 19.0 kg per 10 square metre area for Type A and Type B surfacing respectively.

508.3 Construction Operations

The provisions of Clause 510.1.3.1 through Clause 510.1.3.5 shall apply.

508.4 Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Speed restrictions may be imposed at initial stages.

508.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For control on the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

508.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Clause 112.

508.7 Measurement for Payment

Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square metres at a specified thickness. The area will be the net area covered.

508.8 Rate

The contract unit rate for close-graded premix surfacing, Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

509 SURFACE DRESSING

509.1 Scope

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

509.2 Materials

509.2.1 Binder

The binder shall either be bitumen conforming to JS:73 or rapid setting cationic bitumen emulsion (RS-2) conforming to IS:8887. Grade of bitumen shall depend upon the climatic condition. For selection of grade of bitumen guidance may be taken from Table 500-1. The type of binder to be used shall be stated in the Contract, or as directed by the Engineer.

509.2.2 Aggregates

The stone chips (cover aggregate) shall conform to the requirements of Clause 505.2.2., except that their water absorption shall be restricted to a maximum of 1 percent and they shall have a Polished Stone Value of minimum 60. [in BS:812 (Part-114)], of not less than 60. The size of the aggregate shall depend upon the type of surface on which it is laid and the traffic intensity. The chips shall be single sized, Clean, hard, durable, of cubical shape; and free from dust and soft or friable matter, organic or other deleterious matter and conform to one of the gradings given in Table 500-21. The size of the aggregate shall depend upon the type of surface on which it is laid and the traffic intensity. Table 500-20 may be used as guidance.

Pre-coated Chips :As an alternative to the use of an adhesion agent or wherever specified in the Contract, the chips may be pre-coated before they are spread except when the sprayed binder film is a bitumen emulsion. Pre-coating the chips may be carried out by mixing aggregates with 0.75 to 1.0 percent of bitumen by weight of chips in a suitable mixer. The chips shall be heated to 160°C and mixed with the binder heated to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non sticky and can be spread easily.

Table 500-20 : Recommended Nominal Size of Aggregates (mm)

Type of Surface	Traffic Intensity in Terms of Number of Vehicles Per Day in the Lane Under Consideration		
	1000-2000	200-1000	20-200
Very hard	10	6	6
Hard	13	10	6
Normal	13	10	6
Soft	19	13	13
Very soft	---	19	13

Table 500-21 : Grading requirements for Aggregates used for Surface Dressing

IS Sieve Designation (mm)	Cumulative Percent by Weight of Total Aggregates Passing for the Following Nominal Sizes (mm)			
	19	13	10	6
26.5	100			
19	85-100	100		
13	0-40	85-100	100	
9.5	0-7	0-40	85-100	100
6.3		0-7	0-35	85-100
4.75			0-10	
3.35				0-35
2.36	0-2	0-2	0-2	0-10
0.60				0-2
0.075	0-1.5	0-1.5	0-1.5	0-1.5
Minimum 65% by weight of aggregate	Passing 19 and retained on 13.2	Passing 13.2 and retained on 9.5	Passing 9.5 and retained on 6.3	Passing 6.3 and retained on 3.35

509.2.3 Rates of Spread of Binder and Chips

The rate of spread of binder and chips will depend upon the nominal size of the aggregate and the extent of its embedment into the surface. The rate shall be determined as per the procedure given in Manual for Construction and Supervision of Bituminous Construction. Approximate rate of application of aggregates, and binder under average conditions are given in Table 500-22.

Table 500-22 : Approximate Rate of Application of Binder and Aggregates

Nominal Aggregate Size mm	Binder (Kg/m ²)			Aggregates Cu.m/m ²
	Uncoated Aggregates		Coated Aggregates	
	Bitumen	Emulsion	Bitumen	
19	1.2	1.8	1.0	0.014-0.015

13	1.0	t.5	0.8	0.009-0.011
10	0.9	1.3	0.7.	0.007-0.009
6	0.75	1.1	0.6	0.003-0.005

Note :Bitumen for coated aggregates excludes quantity of bitumen required for coating.

509.2.4 Anti-Stripping Agent

Where the proposed aggregate fails to pass the stripping test then an approved anti- stripping agent (Appendix 4 for details) may be added to the binder in accordance with the manufacturer's instructions. The effectiveness of the proposed anti-stripping agent must be demonstrated by the Contractor, before approval by the Engineer.

509.3 Construction Operations

509.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

509.3.2 Preparation of Base

The base on which the surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Clause 501 or as directed by the Engineer. Prime coat, where needed, shall be provided as per Clause 502 or as directed by the Engineer. Where the existing surface shows signs of fatting up,• the excess bitumen shall be removed as directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and/or compressed air, or any other approved equipment/method as specified in the Contract or directed by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be slightly damp).

509.3.3 Application of Binder

After preparation of base, paving grade binder heated to an appropriate temperature or bitumen emulsion shall be sprayed uniformly using mechanical sprayers. During the operation the ratio between truck speed and pump revolution shall be maintained constant with the help of automatic control. When work resumes, the binder shall not be sprayed on the earlier completed surface. This can be done by covering the completed work with bitumen impregnated paper. Excessive deposit of bituminous material shall be immediately removed. The equipment described in IRC:SP:34 with synchronized spraying and compaction shall be preferred for better control and uniformity in construction.

The spraying temperatures for binder are given below:

Binder Grade	Whirling Spray Jets		Slot Jets	
	Min°C	Max°C	Min°C	Maxoc
VG 10	180	200	165	175

509.3.4 Application of Stone Chips

Immediately after application of the binder, clean, dry chips (in the case of emulsion the chippings may be slightly damp) shall be spread uniformly by means of a mechanical chip spreader on the surface so as to cover the surface completely with a single layer of chips.

509.3.5 Rolling

Rolling of the chips should preferably be carried out by a pneumatic tyre roller in accordance with Clauses 501.6 and 501.7. Rolling shall commence at the edges and progress towards the centre except in super-elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

509.3.6 Application of Second Coat of Surface Dressing

Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for two weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clauses 510.3.3 to 510.3.5.

509.4 Opening to Traffic

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

509.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902.

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

509.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

509.7 Measurement for Payment

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

509.8 Rate

The Contract unit rate for surface dressing, based on the approximate rates of application for binder given in Table 500-22 and each size of chippings given in Clause 509.2.3, shall be adjusted, plus or minus, for the difference between the approximate rate of spread and the rate of spread determined based on design and approved by the Engineer. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

510 OPEN-GRADED PREMIX SURFACING

510.1 Open-Graded Premix Surfacing using Viscosity Grade Paving Bitumen

510.1.1 Scope

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

510.1.2 Materials

510.1.2.1 Binder

The binder shall be viscosity grade bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of 18:73. For selection of grade of bitumen guidance may be taken from Table 500-1.

510.1.2.2 Aggregates

The aggregates shall conform to Clause 504.2.2 except that the water absorption shall be limited to a maximum of 1 percent. The Polished Stone Value, shall not be less than 55, when tested as per BS:812-114.

510.1.2.3 Proportioning of Material

The materials shall be proportioned in accordance with Table 500.;23.

Table 500-23: Quantities of Materials Required for 10m² of Road Surface for 20 mm Thick Open-graded Premix Surfacing

	Materials	Quantity
Aggregates		
a)	Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve)	0.18 m ³
b)	Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve)	0.09 m ³
	.. Total	0.27 m ³
Binder		

a)	For 0.18 m ³ of 13.2 mm nominal size stone of 52 kg bitumen per m ³	9.5kg
b)	For 0.09 m ³ of 11.2 mm nominal size stone of 56 kg bitumen per m ³	5.1 kg
	Total	14.6 kg

510.1.3 Construction Operations

510.1.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

510.1.3.2 Preparation of Surface

The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in accordance with Clause 502 as directed by the Engineer.

510.1.3.3 Tack Coat

A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

510.1.3.4 Preparation of Premix

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

The temperature of the binder and aggregate at the time of mixing, laying and compaction shall be in conformity with the temperature given in Table 500-3. The difference in temperature between the binder and aggregate shall at no time exceed 14°C. Mixing shall be thorough to ensure that a homogeneous mix is obtained in which all particles of the aggregates are coated uniformly.

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

510.1.3.5 Spreading and Rolling

The pre mixed material shall be spread on a previously prepared base to Clause 501 by a paver unless specified otherwise in the Contract to the desired thickness, grades and cross fall (camber). The cross-fall should be checked by means of camber. boards and irregularities levelled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8-10 tonne rollers, smooth wheel tandem type or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on super elevated and unidirectional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions,

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

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below the rolling temperature indicated in Table 500-3.

510.1.3.6 Seal Coat

A seal coat conforming to Clause 511 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

510.1.4 Opening to Traffic

No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to Clause 511.4.

510.1.5 Surface Finish and Quality Control of Work

The surface finish of 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. •

510.1.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

510.1.7 Measurement for Payment

Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, • in square metres.

510.1.8 Rate

The contract unit rate for open-graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for all • components listed in Clause 501.8.8.2.

510.2 Open Graded Premix Surfacing Using Cationic Bitumen Emulsion

510.2.1 Scope

This work shall consist of the preparation, laying and compaction of an open graded premix surfacing of 20 mm thickness composed of small-sized aggregate premixed with a cationic bitumen emulsion on a previously prepared surface, in accordance with the requirements of these Specifications to •serve as a weai"incourse.

510.2.2 Materials

510.2.2.1 Binder

The binder for Premix wearing course shall be Cationic Bitumen emulsion of Medium Setting (MS) grade complying with 18:8887 or as specified in the Contract.

510.2.2.2 Aggregate

The requirements of Clause 511.1.2.2 shall apply.

510.2.3 Proportioning of Materials

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

Table 500-24 : Quantities of Aggregate for 10 m² Area

Aggregates		
a)	Coarse aggregate nominal 13.2 mm size, passing IS 22.4 mm sieve and retained on IS 11.2 mm sieve	0.18 m ³
b)	Coarse aggregate nominal 11.2 mm size; passing IS 13.2 mm sieve and retained on IS 5.6 mm sieve	0.09 m ³
"	Binder	20 to 23 kg

510.2.4 Construction Operations

510.2.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply except that the minimum air temperature for laying shall be 10°C. Cationic bitumen emulsions shall not normally be stored below 0°C.

510.2.4.2 Preparation of Surface

The underlying surface on which the premix surfacing is to be laid shall be prepared, in accordance with the requirements of Clause 504.3.2 for a newly primed surface, and in accordance with Clause 505.4.2 where an existing bituminous surface is to be overlaid.

510.2.4.3 Preparation of Binder

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

510.2.4.4 Tack Coat

A tack coat complying with Clause 503, shall be applied over the surface preparatory to laying of the surfacing where specified in the Contract, as directed by the Engineer.

510.2.4.5 Preparation of Premix

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

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

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

The coarse aggregate of 132 mm size shall be placed into the mixer followed by 5 to 6.5 kg of Cationic bitumen emulsion and then the 11.2 mm size aggregate shall be added, followed by 5 to 6.5 kg of Cationic bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

510.2.4.6 Spreading and Rolling

The premixed cationic bitumen emulsion and aggregates shall be spread uniformly by a paver within 10 minutes of applying the tack coat. All levelling, raking etc. should be completed within 20 minutes of the time of mixing.

The mix shall be spread uniformly to the desired thickness, grades and cross fall (camber). The cross fall shall be checked by means of camber boards and irregularities levelled out. Too much raking is to be avoided.

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

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

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

510.2.5 Seal Coat

A seal coat, conforming to Clause 511, as specified in the Contract, shall be applied immediately after laying the premix carpet.

510.2.6 Opening to Traffic

Traffic should not be allowed over the premix surface till seal coat is laid. After the seal coat is laid, traffic may be allowed in accordance with Clause 511.4.

510.2.7 Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 shall apply.

510.2.8 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

510.2.9 Measurement for Payment

Open graded premix surfacing shall be measured as finished work, for_ the area instructed to be covered, in square metres. All allowances for wastage in cutting of joints shall be deemed to be included in the rate.

510.2.10 Rate

The contract unit rate for premix carpet shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

511 SEAL COAT

511.1 Scope

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

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

- A) Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.
- B) Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

511.2 Materials

511.2.1 Binder

The requirements of Clauses 510.1.2.1 and 510.2.2.1 shall apply.

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

511.2.2 Stone Chips for Type A Seal Coat

The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 percent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chips shall satisfy the quality requirements given in Table 500-8 except that the upper limit for water absorption value shall be 1 percent.

511.2.3 Aggregate for Type B Seal Coat

The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles, and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sqm area.

511.3 Construction Operations

511.3.1 Weather and Seasonal Limitations

The requirements of Clause 501.5.1 shall apply.

511.3.2 Preparation of Surface

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

511.3.3 Construction of Type A Seal Coat

The construction operations shall be the same as described in Clause 509.3.3 to 509.3.5.

511.3.4 Construction Type B Seal Coat

511.3.4.1 Using Paving Bitumen

The construction operations shall be the same as in Clause 510.1.3.

511.3.4.2 Using Emulsion

The construction operations shall be the same as in Clause 510.2.4.

511.4 Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day.

In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases traffic shall be rigorously limited to 20 km per hour until the following day.

511.5 Surface Finish and Quality Control Work

The surface of construction shall conform to the requirements of Clause 902.

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

511.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.♦

511.7 Measurement for Payment

Seal coat,. Type A or B shall be measured as finished work, over the area specified to be covered,. in square metres at the thickness specified in the Contract.

511.8 Rate

The contract unit rate for seal coat Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

512 SLURRY SEAL

512.1 Scope

The work consists of design and laying a mixture of mineral aggregate, slow setting cationic bitumen emulsion, water and additives, if needed, proportioned, mixed and uniformly spread over a previously prepared surface. The finally laid slurry seal shall have a homogenous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its surface life.

512.2 Type of Slurry Seals and Applications

Different types of slurry seal and their applications are given in Table 500-2.5. The type and application of the slurry seal. shall be specified in the Contract.

Table 500-25 : Different Types of Slurry Seals

Items	Type I (2 – 3 mm)	Type II (4– 6 mm)	Type III (6-8 mm)**
Application	Filling of hair cracks	Filling of surface cracks 1- 3 mm and preventive/ renewal treatment (upto 450 . CVPD)***	Filling of surface cracks 3-6 mm and preventive/renewal treatment (upto 1500 CVPD)***
Quantity* of slurry (kg/m ²)	4.3 to 6.5	8.4 to 9.8	10.1 to 12
Residual binder (% by weight of dry aggregate)	10 to 16	7.5 to 13.5	6.5 to 12

* In terms by weight of dry aggregate

** Indicative only

*** CVPD : Commercial Vehicles per day

512.3 Materials

The materials for slurry seal shall conform to the following requirements.

512.3.1 Bitumen Emulsion

The bitumen emulsion shall be a cationic slow setting type SS2, conforming to the requirements of IS:8887.

512.3.2 Aggregates

The mineral aggregates shall be crushed stone dust, clean, sharp, hard, durable and uncoated dry particles and shall be free from soft pieces and organic and other deleterious substances. The aggregate shall satisfy the requirement given in Table 500-26. The target grading shall conform to one of the three types given in Table 500-27.

Table 500-26 : Properties of Aggregates

Properties	Test Method	Specification
Sand Equivalent Value	IS:2720 (Part 37)	Min 50 percent
Water absorption*	IS:2386 (Part 3)	Max 2 percent
Soundness with- Sodium sulphate Magnesium sulphate	IS:2386 (Part 5)	Max 12 percent Max 18 percent

In case water absorption exceeds 2% but is less than 4%, same may be permitted subject to conformity of soundness test and wet stripping test

Table 500-27 : Aggregate Grading

Sieve Size (mm)	Percentage by Mass Passing (Minimum Layer Thickness)		
	Type I (2-3 mm)	Type II (4-6 mm)	Type III (6-8 mm)
9.5	-	-	100
6.3	-	100	90-100
4.75	100	90-100	70-90
2.36	90-100	65-90	45-70
1.18	65-90	45-70	28-50
0.600	40-65	30-50	19-34
0.300	25-42	18-30	12-25
0.150	15-30	10-21	7-18
0.075	10-20	5-15	5-15

Tolerances : Percent passing each sieve shall not vary by more than the tolerance limit indicated in Table 500-2 and shall remain within the gradation band.

Table 500-28 : Tolerances for Slurry Seal

Description	Tolerance
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Aggregate passing 4.75 mm	±5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%
Aggregate passing 0.3 mm	±4%
Aggregate passing 0.15 mm	±3%
Aggregate passing 0.075 mm	±2%

If more than one nominal size aggregate is used to produce the required grading, the correct amount of each type of aggregate used shall be proportioned separately to meet the requirements of grading as per Table 500-27, prior to adding other materials in the mixture. After target gradation has been submitted, the percent passing each sieve shall not vary •by• more than the tolerance limits given in Table 500-29, and shall remain within the gradation band. The aggregate will be acceptable based on average of five gradation tests at• the job location.

512.3.3 Filler

Mineral filler shall be Ordinary Portland Cement. The quantity of filler shall be in the range of 0.5 to 2 percent by weight of dry aggregate.

512.3.4 Water

Water shall be potable, free from harmful salt and contaminants. The pH of the water shall be in the range of 6 to 7.

512.3.5 Additives

Chemical additives may be used to accelerate or retard the break-set time of the slurry or to improve the resulting surface finish. The quantity of additive, if used, shall be decided by mix design and to be adjusted as per the site/climate conditions. The specifications for additive shall be supplied by the supplier of the emulsion. The additive and emulsion shall be compatible with each other.

512.4 Mix Design

The compatibility of aggregate, emulsion, filler and additive(if needed) shall be verified by mix design for a selected type and grading of aggregate as specified in Tables 500-27 and 500-28. the design criteria for slurry seal mixture is specified in Table 500-29. The proposed slurry seal mix shall conform to the specified requirements, when tested in accordance with tests specified in Table 500-30. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of the aggregates, additive usage (if any).

Table 500-29 : Mix Design Criteria for Slurry Seal Mix

Requirement	Specifications	Test Method
Mix Time, minimum	180 seconds	Appendix f IRC:SP:81
Consistency, maximum	3cm	Appendix 3 IRC:SP:81
Wet cohesion, pass % minimum	20 kg.cm	Appendix 4 IRC:SP:81
Wet striping, Pass %, minimum	90	Appendix 5 IRC:SP:81

Wet Track abrasion loss, (one hour soak), maximum	800 g/m ²	Appendix 61RC:SP:81
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Aggregate, bitumen emulsion, water and additive including set control additive (if needed), shall be proportioned by weight utilizing the mix design approved by the Engineer. The final mixture after addition of water and additive (if used) shall be such that the slurry seal mixture has proper workability and permit traffic within four hours (without leading to raveling after placement). Trial mix shall be prepared and laid at site for the designed mix and observed for breaking and setting time. Indicative limits of various ingredients for job mix of slurry seal shall be as given in Table 500-30.

Table 500-30 : Indicative Quantity of Ingredients

Ingredients	Limits (Percent by Weight of Dry Aggregates)
Cationic Bitumen Emulsion	10 to 16 for type I 7.5 to 13.5 for Type II 6.5 to 12 for Type III
Water	6 to 12
Filler	1.0 to 2.0
Additive	0.5 to 2.0

512.5 Construction

512.5.1 Weather and Seasonal Limitations

Laying of slurry seal shall not be undertaken, if either the pavement temperature or air temperature is below 10°C. However during a dry spell, slurry seal may be laid in rainy season also, even if the surface is wet but there is no stagnant water on the pavement surface.

512.5.2 Surface Preparation

The underlying surface on which the slurry seal is to be applied shall be cleaned of all loose material, mud spots, vegetation and extraneous matter and shall be prepared and shaped to the needed profile. It is essential to pretreat cracks on the pavement surface with an appropriate crack sealing material prior to application of slurry seal, if it is used for preventive/ renewal treatment. The surface should be swept clean by removing caked earth and other foreign matter with wire brushes*. sweeping with mechanical brooms and finally dusting with air jet or other means approved by the Engineer

512.5.3 Application of Tack Coat

Tack coat is not required normally for flexible pavements, unless surface is extremely hungry and dry. In case it is needed, Clause 503 shall apply.

512.5.4 Machine

The machine shall be specially designed and manufactured to lay slurry seal. It shall be self-propelled equipment, truck mounted, consisting of following sub-assemblies used to manufacture and simultaneously spread these mixes on the surface:

- i) Aggregate bin
- ii) Filler bin.
- iii) Water and Emulsion Tanks.
- iv) Additive Tanks.
- v) Aggregates and filler conveyors to supply the mixer box.
- vi) Pump or compressed air system to supply the emulsion/water.
- vii) Mixer Box.
- viii) Spreader box to place the mixed slurry on the job.

512.5.5 Calibration of Machine

Slurry seal laying machine shall be calibrated for flow of all the constituents as per the

job mix in presence of Engineer. No machine shall be allowed to work on the project until the calibration has been completed and accepted by the engineer. 2 kg samples of slurry seal mix will be taken and verified for proportioning and mix consistency. The verification for application rate shall also be carried out in presence of the Engineer. The procedure for calibration and verification is as given in Appendix 7 of IRC:SP:81.

512.5.6 Application of Slurry Seal

A calibrated slurry seal machine, as per requirements of job mix, shall be used to spread the material. The surface shall be pre-wetted by fogging ahead of the spreader box (if required under hot weather conditions). The rate of application shall be adjusted during the day to suit temperature, surface texture and humidity. The mixture shall be agitated and mixed uniformly in the spreader box by means of twin shafted paddles or spiral augurs fixed in spreader box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The spreader box and rear strike off shall be so designed and operated that a uniform consistency is achieved to produce free flow of material to the rear strike off. A secondary strike off shall have the same adjustment as the spreader box. The spreader box shall have the suitable means provided to side shift the box to compensate for variation in pavement geometry. Sufficient amount of material shall be carried in all parts of spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling and unmixed aggregates shall be permitted. No streak, caused by oversized aggregates shall be left on the finished surface. Longitudinal joints shall correspond with the edges of existing traffic lanes. Other patterns of longitudinal joints may be permitted, if pattern will not adversely affect the quality of finished surface. In case streak is formed, it shall be corrected immediately by fresh material and with use of squeeze. Longitudinal joints, common to two traffic lanes shall be butt joints with overlap not exceeding an average of 60-100 mm. The mixture shall be uniform and homogeneous after spreading on existing surfaces and shall not show separation of the emulsion and aggregates after setting.

512.5.7 Rate of Application

The rate of application shall be as per Table 500-26 (by weight of dry aggregates).

512.5.8 Roiling

Generally rolling is not required. Where rolling is felt necessary due to inadequate cohesion, a pneumatic tyred roller having individual wheel load between 0.75 to 1.5 tonne shall be used. Rolling shall commence as soon as the slurry has set.

512.6 Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 shall apply.

512.6.1 Opening to Traffic

Surface shall be opened to traffic after slurry is in a completely set condition. The maximum setting time shall be 4 hours. Speed of traffic shall be restricted to 20 km per

hour for next 12 hours.

512.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

512.8 Measurement for Payment

Slurry seal shall be measured as finished work as specified, in square metres.

512.9 Rate

The contract unit rate for slurry seal shall be payment in full for carrying out the required operations including full compensation for the specified rate of application of the mix and the quantity of residual binder. The variation in rates of actual application shall be suitably adjusted plus or minus as provided in the Contract. The contract unit rate shall cover all operations listed in Clause 501.8.8.2.

513 FOG SPRAY

513.1 Scope

The work covers a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing, and to help reduce loosening of chips by traffic on newly finished surface dressing.

513.2 Material

The bitumen emulsion shall be as specified in the Contract or as instructed by the Engineer. The emulsion shall be SS-1 complying with the requirements of IS:8887.

513.3 Weather and Seasonal Limitations

Spraying shall not take place when the temperature is below 10°C, nor in windy or dusty conditions, nor when it is raining or the surface to be sprayed is wet (a damp surface is acceptable but refer to Clause 513.4.2.).

513.4 Construction Operations

513.4.1 Equipment

The fog spray shall be applied by means of a self-propelled or towed bitumen pressure sprayer complying with the requirements of the Manual for Construction and Supervision of Bituminous Works. The spraybar should be protected from gusts of wind by means of a hood.

513A.2 Preparation of Surface

The surface on which the fog spray is to be applied shall be thoroughly cleaned with compressed air, scrubbers etc. The cracks shall be cleaned with a pressure air jet to remove all dirt, dust etc.

513.4.3 Application

The fog seal shall be applied at a rate of 0.5-1.0 litres/m², using equipment such as pressure tank, flexible hose and spray bar or lance.

513.5 Blinding

If specified in the Contract or ordered by the Engineer, the fog spray shall be blinded with graded grit of 3 mm size and under, coated with about 2 percent of the emulsion by weight. The pre coated grit shall be allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

513.6 Quality Control of Work

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

513.7 Arrangements for Traffic

During the spraying operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112. The surface should not be opened to traffic for 24 hours after spraying. If pick-up does occur a light blinding of crusher dust or sand should be applied.

513.8. Measurement of Payment

Fog spray and blinding (if used) shall be measured in terms of surface area of application, for the area covered, in square metres.

513.9 Rate

The contract unit rate for fog spray and blinding (if used) shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. {i) to {xi) as applicable to the work specified in these Specifications.

514 MICRO-SURFACING

514.1 Scope

The work shall consist of design, testing and construction of micro-surfacing composed of modified bitumen emulsion, mineral aggregate, water and necessary additives (if needed), proportioned, mixed and uniformly spread over a properly prepared surface for surface treatment of pavements in accordance with these Specifications.

514.2 Type of Mirco-Surfacing

Micro-surfacing is applied on an existing pavement surface which is structurally sound but the surface shows signs of premature ageing, aggregate loss, cracking, high degree of polishing etc, It may be used as surface sealing treatment to improve skid resistance, surface durability, to seal fine and medium cracks and for preventive maintenance and periodic renewal treatment on low and medium traffic roads. Types of micro-surfacing and rates of application are given in Table 500-31.

Table 500-31 :Types of Micro-Surfacing and Rate of Application

Items	Type II (4 to 6 mm)**	Type III (6 to 8 mm)**
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Application	Preventive and Renewal Treatment for Roads Carrying <1500 CVPD	Preventive and Renewal Treatment for Roads Carrying 1500 to 4500 CVPD
Quantity of mix* {kg/m ² }	8.4 to 10.8	11.1 to 16.3
Residual binder (percentage by weight of dry aggregate)	6.5 to 10.5	5.5 to 10.5

* By weight of dry aggregate. **Indicative only.

514.3 Materials

514.3.1 Binder

The bitumen emulsion shall be a modified bitumen emulsion conforming to requirements specified in Table 500-32. The modifier shall be polymer/rubber, preferably synthetic or natural rubber latex.

Table 500-32 : Requirement of Modified Bitumen Emulsion for Micro-Surfacing

Requirements	Specifications	Method of test
Residue on 600 micron IS sieve (percent by mass), maximum	0.05	IS:8887
Viscosity by Say bolt Furol Viscometre, at 25°C, in second	20-100	IS :8887
Coagulation of emulsion at low temperature	Nil	IS :8887
Storage stability after 24 h (168 h),% maximum	2(4)	IS :8887
Particle charge, + ve/-ve	+ve	IS :8887
Tests on residue:		
a) Residue by evaporation, % minimum	60	IS :8887
b) Penetration at 25°C/100 g/5 s	40-100	IS :1203
c) Ductility at 27°C, cm, minimum	50	IS :1208
d) Softening point, in °C, minimum	57	IS :1205
e) Elastic recovery*,%, minimum	50	IS :15462
f) Solubility in tri-chloroethylene, % minimum	97	IS :1216

In case, elastic recovery is tested for Torsional Elasticity Recovery as per Appendix-8 of IRC:81, the minimum value shall be 20 percent.

514.3.2 Aggregates

As per Clause 512.3.2 (Type II and Type III Grading, Table 500-27).

514.3.3 Filler

As per Clause 512.3.3.

514.3.4 Water

As per Clause 512.3.4.

514.3.5 Additives

As per Clause 512.3.5.

514.4 Design and Proportioning of Micro-Surfacing Mix

514.4.1 The design criteria for micro-surfacing mixture is specified in Table 500-33. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of aggregates and additives used (if any). The set time shall be determined by the method given in Appendix-2 of IRC:SP:81.

Table 500-33 :Mix Design Criteria for Micro-Surfacing Mix

Requirements	Specifications	Method of Test as given in IRC:SP:81
Mix time: minimum	120 s	Appendix-1
Consistency, maximum	3cm	Appendix-3
Wet Cohesion, within 30 min, minimum.	12 kg em	Appendix-4
Wet Cohesion, within 60 min, minimum	20 kg em	Appendix-4
Wet stripping, pass %, minimum	90	Appendix-5
Wet track abrasion loss (one hour soak), maximum	538 g/m ²	Appendix-6

- 514.4.2 Aggregate, modified bitumen emulsion, water and additive (if used), shall be proportioned by weight of aggregate utilizing the mix design approved by the Engineer. If more than one type of aggregates is used, the correct amount of each type of aggregate used to produce the required grading shall be proportioned separately prior to adding other materials of the mixture, in a manner that will result in a uniform and homogenous blend. Final completed mixture, after addition of water and any additive, if used shall be such that the micro-surfacing mixture has proper workability and permit traffic within a short period depending upon the weather conditions without occurrence of raveling and bleeding. Trial mixes shall be prepared and laid for the designed mix and observed for breaking time and setting time. The wet track abrasion test is used to determine the minimum residual bitumen content. Indicative limits of various ingredients for job mix of micro-surfacing shall be as given in Table 500-34.

Table 500-34 :Indicative ingredients in mix

Ingredients	Limits (Percent Weight of Aggregate)
Residual bitumen	6.5 to 10.5 for type II and 5.5 to 10.5 for Type III
Mineral filler	0.5 to 3.0
Additive	As needed
Water	As needed

514.5 Construction

As per Clause 512.5.

514.5.1 Weather and Seasonal Limitations

As per Clause 512.5.1.

514.5.2 Surface Preparation

As per Clause 512.5.2.

514.5.3 Application of Tack Coat

As per Clause 512.5.3.

514.5.4 Machine

As per Clause 512.5.4.

514.5.5 Calibration of Machine

As per Clause 512.5.5.

514.5.6 Application of Micro-Surfacing

A calibrated micro-surfacing machine as per requirements of job mix shall be used to spread the material. The surface shall be pre-wetted (if required under extreme hot weather conditions) by spraying water ahead of the spreader box. The rate of application of spray shall be adjusted during the day to suit temperature, surface texture and humidity. The application of micro-surfacing shall be as per Clause 512.5.6.

514.5.7 Rate of Application

The micro-surfacing mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The quantities of micro-surfacing mix (by weight of dry aggregate) to be used shall be as given in Table 500-31.

514.5.8 Rolling

As per Clause 512.5.8.

514.5.9 Quality Control and Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 shall apply.

514.6 Control of Traffic

Micro-surfacing mix requires about 2 hours to set. Traffic may be opened only after 2 hours restricting the speed to 20 km/h till 12 hours thereafter.

514.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

514.8 Measurement for Payment

Micro-surfacing shall be measured as finished work as specified, in square metres.

514.9 Rate

The contract unit rate for micro-surfacing shall be payment in full for carrying out the required operations including full compensation for the specified rate of application of the mix and the quantity of residual binder. The variation in rates of actual application shall be suitably adjusted plus or minus as provided in the Contract. The contract unit rate shall include full compensation for all operations listed in Clause 501.8.8.2.

515 STONE MATRIX ASPHALT (SMA)**515.1 Scope**

This work shall consist of construction in a single or multiple layer of fibre-stabilized SMA for use as wearing course/ binder course on a previously prepared bituminous bound surface. The 13 mm SMA in this Specification shall be used for wearing course with nominal layer thickness of 40 to 50 mm. The 19 mm SMA shall be used for binder (or intermediate) course with nominal layer thickness of 45 to 75 mm.

515.2 Materials**515.2.1 Bitumen**

The bitumen for fibre-stabilized SMA shall be viscosity grade paving bitumen conforming to Indian Standard Specification IS:73 or Modified. Bitumen complying with IS:15462 and IRC:SP:53 of appropriate type and grade capable of yielding the design mix requirements, and as per Table 500-2.

515.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock retained on 2.36 mm sieve. It shall be clean, hard, durable, of cubical shape and free from dust and soft organic and other deleterious substances. The aggregates shall satisfy the physical requirements given in Table 500-35.

Table 500-35 :Physical Requirements for Coarse Aggregates for Stone Matrix Asphalt

Property	Text	Method	Specification
Cleanliness	Grain Size Analysis	IS:2386 (P-1)	< 2% passing 0.075 mm sieve
Particle Shape	Combined Flakiness and Elongation Index	IS:2386 (P-1)	<30%
Strength	Los Angeles Abrasion Value	IS:2386(P-4)	<25%
	Aggregate Impact Value	IS:2386 (P-4)	<18%
Polishing	Polished Stone Value	IS:2386 (P-114)	>55%
Durability	Soundness (either Sodium or Magnesium)- 5 cycles		
	Sodium Sulphate	IS:2386 (P-5).	<12%
	Magnesium Sulphate	IS:2386 (P-5)	

Property	Text	Method	Specification
Water Absorption	Water Absorption	. IS:2386 (P-3)	<2%

* Polishing requirement does not apply when the coarse aggregate is used for intermediate (binder) course.

515.2.3 Fine Aggregates

Fine aggregates (passing 2.36 mm sieve and retained on 0.075 mm sieve) shall consist of 100 percent crushed, manufactured sand resulting from crushing operations. The fine aggregate shall be clean, hard, durable-, of fairly cubical shape and free from soft pieces, organic or other deleterious substances. The Sand Equivalent Test (IS:2720, Part 37) value for the fine aggregate shall not be less than 50. The fine aggregates shall be non plastic.

515.2.4 Mineral Filler

Mineral filler shall consist of finely divided mineral matter such as stone dust and/or hydrated lime. Fly ash shall not be permitted as a filler. The filler shall be graded within the limits indicated in Table 500-36.

Table 500-36 : Grading Requirement of Mineral Filler

S Sieve (mm)	Cumulative % Passing by Weight of Total Aggregate
0.6	100
0.3	95-100
0.075	85-100

The filler shall be inert material free from organic impurities and shall have plasticity index not greater than 4. Plasticity index requirement will not apply if filler is hydrated lime. Where the complete SMA mixture fails to satisfy the requirement of Moisture Susceptibility Test (AASHTO T283), at least 2 percent by total weight of aggregate of hydrated lime shall be used as filler and the percentage of fine aggregate reduced accordingly.

515.2.5 Stabilizer Additive

Only pelletized cellulose fibres shall be utilized. The dosage rate for cellulose fibres is 0.3 percent minimum by weight (on loose fibre basis) of the total mix. The dosage rate shall be confirmed so that the bitumen draindown does not exceed 0.3 percent when the designed mix is tested in accordance with ASTM D 6390.

515.2.6 The cellulose fibres to be used in pellets shall meet the following requirements:

Maximum fibre length	Bmm
Ash content	Oil
Absorption	more than 4 times of the fibre weight
Moisture content	less than 5 percent by weight

When the Contractor submits the proposed job-mix formula for SMA for approval, it shall include the fibre manufacturer's most recently dated actual test data showing that the fibres meet the above requirements. The contractor shall protect the cellulose from moisture and contamination prior to incorporating it into the SMA.

515.3 SMA Mix Design

515.3.1 The combined grading of the coarse aggregate, fine aggregate and mineral filler (including hydrated lime if used) shall be within the limits shown in Table 500-37.

Table 500-37 : composition of Stone Matrix Asphalt

SMA Designation	13mm SMA	19 mm SMA
Course where used	Wearing course	Binder (intermediate) course
Nominal aggregate size	13mm	19mm
Layer thickness	40-50 mm	45-75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	Cumulative % by weight of .. total aggregate passing
26.5	–	100
19	100	90-100
13.2	90-100	45-70
9.5	50-75	25-60
4.75	20-28	20-28
2.36	16-24	16-24
1.18	13-21	13-21
0.600	12-16	12-18
0.300	10-20	10-20
0.075	8-12	8-12

515.3.2 The SMA mixture will be designed using AASHTO MP8, Standard Specification for Designing Stone Matrix Asphalt and AASHTO PP 41, Standard Practice for Designing Stone Matrix Asphalt. The SMA mixture shall be compacted with 50 blows on each side using the Marshall procedure given in the Asphalt Institute MS-2 (Sixth edition). The designed mix shall meet the requirements given in Table 500-38.

Table 500-38 : SMA Mix Requirements

Mix Design Parameters	Requirement
Air void content, percent	4.0
Bitumen content, percent	5.8 min.
Celluloid fibres	0.3 percent minimum by weight of total mix
Voids in mineral aggregate (VMA), percent	17 min.

Voids in Coarse Aggregates (VCA) mix, percent	Less than VCA (dry rodded)
Asphalt drain down, percent ASTM D 6390 (Annex C of IRC:SP:79)	0.3 max.
Tensile Strength Ratio (TSR), per cent AASHTO T 283 (Annex E of IRC:SP:79)	85min.

515.4 SMA Production

515.4.1 Mixing

The SMA mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate.

When viscosity grade bitumen is used, the mix temperature shall range from 150°C to 165°C. 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 ensure uniform quality of mix, the plant shall be calibrated from time to time.

515.4.2 Handling Mineral Filler

Adequate dry storage will be provided for the mineral filler and provisions shall be made for proportioning the filler into the mixture uniformly and in the desired quantities. This is necessary because relatively large amounts of mineral filler are required in SMA mixes.

515.4.3 Fibre Additive

For batch plant the fibre will be added directly into the weigh hopper above the pugmill. Adequate dry mixing time is required to disperse the fiber uniformly throughout the hot aggregate. Dry mixing time will be increased by 5 to 10 seconds. Wet mixing time shall be increased by at least 5 seconds. For drum mix plant, a separate fibre feeding system shall be utilized that can accurately and uniformly introduce fibre into the drum at such a rate as not to limit the normal production of mix through the drum. At no time shall there be any evidence of fibre in the bag house/wasted bag house fines.

515.5 SMA Placement and Compaction

515.5.1 Preparation of Existing Bituminous Surface

The existing bituminous surface shall be cleaned of all loose extraneous matter by means of mechanical broom and high-pressure air jet from compressor or any other approved equipment/method. Any potholes and/or cracks shall be repaired and sealed.

515.5.2 Tack Coat

Clause 503 shall apply.

515.5.3 Transportation

Clause 501.4 shall apply.

515.5.4 Laying

515.5.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

515.5.4.2 Spreading

Clause 501.5.3 shall apply.

515.5.5 Compaction

Clause 501.6. shall apply, except that the use of pneumatic roller shall not be permitted if there is a possibility of pick-up.

The density of the finished paving layer shall be determined by taking 150 mm diameter cores. The density of finished paving layer shall not be less than 94 percent of the average (sample size N=2) theoretical maximum specific gravity of the loose mix (G_{mm}) obtained on that day in accordance with ASTM 02041. That is, no more than 6 percent air voids shall be allowed in the compacted SMA mat.

515.5.6 Joints

Clause 501.7 shall apply.

515.6 Quality Control and Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and work carried out, relevant portion of Section 900 shall apply.

515.7 Control of Traffic

It shall be ensured that traffic is not allowed on the SMA surface until the paved mat has cooled to ambient temperature in its entire depth.

515.8 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

515.9 Measurement for Payment

SMA shall be measured as finished work in sq.m at this specified thickness or in cu.m as specified in the Contract.

515.10 Rate

The contract unit rate for SMA shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

516 MASTIC ASPHALT

516.1 Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for

road pavements and bridge decks.

Mastic asphalt is an intimate homogenous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and void less mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

516.2 Materials

516.2.1 Binder

Subject to the approval of the Engineer, the binder shall be a paving/Industrial grade bitumen meeting the requirements given in Table 500-39.

Table 500-39 : Requirements for Physical Properties of Binder

Property	Test Method	Requirements
Penetration at 25°C	IS:1203	15 ± 5*
Softening point, °C	IS:1205	65 ± 10
Loss on heating for 5h at 163°C, % by mass Max.	IS:1212	2.0
Solubility in trichloroethylene, % by mass Min.	IS:1216	95
Ash (mineral matter), % by mass Max.	IS:1217	1.0

* In cold climatic regions (temperature less. than 10°C), VG 40 grade bitumen may be used.

516.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from soft, organic or other deleterious substances. They shall satisfy the physical requirements given in Table 500-6.

The percentage and grading of the coarse aggregates to be incorporated in the mastic asphalt depending upon the thickness of the finished course should be as specified in Table 500-40.

Table 500-40 : Grade and Thickness of Mastic Asphalt Paving and Grading of Coarse Aggregates

Application	Thickness Range (mm)	Nominal Size of Coarse Aggregate (mm)	Coarse Aggregate Content, % by Mass of Total Mix
Roads and bridge decks	25-50	13	4G±10
Heavily stressed areas i.e. Junctions and toll plazas	40-50	13	45±10

Nominal size of coarse aggregate IS Sieve (mm)	13mm
0.19	Cumulative % passing by weight 100
13.2	88-96
2.36	0-5

Fine Aggregates :The fine aggregates shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry, and free from soft or flaky pieces and organic or other deleterious substances.

Filler : The filler shall be limestone powder passing the 0.075 mm sieve and shall have a calcium carbonate content of not less than 80 percent by weight when determined in accordance with IS:1514.

The grading of the fine aggregate inclusive of filler shall be as given in Table 500-41.

Table 500-41 :Grading of Fine Aggregate (Inclusive of Filler)

IS Sieve	Percentage by weight of aggregate
Passing 2.36 mm but retained on 0.600 mm	0-25
Passing 0.600 mm but retained on 0.212 mm	10-30
Passing 0.212 mm but retained on 0.075 mm	10-30
Passing 0.075 mm	30-55

516.3 Mix Design

516.3.1 Hardness Number

The mastic asphalt shall have a hardness number at the time of manufacture of 50 to 70 at 25°C prior to the addition of coarse aggregate and 10 to 20 at 25°C at the time of laying after the addition of coarse aggregate.

The hardness number shall be determined in accordance with the method specified in IS:1195-1978.

516.3.2 Binder Content

The binder content shall be so fixed as to achieve the requirements of the mix specified in Clause 516.3.1 and shall be in the range of 14 to 17 percent by weight of total mix as indicated in Table 500-42.

**Table 500-42 : Composition of Mastic Asphalt Blocks
Without Coarse Aggregate**

IS Sieve	Percentage by Weight of Mastic Asphalt	
	Minimum	Maximum
Passing 2.36 mm but retained on 0.600 mm	0	22
Passing 0.600 mm but retained on 0.212 mm	4	30
Passing 0.212 mm but retained on 0.075 mm	8	18
Passing 0.075 mm	25	45
Bitumen Content % by mass	14	17

516.3.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of the work the job mix formula proposed to be used by him for the work, indicating the source and location of all materials, proportions of all materials such as binder and aggregates, single definite percentage passing each sieve for the mixed aggregate and results of the tests recommended in the various Tables and Clauses of this Specification.

516.4 Construction Operations

516.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply, except that laying shall not be carried out when the air temperature at the surface on which the Mastic Asphalt is to be laid is below 10°C.

516.4.2 Preparation of the Base

The base on which mastic asphalt is to be laid shall be prepared, shaped and conditioned to the profile required, in accordance with Clause 501 or 902 as appropriate or as directed by the Engineer. In the case of a cement concrete base, the surface shall be thoroughly

power brl,shed clean and free of dust and other deleterious matter. Under no circumstances shall mastic asphalt be spread on a base containing a binder which might soften under high application temperatures. If such material exists, the same shall be cut out and repaired before the mastic asphalt is laid.

516.4.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied on the base or as directed by the Engineer.

516.4.4 Preparation of Mastic Asphalt

Preparation of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170°C to 210°C. Required quantity of bitumen shall be heated to 170°C to 180°C and added to the heated aggregate. They shall be mixed and cooked in an approved type of mechanically agitated mastic cooker for some time till the materials are thoroughly mixed. Initially the filler alone is to be heated in the cooker for an hour and then half the quantity of binder is added. After heating and mixing for some time, the fine aggregates and the balance of binder are to be added and further cooked for about one hour. The second stage is incorporation of coarse aggregates and cooking the mixtures for a total period of 3 hours. During cooking and mixing care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210°C.

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 kg each. Before use, these blocks shall be reheated to a temperature of not less than 175°C and not more than 210°C. Thoroughly incorporated with the requisite quantity of coarse aggregates and mixed continuously. Mixing shall be continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-42.

The mix shall be transported to the laying site in a towed mixer transporter having arrangements for stirring and keeping the mix hot during transportation

516.4.5 Spreading

The mastic asphalt shall be laid, normally in one coat, at a temperature between 175°C and 210°C and spread uniformly by hand using wooden floats or by machine on the prepared surface. The thickness of the mastic asphalt and the percentage of added coarse aggregate shall be in accordance with Table 500-40 or as specified by the Engineer. Where necessary, battens of the requisite dimensions should be employed. Any blow holes that appear in the surface shall be punctured while the material is hot, and the surface made good by further floating.

Laying surface over existing bridge deck : Before laying bitumen over existing bridge deck, the existing cross fall/camber, expansion joint members and water drainage spouts shall be carefully examined for their proper functioning in the bridge deck structure and any deficiency found shall be removed. Loose elements in the expansion joint shall be firmly secured. The existing wearing coat shall be removed, as per Clause 2809. The cracks in the concrete surface, if any, shall be repaired and filled up properly or replaced by new concrete of specified grade before laying the bitumen mastic over bridge deck.

Laying over new bridge deck New concrete bridge deck which is not in camber/cross fall shall first be provided with required camber and cross fall by suitable concrete or bituminous treatment.

Treatment where mastic asphalt is laid over a concrete surface : In case of laying over concrete surface, following measures shall be taken :

- 1) For proper bond with new concrete deck, surface shall be roughened by means of stiff broom or wire brush and it shall be free from ridges and troughs.
- 2) A thin bituminous tack coat (with bitumen of grade VG 30) shall be applied on the concrete deck before pouring mastic. The deck shall be dry. The quantity of bitumen for tack coat shall be as per Table 500-6.
- 3) After applying tack coat, chicken-mesh reinforcement of 1.5 mm dia steel wire with hexagonal or rectangular openings of 20-25 mm shall be placed and held properly in position on the concrete surface before pouring mastic.

516.4.6. Joints

All construction joints shall be properly and truly made. These joints shall be made by warming existing mastic asphalt by the application of an excess quantity of the hot mastic asphalt mix which afterwards shall be trimmed to leave it flush with the surfaces on either side

516.4.7 Surface Finish

The mastic asphalt surface can have poor skid resistance after floating, in order to provide resistance to skidding, the mastic asphalt after spreading, while still hot and in a plastic condition, shall be covered with a layer of stone aggregate. This aggregate shall be 13.2 mm size (passing the 19.0 mm sieve and retained on the 6.7 mm sieve) or 9.5 mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the Engineer. Hard stone chips, complying with the quality requirements of Table 500-16, shall be precoated with bitumen at the rate of 2 ± 0.4 percent of VG 30 grade. The addition of 2 percent of filler complying with Table 500-9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cu.m per 10 sq.m and rolled or otherwise pressed into the surface of the mastic layer when the temperature of the mastic asphalt is not less than 100°C.

516.5 Opening of Traffic

Traffic may be allowed after completion of the work when the mastic asphalt temperature of the completed layer has cooled to the daytime maximum ambient temperature.

516.6 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.

The surface of the mastic asphalt, tested with a straight edge 3 m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7 mm. The same shall also apply to the transverse profile when tested with a camber template.

516.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

516.8 Measurement for Payment

Mastic asphalt shall be measured as finished work in square metres at a specified thickness, or by weight in tonnes as stated in the Contract.

516.9 Rate

The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under Clause 501.8.2.2.

517 CRACK PREVENTION COURSES

517.1 Scope

The work shall consist of providing one or two coats of an elastomeric rubber membrane known as Stress Absorbing Membrane (SAM) over a cracked surface, followed by a covering of aggregate chips, and a Stress Absorbing Membrane Interlayer (SAMI), which is a material similar to SAM or which consists of a bitumen impregnated geotextile, as specified in the Contract.

517.2 Materials

517.2.1 Binder

Binder shall be a modified binder complying with the requirements of IS:15462 and IRC:SP:53, according to the requirements of the Contract, except that viscosity grade VG 10 complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

517.2.2 Aggregate

The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of SAMI. Where required by the contract, aggregates shall be pre-coated by mixing them with 0.75 to 1.0 percent of paving bitumen by weight of chips in a suitable mixer, the chips being heated to 160°C and the bitumen to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non-sticky and can be spread easily.

517.2.3 Rates of Spread of Binder and Aggregate

The rate of spread of binder and aggregate shall be as given in Table 500-43, as required by the Contract.

517.2.4 Geotextile

The geotextile as prescribed shall conform to the requirements of Clause 703.3.

517.3 Construction Operations

517.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

517.3.2 Preparation of Base

The base on which the SAM, SAMI or bitumen impregnated geotextile is to be laid shall be prepared, in accordance with Clause 501 and as directed by the Engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment/method approved by the Engineer. Dust removed in the process shall be blown off with compressed air.

517.3.3 Application of Binder

517.3.3.1 The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 160°-170°C. Binder for bitumen impregnated geotextile shall be

applied according to Clause 703.4.4. The surface on which the binder is to be applied shall be dry.

Table 500-43 : Quantity of Materials Required for 10 sq.m of Road Surface for Stress Absorbing Membrane

S.No.	Type and Width of Crack	Specification of SAM to be	Quantity of Binder	Quantity of Chipping
1)	Hair cracks and map cracks upto 3 mm width	Single coat SAM or 2nd coat of two coat SAM	8-10	0.10 m ³ of 5.6 mm chips
2)	Map cracks or alligator cracks 3 mm to 6 mm width	Single coat SAM	10-12	0.11 m ³ of 5.6 mm chips
3)	Map cracks or alligator cracks 6 mm to 9 mm width	Two coat SAM 1st coat 2nd coat	12-14 8-10	0.12 m ³ of 5.6 mm and 11.2 mm chips in 1:1 ratio
4)	Cracks above 9 mm width and cracked area above 50 percent	Two coat SAM 1st coat	14-16 8-10	0.12 m ³ of 11.2 mm chips 0.10 m ³ of 5.6 mm chips
5)	All types of cracks with crack width below 6 mm	Single coat SAM I	8-10	0.10 m ³ of 5.6 mm chips
6)	All types of cracks with crack width above 6 mm	Single coat SAM I	10-12	0.10 m ³ of 11.2 mm chips

517.3.3.2 Binder quantity for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 litres/m². Binder quantity outside this range is permitted according to the geotextile manufacturer's instructions and subject to the agreement of the Engineer.

517.3.4 Application of Aggregates

The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the modified binder, clean, dry aggregate shall be spread uniformly on the surface.

517.3.5 Sweeping

The surface of SAMs and SAMIs shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

517.3.6 Two Coat SAM or SAMI

Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first coat.

517.3.7 Geotextile Placement

For bitumen in impregnated geotextile, the requirements of Clause 703.4.4 shall apply.

517.4 Opening to Traffic

Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20 km/h, until the following day. Speed control measures are to be approved by the Engineer, prior to laying. Traffic shall not be allowed on the bitumen impregnated geotextile layer unless it is overlaid.

517.5 Surface Finish and Quality Control of Work

The surface finish shall conform to the requirements of Clause 902.

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

517.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

517.7 Measurement for Payment

Each application of SAM, SAMI or bitumen impregnated geotextile shall be measured as finished work, for the area specified, in square metres.

517.8 Rate

The contract unit rate for SAM, SAMI or bitumen impregnated geotextile shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

518 BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION)

518.1 The Design Mix

The work shall consist of providing a bituminous cold mix consisting of a mixture of unheated mineral aggregate and emulsified or cutback bitumen, laid in a single layer of 25-75 mm. The mix shall either be a design mix or a recipe mix.

518.2 Materials

518.2.1 Binder

The binder shall be a slow/ medium setting bitumen emulsion conforming to IS:8887 or a medium curing cut-back conforming to IS:217.

The final selection of the binder shall be made only after laboratory evaluation with the aggregates to be used. A general guide for the selection of the binder is given in the Manual for Construction and Supervision of Bituminous Works.

The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

518.2.1.1 Aggregates

The aggregates shall comply with the requirements of Clauses 505.2.2. and 505.2.3. If the aggregates are not properly coated with the binder, a small amount of hydrated lime or an approved ant stripping agent (see Appendix-4) shall be proposed by the Contractor, for the approval of the Engineer.

518.2.1.2 Aggregate Grading and Binder Content

The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part I, (wet sieving method), shall fall within the limits shown in Table 500-44.

518.2.2 Mix Design

518.2.2.1 Requirements for the Mixture

Apart from conformity with the grading and quality requirements for individual ingredients, the mix shall meet the requirements set out in Table 500-45.

Table 500-44 : Aggregate Grading and Bitumen Content

Nominal Maximum Size (mm)	9.5	13.2	19.0
Allowable Thickness (mm)	25-35	36-50	51-75
IS Sieve (mm)	Cumulative % by weight of total aggregate passing		
37.5	—	—	—
26.5	—	—	100
19.0	—	100	90-100
13.2	100	90-100	—

9.5	90-100	–	• 60-80
4.75	60-80	45-70	35-65
2.36	35-65	25-55	20-50
0.30	6-25	5-20	. 3-20
0.075	2-10	2-9	2-8
Cutback Emulsion	Binder content, percent by weight of total mix		
		4-6	
		7-10	

The binder content shall be determined by the modified Marshall Test.

Table 500-45 : Mix Requirements for Designed Cold Mix

Parameter	Emulsion ¹	Cutback ²
Minimum Stability	2.2 kN at 22.2°C for paving	2.2 kN at 25°C for maintenance 3.3 kN at 25°C for paving
Percent maximum stability loss on soaking	50 ³	25 ⁴
Minimum flow (mm)	2	2
Compaction level (number of blows)	50	75
Per cent air voids	3-5 ⁵	3-5
Per cent voids in mineral aggregate (VMA)	See Table 500-46	
Per cent minimum coating ⁶	50	

Notes: Using Marshall method for emulsified asphalt-aggregate cold mix design.

Appendix F, MS-14

2Using Marshall method for cut-back asphalt-aggregate cold mix design:, Appendix H, MS-14

3With vacuum saturation and immersion

4Four days soak at 25°C.

5Refers to total voids in the mix occupied by air and water

6Coating Test, Appendix F, MS-14.

Table 500-46 : Minimum Percent Voids in Mineral Aggregate (VMA)

Nominal Maximum Particle Size IS Sieve (mm)	Minimum MA (Percent)
9.5	16.0
12.5	15.0
19.0	14.0
25.0	13.0
37.5	12.0

518.2.2.2 Binder Content

The binder content shall be optimized by the Modified Marshall Test to achieve the requirements of the mix set out in Table 500-45. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

518.2.2.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of 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 where each is applicable:
 - a) Binder, as percentage by weight of total mix;
 - b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The results of tests enumerated in Table 500-46 as obtained by the Contractor;
- v) Test results of the physical characteristics of the aggregates to be used;
- vi) Spraying temperature of binder if appropriate.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the 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 selected jointly with the Engineer of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established by the Contractor and approved by the Engineer before actually using the materials.

518.2.2.4 Permissible Variation from the Job Mix Formula

It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Tables 500-13 and 500-18. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

518.2.3 Construction operations

518.2.3.1 Weather and Seasonal Limitations

Construction with cold mix must not be undertaken when ambient temperatures below 10°C are expected, during rain, in standing water, or generally when poor weather is predicted. Bitumen emulsions and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesion characteristics. Cold weather, rain and high humidity slow down the rate of curing. Extra manipulation may be required to remove volatiles in cool and humid conditions. Wind increases the rate of evaporation.

518.2.3.2 Preparation of the Base

The base on which cold mix is to be laid shall be prepared, shaped and levelled to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

518.2.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid where specified in the Contract.

518.2.3.4 Preparation and Transportation of the Mix

Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

- a) rotary drum type concrete mixer for small jobs or asphalt cold mix plant;
- b) batch or continuous type mixer without dryer

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site shall suit to the Contractor's proposed laying procedure methodology.

518.2.3.5 Spreading

Designed cold mix shall be placed by a paver or grader as specified in the Contract. The mix shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader shall have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mix.

If climatic conditions and aggregate grading do not permit evaporation of moisture or volatiles without aeration by manipulation, a grader shall be used to place designed cold mix.

Other methods of spreading may be used as approved by the Engineer.

518.2.3.6 Compaction

Initial compaction of the laid material shall preferably be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thickness being 25-100 mm and all compaction being in accordance with Clauses 501.6 and

- 501.7. Smooth tyres shall be used. Final rolling and smoothening of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

518.2.4 Opening to Traffic

Traffic shall not be allowed to run on new work until all the water or volatiles in the mix have evaporated, as determined by the Engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

518.2.5 Surface Finish and Quality Control of Work

The surface finish of 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.

518.2.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

518.2.7 Measurement for Payment

Designed Cold Mix shall be measured as finished work, for the area covered, in cubic metres, by weight in metric tonnes, or by square metres at a specified thickness as specified in the Contract.

518.2.8 Rate

The contract unit rate for Designed Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. The rate shall cover the provision of the specified grade of cutback in the mix at 5 percent of the weight of the total mix or emulsion at 8 percent of the weight of the total mix. However any variation in quantity of binder will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted, plus or minus, as per the rate for cutback or emulsion quoted in the Bill of Quantities.

518.3 Recipe Cold Mix

518.3.1 Scope

The work consists of construction of Recipe Cold Mixes composed of aggregate and emulsion binder which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. These mixes are considered suitable for emergency and repair work and temporary road surface improvement.

518.3.2 Materials

518.3.2.1 Binder

Emulsions of sufficient stability for mixing with the particular graded aggregate should be used. Bitumen emulsion shall be slow/ medium setting conforming to IS:8887.

518.3.2.2 Aggregates

Any normal, clean, but not necessarily dry, aggregate shall be used, conforming to Clauses 505.2.2 and 505.2.3 provided that it has sufficiently high crushing strength with regard to the traffic to be carried. Typical gradings are given in Table 500-47.

518.3.2.3 Aggregate Grading and Binder Content

When tested in accordance with IS:2386 Part 1 (wet sieving methods) the combined aggregate grading for the particular mix shall fall within the limits shown in Table 500-47. The actual quantity of emulsion to be used shall be approved by the Engineer after seeing the results of trial mixes made in the laboratory.

518.3.3 Construction Operations

518.3.3.1 Weather and Seasonal Limitations

As per Clause 518.2.3.1.

518.3.3.2 Preparation of Base

As per Clause 518.2.3.2.

518.3.3.3 Tack Coat

A tack coat in accordance with clause 503 shall be applied over the base on which the cold mix is to be laid if specified in the Contract or required by the Engineer.

518.3.3.4 Preparation and Transportation of the Mix

As per Clause 518.2.3.4.

518.3.3.5 Spreading

As per Clause 518.2.3.5.

Table 500-47 : Composition of Recipe Mixes

Nominal Size (mm) and Type of Course	40 Single Course	40 Open Textured Base Course	14 Open Textured Wearing Course	6 Medium Textured Wearing Course
Allowable Thickness (mm)	75	75	31-50	21-30
IS Sieve Size mm	Cumulative % by weight of total aggregate passing			
45	100	100	-	-
37.5	90-100	90-100	-	-
26.5	55-90	55-85	-	-
19	-	-	100	-
13.2	35-55	15-35	90-100	-
9.5	-	-	55-75	100
6.3	20-30	-	25-45	90-100
3.35	10-20	0-10	15-25	45-65
2.36	-	-	-	75-100
1.18	-	-	-	10-30
0.60	-	-	-	-
0.30	2-10	-	-	-
0.15	-	-	-	-
0.075	-	-	2-6	2-8
Emulsion grade and quantity				
Quantity ⁽¹⁾ Kg/ tonne	55 to 70	45 to 65	70 to 90	85 to 100

518.3.3.6 Compaction

As per Clause 518.2.3.6.

518.3.4 Opening to Traffic

As per Clause 518.2.4.

518.3.5 Surface Finish and Quality Control of Work

As. per Clause 518.2.5.

518.3.6 Arrangements for Traffic

As per Clause 518.2.6.

518.3.7 Measurement for Payment

As per Clause 518.2.7.

518.3.8 Rate

The contract unit rate for Recipe Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. The rate shall cover the provision of the specified grade of emulsion at the lower quantity in the range for each type of mix indicated in Table 500-47. However any variation of quantity in emulsion will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted plus or minus, as per the rate for emulsion quoted in the Bill of Quantities.

519 RECYCLING OF BITUMINOUS PAVEMENT

519.1 Scope

This work covers the recycling of existing bituminous pavement materials to upgrade an existing bituminous pavement which has served its initially intended purpose. The work shall be performed on such widths and lengths as shall be directed by the Engineer and may consist of pavement removal, stockpiling of materials from the old pavement, addition of new bitumen and untreated aggregates in the requisite proportions, mixing, spreading and compaction of the blended materials.

These specifications cover the hot process.

519.2 Reclaimed Bituminous Materials for Central Plant Recycling

519."2.1 The reclaimed bituminous material shall be used in the production of bituminous macadam and dense bituminous macadam subject to the Clauses 519.2.3 to 519.2.8, and subject to satisfactory completion of full investigations in respect of all related materials entirely at the Contractor's cost and subject to the approval of the Engineer. For estimation purposes, an amount not greater than 60 per cent of reclaimed bituminous material shall be assumed.

519.2.2 Materials for Recycled Pavement

The recycled materials shall be a blend of reclaimed and new materials proportioned to achieve a paving mixture with the specified engineering properties. The reclaimed materials shall be tested and evaluated to find the optimum blend meeting the mixture

requirements. Such testing and evaluation shall be carried out on representative sample, either cores sampled from the carriageway or samples taken from stockpiles in accordance with current practice. The sampling frequency should be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder. As an absolute minimum, one sample to represent 500 m two lane carriageway shall be taken.

519.2.3 Bitumen Extraction

The procedure described in ASTM D-2172 shall be used to quantitatively separate aggregates and bitumen from any representative sample of reclaimed bituminous pavement.

519.2.4 Aggregate Evaluation

Mechanical sieve analysis (15:2386, Part I, wet sieving method) shall be performed on the aggregate portion of the reclaimed bituminous pavement sample to determine the grading. It is essential that the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material either in existing pavements, from stockpiled of known origin or from another suitable source shall be identified before a decision can be made on the optimum percentage of reclaimed material.

After selecting the proportion of reclaimed materials to be recycled, the grading of the mixture may need adjustment, to meet Specification requirements, by the addition of selected aggregate sizes.

519.2.5 Evaluation of Bitumen

When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10 percent, the penetration value of the recovered binder from the reclaimed bituminous material, before mixing, shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS:2000:Part 397, when tested in accordance with 18:1203. Provided the above requirement is met, hardening of the old binder; during the original mixing process or through ageing, can be compensated for by adding softer bitumen, to obtain the appropriate final grade of binder.

The determination of the type and amount of binder required to be added in the final mix is essentially a trial and error procedure.

After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified in Table 500-48.

Table 500-48 : Minimum Recovered Binder Penetration of Recycled Mixture

Specified Grade of Binder Viscosity Grade	Minimum Recovered Penetration Value of Binder after Mixing
40 (45 pen)	27
30 (65 pen)	39

10 (90 pen)	54
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519.2.6 Rejuvenators

The use of rejuvenators, and a test to measure their effectiveness, is given in Clause 519.6.3.

519.2.7 Untreated Aggregates

If necessary, fresh untreated aggregates shall be added to the reclaimed bituminous pavement to produce a mix with the desired grading. The aggregate shall be checked for quality requirements in accordance with Table 500-7 or Table 500-10 as appropriate. Reclaimed aggregate, if any, or any aggregate normally used for the desired bituminous mix, or both, may be used for this purpose.

519.2.8 Combined Aggregate Grading

The blend reclaimed and new aggregate shall meet the grading criteria specified in the relevant parts of Clauses 505 or 506, as appropriate and as approved by the Engineer. The blend of aggregates shall be checked for resistance to stripping as specified in Tables 500-7 or 500-10 as appropriate.

519.3 Mixture Design

The combined aggregate grading and binder content shall comply with the relevant tables in Clauses 504 or 505 as appropriate. The mix design shall also comply with the requirements of Table 500-10. There may be a variation on three to four sieves with respect to percent passing, the permissible variation shall not exceed 3 to 4 percent per sieve.

519.4 Reclaiming Old Pavement Materials

The removal of pavement materials to the required depth shall be accomplished either at ambient temperature (cold process) or at an elevated temperature (hot process), as approved by the Engineer.

519.4.1 Cold Removal Process

In the cold process, the ripping and crushing operations shall be carried out using scarifiers, grid rollers, or rippers or by any other means as directed by the Engineer. The removed materials shall be loaded and hauled for crushing to the required size as directed by the Engineer. Alternatively, cold milling or planning machines can be used to reclaim bituminous pavement to controlled depths. Thereafter the bituminous layers are removed, any remaining aggregate materials that are to be incorporated in the recycled hot mix shall be scarified and removed. When the pavement material removal is completed, any drainage deficiencies shall be corrected. After that, the base/sub-base, as the case may be, shall be cut, graded and compacted to the required profile and density.

519.4.2 Hot Removal Process

In the hot process, the road surface shall be heated, by infra-red/ hot-air heating system, before scarification. A self-propelled plant fitted with suitable arrangement for heating the existing bituminous surface shall be used. A milling drum shall follow the planer for removing the heated soft bituminous layer. The depth, width and speed of travel shall be adjusted to suit specific requirements as directed by the Engineer. During the heating process, the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

519.4.3 Stockpiling

In the cold process, the reclaimed bituminous pavement material shall be stockpiled with height of stockpiles not exceeding 3m. The reclaimed untreated aggregate base/sub-base material shall be stockpiled in the same manner as new aggregate. The number and location of stockpiles shall be carefully planned for efficient operation of the hot-mix plant.

519.5 Mixing and Laying

The requirements of Clauses 504.3 or 505.4, as appropriate shall apply.

519.6 In Situ Recycling - The Remix and Repave Processes

519.6.1 Scope

In the process of repaving, the existing surface is preheated and scarified but the scarified material is not removed. A layer of fresh bituminous mix material prepared in the integrated mixing unit of the plant is then spread evenly on the scarified surface to give a uniform profile. The spread material should be compacted as soon as possible after laying. In the process, the total thickness of the pavement is increased by up to 50 mm.

In the remix process, the scarified material should be taken from the mixing unit of the plant where it is recycled with fresh binder, aggregate and recycling agent. Then the recycled mixture is spread on the preheated surface and tamped and compacted to the required profile.

519.6.2 Heating and Scarifying

Surfaces to be treated shall be heated by plant with surfaces insulated and fully enclosed. The heated width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilled onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified. A tolerance of ± 6 mm is permissible.

Where street furniture and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressing and large areas of road markings shall be removed by milling, planning scarifying or by similar approved processes.

The heated surface shall be evenly scarified to comply with the requirements of this Clause. When street furniture is left in place or raised, the adjacent area shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If furniture needs to be repositioned on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the obstruction.

519.6.6 Additional Aggregate (Remix Process)

The coarse aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of Clause 507.2.

519.6.7 New Surfacing (Repave and Remix/Repave Processes)

New surfacing material shall be bituminous concrete wearing course complying with Clause 508, or other wearing course material approved by the Engineer.

The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°C to 150°C.

519.6.8 Binder

The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS:2000: Part 397 or an equivalent test. The penetration of the binder shall be in the range 35-70 pen.

519.6.9 Mixture Design

The surfacing material shall be sampled from the paver hopper or augers. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced at site by rifling or quartering to approximately 5 kg and placed loose in an air-tight container.

The sample shall only be reheated once whilst within the container. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three Marshall test specimens prepared in accordance with the procedures specified in MS-2.

The bulk density of each specimen shall be measured before Marshall Stability testing. The mean stability and flow of the three specimen measured in accordance with the procedures specified in MS-2, shall comply with the requirements of Table 500-11.

The three Marshall specimens shall be combined and the maximum theoretical specific gravity (G_{mm}) of the mix shall be determined in accordance with ASTM D 2041. This maximum theoretical specific gravity (G_{mm}) corresponds to 0% air voids in the mix. The percent air voids (P_a) in the specimen of the compacted mixture given by $P_a = (G_{mm} - G_{mb} \times 100) / G_{mm}$ shall meet the requirements of air voids laid down in Table 500-10, where G_{mb} is the actual bulk specific gravity of a Marshall specimen determined in the Laboratory.

519.7 Opening to Traffic

For recycled material forming the base or binder course layer, Clauses 504.5 or 505.5 shall apply as appropriate. For recycled material forming the wearing course layer, Clause 508.4 shall apply.

519.8 Surface Finish and Quality Control •

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.

519.9 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

519.10 Measurement for Payment

The recycled pavement work shall be measured in cubic metres or tonnes of finished work as stated in the Contract.

519.11 Rate

The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for all items s Clause 501.8.8.2.

520 SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES

520.1 Scope

This Clause shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates and stone filler for subsequent use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual Specification Clause for the actual work, given elsewhere in these Specifications. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Specification Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective Specification Clauses for the individual items given elsewhere in these Specifications.

520.2 Sizes of Stone Aggregates

The stone aggregates shall be designated by their standard sizes in the Contract and shall conform to the requirements shown in Table 500-49.

520.3 Stacking

520.3.1 Coarse Aggregates

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

Table 500-49 : Size Requirements for Coarse Stone Aggregates

s. No.	Nominal Size of Aggregate	Designation of Sieve Through which the Aggregates shall Wholly Pass	Designation of Sieve on which the Aggregates shall be Wholly Retained
1)	75mm	106mm	63mm
2)	63mm	90mm	53mm
3)	45mm	53mm	26.5mm
4)	26.5mm	45mm	22.4 mm
5)	22.4 mm	26.5mm	13.2 mm
6)	13.2 mm	22.4mm	11.2 mm
7)	11.2 mm	13.2 mm	6.7mm
8)	6.7mm	11.2 mm	2.8mm

520.3.2 Fine Aggregate

As stated in the individual relevant Specification Clauses.

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

The dimensions of the stockpiles and their locations shall be approved by the Engineer. Where the material is improperly stacked, the Engineer shall direct complete re-stacking of the materials in an approved manner at the Contractor's cost.

Stone filler shall be supplied in a dry state in bags or other suitable containers approved by the Engineer and shall be protected from the environment, so as to prevent deterioration in quality.

520.4 Quality Control of Materials

The Engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the Specifications requirements, by carrying out tests for the specified properties in accordance with Section 900 of these Specifications.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the Specification shall be rejected by the Engineer and removed from the work site at the cost of the Contractor.

520.5 Measurement for Payment

Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in Table 500-50, from the volume computed by stack measurements, to allow for bulking.

Table 500-50 : Percent Reduction In Volume of Aggregates

s. No.	Standard Size of aggregates	Percentage Reduction in Volume Computed by Stack Measurements to Arrive at the Volume to be Paid for
1)	75 mm and 63 mm	12.5
2)	45 mm and 26.5 mm	10.0
3)	22.4 mm, 13.2 mm, 11.2 mm and 6.7 mm	5.0
4)	Fine aggregate	5.0

Unless other-Wise directed by the Engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the Engineer.

Stone filler as delivered to the site shall be measured in tonnes.

520.6 Rates

The contract unit rates for different sizes of coarse aggregate, fine aggregate and stone filler shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for:

- i) all royalties, fees, rents where necessary;
- ii) all leads and lifts; and
- iii) all labour, tools, equipment and incidentals to complete the work to the specifications.
- iv) All necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

800

TRAFFIC SIGNS, MARKINGS AND OTHER
ROAD
APPURTENANCES

801 TRAFFIC SIGNS

801.1 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.

801.2 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

801.2.1 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.

801.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirement of IS:1786 unless otherwise shown on the drawing.

801.2.3 Bolts, Nuts, Washers

High strength bolts shall conform to IS:1367 whereas precision bolts, nuts, etc., shall conform to IS:1364.

801.2.4 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.

801.2.5 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 1.8:736-Material Designation 24345 or 1900. Aluminium Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low Density Polyethylene (LOPE) 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
A	Mechanical Properties of ACM		
1)	Peeloff strength with retro reflective sheeting (Drum Peel Test)	ASTM 0903	Min. 4 N/mm
2)	Tensile strength	ASTM E8	Min. 4P N/mm ²
3)	0.2% Proof Stress	ASTM E8	Min. 34 N/mm ²
4)	Elongation	ASTM E8	Min. 6%
5)	Flexural strength	ASTM 393	Min. 130 N/mm ²
6)	Flexural modulus	ASTM 393	Min. 44.00 N/mm ²
7)	Shear strength with Punch shear test	ASTM 732	Min. 30N/mm ²
8	Properties of Aluminium Skin		
1)	Tensile strength (Rm)	ASTM E8	Min. 65 N/mm ²
2)	Modulus of elasticity	ASTME8	Min. 70.000 N/mm ²
3)	Elongation	ASTM E8	A50 Min. 2%
4)	0.2% Proof Stress	ASTM E8	Min. 10 N/mm ²

801.2.6 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.

801.2.7 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 Sheetting

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 0:4956-09) as indicated in Table 800-2.

Table 800-2 : Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Grade Sheetting (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
0.108	-40	300	200	120	54	54	24	14
0.108	+30°	180	120	72	32	32	14	10
0.2°	-40	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-40	95	62	30	15	15	7.5	5.0
0.5°	+30°	65	45	25	10	10	5.0	3.5

- A minimum of Coefficient of Retro-reflection (RA) $\text{cd}/\text{fc}/\text{ft}^2$ ($\text{cd}/\text{lx}/\text{m}^2$).
- B Values for 0.10 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 Sheetting (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 A.STM 0:4956-09) 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)

Observation	Entrance	White	Yellow	Orange	Green	Red	Blue	Brown
0.10B	-40	500	380	200	70	90	42	25
0.10B	+30°	240	175	94	32	42	20	12
0.2°	-40	360	270	145	50	65	30	18
0.2°	+30°	170	135	68	25	30	14	8.5
0.5°	-40	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) cd/fc/ft² (cd-lx-1m²).

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).

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow /	Fluorescent Yellow	Fluorescent Orange
0.108	-40	1000	750	375	100	150	45	30	800	600	300
0.10B	+30°	460	345	175	46	69	21	14	370	280	135
0.2°	-40	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°	-40	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 (RA) cd/fc/ft² (cd-lx-1m²).

- 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)

Observation	Entrance	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.108	-40	600	500	250	66	130	130	530	400	200
0.108	+30°	370	280	140	37	74	17	300	220	110
0.2°	-40	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	-40	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-40	80	60	30	8.0	16	3.6	64	48	24
1.0°	+300	45	34	17	4.5	9.0	2.0	36	27	14

- A Minimum Coefficient of Retro reflection (RA) cd/fc/ft² (cd-lx-1m²). -
- 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.

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)**

Observation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.106	-40	830	620	290	83	125	37	25	660	500	250
0.106	+30°	325	245	115	33	50	15	10	260	200	100
0.20	-40	580	435	200	58	87	26	17	460	350	175
0.2°	+30°	220	165	77	22	33	10	7.0	180	130	66
0.5°	-40	420	315	150	42	63	19	13	340	250	125
0.5°	+30°	150	110	53	15	23	7.0	5.0	120	90	45
1.0°	-40	120	90	42	12	18	5.0	4.0	96	72	36
1.0°	+30°	45	34	16	5.0	7.0	2.0	1.0	36	27	14

- A Minimum Co-efficient of Retro-reflection (RA) $\{ \text{cd}/\text{fc}/\text{ft}^2 (\text{cd}/\text{lx}-1\text{m}^2)$.
- 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 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.

801.3.7 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 informatory 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 co-efficient 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.

801.3.8 Colour for Signs

- 801.3.8.1 Signs shall be provided with retro-reflective sheeting and/or overlay film/ screening ink. The reverse side of all signs shall be painted grey.
- 801.3.8.2 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.
- 801.3.8.3 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	--

Colour	1		2		3		4		Daytime Luminance Factor (Y%)	
	X	y	X	y	X	y	X	y	Min.	Max.
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.

801.3.8.4 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.

801.3.8.5 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.

801.3.9 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.

801.3.10 Sizes of Letters

801.3.10.1 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

Design Speed (Km./hr.)	Minimum 'x' Height of the Letters (mm)	Minimum Sight Distance/ Clear Visibility Distance (m)	Maximum Distance from Centre Line (m)
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.

801.3.10.2 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.

801.3.10.3 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.

801.3.11 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

801.4.1 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.

801.4.2 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.

801.4.3 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 by area in square metres.

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.

802 OVERHEAD SIGNS

802.1 Scope

The work shall consist of fabrication, supply and installation of overhead 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, JRC:67-2010. -

802.2 Height

Overhead signs shall provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 300 mm in excess of the minimum clearance of other structures.

802.3 Lateral Clearance

802.3.1 The minimum clearance outside the usable roadway shoulder for signs mounted at the road side or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 1.80 m shall also apply outside of an unmountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lane. Large guide signs should be farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified. Lesser clearances, but not generally less than 1.80 m, may be used on connecting roadways or ramps at inter-changes.

802.3.2 Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimize the impact forces or protect

motorists adequately by a physical barrier or guard rail of suitable design.

802.4 Materials for Overhead Sign and Support Structures

- 802.4.1 Aluminium alloy or galvanized steel to be used as truss design supports shall conform to relevant IS. These shall be of sections and type as per structural design requirements as shown on the plans.
- 802.4.2 After steel trusses have been fabricated• and all required holes punched or drilled on both the horizontal truss units and the vertical and support units, they shall be galvanized in accordance with IS Specifications.
- 802.4.3 Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS:736 - Material Designation 24345 or 1900. The thickness of sheet shall be related to the size of the sign with minimum thickness of sheet as 1.5 mm.
- 802.4.4 High strength bolts shall conform to IS:1367 whereas precision bolts, nuts etc. shall conform to IS:1364.
- 802.4.5 Plates and support sections for sign posts shall conform to IS:226 and 18:2062.
- 802.4.6 The overhead signs shall be of micro prismatic retro-reflective sheeting.

802.5 Size and Locations of Signs

- 802.5.1 The size of the signs, letters and their placement shall be as specified in the Contract drawings and Specifications.
- 802.5.2 In the absence of details or for any missing details in the Contract documents, the signs shall be provided as .directed by the Engineer.

802.6 Installation

- 802.6.1 From safety and aesthetic considerations, overhead signs shall be mounted on overhead bridge structures. Where these are required to be provided at some other locations, the support system providing pleasing aesthetics, should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m² normal to the face of the sign and 30 kg/m² transverse to the face of the sign. In addition to the dead load of the structure, walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.
- 802.6.2 The supporting structure and signs shall be fabricated and erected as per details given in the plans and at locations directed by the engineer.
- 802.6.3 Sign posts, their foundations and sign mountings shall be so constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism.
- 802.6.4 The work of construction of foundation for sign supports including excavation and backfill, forms, steel reinforcement, concrete and its placement shall conform to the relevant Specifications given in these Specifications.

- 802.6.5 The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement.
- 802.6.6 Brackets shall be provided for mounting signs of the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degree from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the heights of the signs being supported.
- 802.6.7 Before erecting support structures, the bottom of each base plate shall be protected with an approved material which will adequately prevent any harmful reaction between the plate and the concrete.
- 802.6.8 The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall be completely filled with an anti-shrink grout.
- 802.6.9 Anchor bolts for sign supports shall be set to proper locations and elevation with templates and carefully checked after construction of the sign foundation and before the concrete has set
- 802.6.10 All nuts on aluminium trusses, except those used on the flanges shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut.
- 802.6.11 All nuts on galvanized steel trusses, with the exception of high. strength bolt connections, shall be tightened only to a snug condition.
- 802.6.12 Field welding shall not .be permitted.**
- 802.6.13 After installation of signs is complete, the sign shall be inspected by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor to eliminate or minimize this condition.
- 802.7 Measurements for Payment**
- 802.7.1 Aluminium or steel overhead sign structure shall be measured for payment by the specific unit (each) complete in place as indicated in the Bill of Quantities and the detailed drawings(s).
- 802.7.2 Flat sheet aluminium signs with retro-reflective sheeting thereon shall be measured for payment by the square metre, complete in place.
- 802.8 Rate**
- 802.8.1 The Contract unit rate for overhead sign structure shall be payment in full compensation for furnishing all labour, materials, tools, equipment, excavation for foundation, concrete, reinforcement, painting of structural steel and sign back, fabrications and installation, furnishing of necessary test certificates, warranty and all other incidental costs necessary to complete the work to these Specifications.
- 802.8.2 The Contract unit rate for aluminium sheet signs shall include the cost of making the sign including all materials and fixing the same in position and all other incidental costs necessary to complete the work to these Specifications.

803 ROAD MARKINGS

803.1 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.

803.2 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.

803.3 ROAD MARKINGS

803.1 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.

803.2 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.

803.3 Ordinary Road Marking Paint

803.3.1 Ordinary paint used for road marking shall conform to Grade I as per IS:164.

803.3.2 The road marking shall preferably be laid with appropriate road marking machinery.

803.4 Hot Applied Thermoplastic Road Marking

803.4.1 Thermoplastic Material

803.4.1.1 General

The thermoplastic material shall be homogeneously composed of aggregate, pigment resins and glass reflectorizing 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.

803.4.1.2 Requirements :

- i) 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.

- ii) Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part 1), shall be as below:
 - a) Luminance:
 - White: Daylight luminance at 45°-65 percent min. as per AASHTO M249
 - Yellow: Daylight luminance at 45°-45 percent min. as per AASHTO M249
 - 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
- iii) 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.
- iv) 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.
- v) 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.
- vi) 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 Reflectorizing Glass Beads

803.4.2.1 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.

- 803.4.2.2 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 Clause 803.4.2.3.

803.4.2.3 Specific Requirements

- a) 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	Type2
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

- b) Roundness: The glass beads shall have a minimum of 70 percent true spheres.
- c) Refractive index: The glass beads shall have a minimum refractive index of 1.50.
- d) 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.

803.4.2.4 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

803.4.3.1 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.

803.4.3.2 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

803.6.1 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.

803.6.2 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.

803.6.3 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.

803.6.4 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.

803.6.5 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).

803.6.6 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.

803.6.7 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

803.6.8 Measurements for Payment

803.6.8.1 The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any)..

803.6.8.2 In respect of markings like directional arrows and lettering, etc. the measurement shall be by numbers.

803.6.9 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.

803.7 Cold Applied Reflective Paint

803.7.1 General

The work shall consist of marking traffic stripes using a solvent based cold applied paint, which shall be applied on the asphalt/cement concrete road surface by brush or by Road Marker (Spray equipment capable of spraying the paint on the road). Glass beads shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying. Colour of the paint shall be white or yellow (IS Colour No. 356) as specified in the drawings or as directed by the engineer.

803.7.2 Material

803.7.2.1 The cold applied paint material shall be homogeneously composed of binder, pigment, extenders and other additives as required for the formulation.

803.7.2.2 Composition

The pigments and extenders shall be uniformly dispersed in the binder medium dissolved in organic solvents. The material shall be free from skin, dirt and foreign objects and shall comply with requirements indicated in Table 800-11.

Table 800-11: Proportions of Constituents of Paints (Percentage by Weight)

Component	White	Yellow
Binder	25.0 min.	18.0 min.
Titanium Dioxide	20.0 min.	--
Calcium Carbonate and Inert Fillers	16.0 min.	29.0 min.
Yellow Pigments		14.0 min.

803.7.2.3 Properties

Non-Volatile Matter content by weight shall be a minimum of 65 percent as determined in accordance with test method ASTM D1644. The liquid paint shall have a density of 1.3 g/cc minimum as determined in accordance with test method ASTM D1475.

803.7.2.4 Appearance

Drying Time of the paint as determined by the test method ASTM D711 shall be a maximum of 20 minutes at a wet film thickness of 350 micron. The paint shall set to bear traffic after 40 minutes when the ambient temperature is higher than 24°C. The paint shall not be applied when the surface temperature of the road is higher than 40°C.

803.7.2.5 Properties of the Dried Paint Film

When tested using a sand abrasion tester as described in ASTM 0968, the quantity of sand required for removal of a 75 micron thick unbeaded dry film shall be greater than 65 litres.

803.7.2.6 Elongation

The unbeaded dry film shall pass the test in accordance with ASTM D 1737 and ASTM D2205.

803.7.2.7 Water Resistance

The unbeaded dry film shall pass the test in accordance with ASTM D1647 and ASTM D2205.

803.7.2.8 Skid Resistance

Skid resistance for the beaded dry film shall be not less than 45 as per BS6044.

803.7.2.9 Storage Life

The material shall meet the specifications for a period of one year. During this period, the paint material when stored in an airtight container shall not form skin. The material shall also not form a cake at the bottom of the container.

803.7.2.10 Minimum Thickness of the Unbeaded Cold Applied Paint Coat

The minimum thickness of the wet unbeaded coat of paint shall not be less than 400 micron, and the minimum thickness of the dry unbeaded coat of paint shall not be less than 200 microns.

803.7.2.11 Retro-reflective Properties

The co-efficient of retro-reflection as per British Standards BS EN 1436:1998 shall be as under:

For white paint (Beaded)	-300 mcd/m ² /lux on application
	-100 mcd/m ² /lux after defect liability period of one year
For yellow paint (Beaded)	-200 mcd/m ² /lux on application
	-100 mcd/m ² /lux after defect liability period of one year

The luminous Co-efficient as per British Standards BS EN 1436:1998 shall be as under:

For white paint (Un-beaded)	100 mcd/m ² /lux on application
For yellow paint (Un-beaded)	80 mcd/m ² /lux on application

803.7.3 Marking

Each container of the cold-paint shall be clearly and indelibly marked with the following information:

- i) The name, trade/patent mark
- ii) Batch No.
- iii) Month of Manufacture
- iv) Colour (White or Yellow)

803.7.4 Sampling and Testing

The cold applied reflective road marking paint shall be sampled and tested in accordance with appropriate ASTM/BS test methods.

The contractor shall furnish to the Engineer a copy of certified test methods from the manufacturer of cold applied reflective road marking paint showing the results of:

- a) No pick up time as per ASTM D 711.
- b) Resistance to wear as per ASTM D 4060 or as per ASTM D 968 from approved laboratories.
- c) Material safety data sheet shall be obtained from the manufacturer and kept with the paint materials.

803.7.5 Reflectorising Glass Beads

803.7.5.1 General

Reflection shall be achieved by pneumatically spreading glass beads on to the paint when it is still wet. The beads shall be firmly held by the paint after drying.

803.7.5.2 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 Clause 803.6.7.3.

803.7.5.3 Specific Requirements

- i) Gradation: The glass beads shall meet the gradation requirements as per No.4 of BS:6088 as given in Table 800-12.

Table 800-12: Gradation Requirements for Glass Beads

Sieve Size	Percentage Retained
250 micron	0-10
150 micron	80-100
Below 150 micron	0-20

- ii) Roundness : The glass beads shall have a minimum of 70 percent true Spheres
- iii) Refractive Index: The glass beads shall have a minimum refractive Index of 1.50.
- iv) Free Flowing Properties: The glass beads shall be free of hard lumps, clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test as given in Clause 803.6.5.4.

803.7.5.4 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-1)
- 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.

803.7.5.5 Preparation

The cold applied reflective road marking paint shall be stirred well to form homogeneously with the thinner recommended/supplied by the manufacturer and put into the machine with the consistency level recommended by the machine manufacturer by using proper viscometers. The thinner shall not be added more than that recommended by the manufacturer to avoid bleeding.

803.7.5.6 Application

803.7.5.6.1 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 operation are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

803.7.5.6.2 The cold applied paint shall be applied on the asphalt/cement concrete road surface by brush or by Road Marker/Spray equipment capable of spraying the paint on the road surface. Glass beads@ 300 gms per sq.m shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying.

803.7.5.6.3 The pavement temperature shall not be more than 40°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease oils and all other foreign matter before application of paint.

803.7.5.6.4 The material, when formed into traffic stripes, must be readily renewable by placing an overlay of a 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.

803.7.5.6.5 Cold applied paint shall be applied in intermittent or continues lines of uniform thickness of at least 200 micron of unbeaded dry film thickness unless specified otherwise. When arrows or letters are to be provided, cold applied paint may be applied manually. In addition to the beads recommended for, a further quantity of 300 gms of glass beads per sqm conforming to the specification shall be sprayed uniformly in to a mono-layer on to the cold paint line in quick succession of the cold paint spraying operation.

803.7.5.6.6 The minimum thickness specified above in Clause 803.7.5.5.5 is exclusive of surface applied glass beads.

803.7.5.6.1 The finished line shall be free from ruggedness on sides and ends and be parallel to general alignment of the carriage way.

The upper surface of the lines shall be of uniform level and free from streaks.

803.7.5.7 Properties of Finished Road Marking

As per Clause 803.6.7.

803.7.6 Measurement for Payments

As per Clause 803.5.2.1.

803.7.7 Rate

As per Clause 803.5.3.

803.8 Audible and Vibratory Pavement Markings

803.8.1 Description

The work shall involve application of audible and vibratory pavement markings in accordance with the drawings or the direction of the Engineer.

803.8.2 Materials

Thermoplastic : thermoplastic material shall meet the requirements of Clause 803.4.1 of these Specifications.

Glass Spheres: Use glass spheres meeting the requirements of Clause 803.4.2. The Engineer will take random samples of glass spheres in accordance with ASTM D 1214 and the Department's Sampling, Testing and Reporting Guide schedule.

803.8.3 Equipment

The equipment capable of providing continuous, uniform heating of the striping material to temperatures exceeding 200°C, mixing and agitating the material in the reservoir shall be used to provide a homogenous mixture without segregation. Equipment will maintain the striping material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Equipment shall be capable of producing a consistent pattern of transverse bars positioned at regular and predetermined intervals. It shall meet the following requirements:

- a) capable of travelling at a uniform rate of speed, both uphill and downhill, to produce a uniform application of striping material and capable of following straight lines and making normal curves in a true arc.
- b) capable of applying glass spheres to the surface of the completed stripe by automatic sphere dispensers attached to the striping machine such that the glass spheres are dispensed closely behind the installed line. The glass sphere dispensers should be equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the glass spheres uniformly on the entire traffic stripe surface with 50 percent to 60 percent embedment equipped with a special kettle for uniformly heating and melting the striping material.
- c) equipped with special kettle for uniformly heating and melting the striping material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.
- d) meets the requirements of the fire safety standards.

803.8.4 Application

803.8.4.1 General

Before applying traffic stripes and markings, any material that would adversely affect the bond of the traffic stripes shall be removed by a method approved by the Engineer.

Before applying traffic stripes to any portland cement surface, a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer shall be applied. Longitudinal lines should be offset by at least 50 mm from construction joints of Portland cement concrete pavement.

Traffic stripes or markings shall be applied only to dry surface, and when the ambient air and surface temperature is at least 10°C and rising for asphalt surfaces and 16°C and rising for concrete surface.

Striping shall be applied to the same tolerances .in dimensions and in alignment. When applying traffic stripes and marking over existing markings, ensure that not more than 50 mm on either end and not more than 25 mm on either side of the existing line is visible.

803.8.4.2 Thickness

Base lines shall be applied having a thickness of 2 mm to 2.2 mm exclusive of the transverse audible bars, when measured above the pavement surface at the edge of the base line.

As an alternative to the flat base line, a profiled baseline meeting the following dimensions may be applied. The profiled baseline shall have a minimum height of 4 mm, when measured above the pavement surface at the edge of the inverted rib profile. The thickness in the bottom of the profile marking shall be 0.9 mm to .3 mm. The individual profiles shall be located transversely across the full width of the traffic stripe at approximately 25 mm. On center, with a bottom width between 2.5 mm and 8 mm.

803.8.5 Dimensions of Transverse Audible Bars

The raised transverse bars shall be applied with a profile such that the leading and trailing edges are sloped at a sufficient angle to create an audible and vibratory warning,

Transverse bars on shoulder and centerline markings shall have a height of 11 mill to 14 mm including the base line. The height shall be measured above the pavement surface at the edge of the marking, after application of drop-on glass spheres. The bars shall have an approximate length of 65 mm. The bars may have a drainage channel on each bar the width of each drainage channel will not exceed 6.5 mm at the bottom of the channel. The longitudinal distance between bars shall be 750 mm.

803.8.6 Retro-reflectivity

White and yellow audible and vibratory markings shall attain an initial retro reflectance of not less than 300 m.cd/1xm2 and not less than 250 mcd/1x m2 respectively.

803.8.7 Glass Spheres

Glass spheres shall be applied to all markings. The manufacturer shall determine if a single or double application of glass spheres is used and the recommended drop rates for each application shall be adopted.

803.8.8 Contractor's Responsibility

The Engineer shall be notified by the contractor, prior to the placement of audible and vibratory markings. The contractor shall furnish the Engineer with the manufacturer's name and LOT numbers of the thermoplastic materials and glass spheres to be used. He will ensure that the LOT numbers appear on the thermoplastic materials and glass spheres packages. The contractor shall furnish a copy of certified test reports to the Engineer, showing results of tests specified in these Specifications or as per appropriate ASTM/BS method. The Engineer would have the right to test the markings within 3 days of receipt of the Contractor's certification. If the retro reflectivity values measure less than the values shown above, it shall be removed and the stripping reapplied.

803.8.9 Protection of Newly Applied Audible and Vibratory Markings

Traffic shall not be allowed onto or vehicles permitted to cross newly applied pavement markings until they are sufficiently dry. Any portion of the pavement markings damaged by passing traffic or from any other cause shall be removed and replaced.

803.8.10 Observation Period

Pavement markings shall be subject to a 180 day observation period under normal traffic. The observation period will begin with the satisfactory completion and acceptance of the pavement marking work. The pavement markings shall show no signs of failure during the observation period. Any pavement markings that do not perform satisfactorily under traffic during the 180 day observation period shall be replaced by the contractor at his own cost.

803.11 Measurement for Payment

Audible and vibratory pavement markings shall be measured in linear metre, Payments will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of aft tools, machines and equipment, and all incidentals necessary to complete the work.

804 REFLECTIVE PAVEMENT MARKERS (ROAD STUDS) AND SOLAR POWERED ROAD MARKERS (SOLAR STUDS)

804.1 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.

804.2 Material

804.2.1 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.

804.2.2 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.

804.3 Design

The slope or retro-reflecting surface shall preferably be $35 \pm$ so to base and the area of each retro-reflecting surface shall not be less than 13.0 sq.cm.

804.4 Optical Performance

804.4.1 Unidirectional and Bi-directional Studs

Each reflector or combination of reflectors on each face of the stud shall have a Coefficient of Luminous Intensity (C.I.L.) not less than that given in Tables 800-13 or 800-14 as appropriate.

804.4.2 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 50° 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	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:

- 1) 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.
- 2) The stud incorporating one or more corner cube reflectors shall be included in Category 'P'. The stud incorporating one or more bi-convex reflectors shall be included in Category 'B'.

804.5 Tests

804.5.1 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.

804.5.2 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

- i) the value is not less than 80 percent of the specified minimum, and
- ii) the average of the left and right measurements for the specific angle is greater than the specified minimum.

804.6 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 04280. 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 1Hz. Its should be able to give the prescribed performance in the temperature range of -40°C to $+55^\circ\text{C}$. Its life shall be not less than 3 years.

804.7 Fixing of Reflective Markers

804.7.1 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 130mm. 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.

804.7.2 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 contract 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.

804.7.3 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.

805 DISTANCE INDICATOR POSTS

805.1 Scope

The work shall cover the supply, painting, lettering and fixing of distance indicator stones along the highway to assist the .drivers/users in estimating the distance travelled or remains to be travelled to reach destination, to identify incident location and to provide assistance in maintenance and operations. These devices shall show Hectometre, Kilometre and Kilometres as the case may be.

805.2 These posts shall be in accordance with those prescribed in IRC:26 "Type Designs for 200 Metre Stones" and IRC:8 "Type Designs for Highway Kilometre Stones". They may also be provided in the form of sign systems on highways and roads.

805.3 The material may be made of local stones, concrete or any other material available locally and approved by the Engineer for the devices in accordance with the IRC:26 and IRC:8. For the device(s) provided as the sign system, the material shall be same as that for a traffic sign with retro-reflective sheeting; rectangular in shape (longer side vertical), with colour scheme as that for Advance Direction/Destination signs. The signs shall contain 250 mm white numerals on a 300 mm wide blue or green

background (as the case may be) with white border. They shall be 600, 900 or 1200 mm in height for one, two or three digits respectively and shall contain the abbreviation km in 100 mm white letters so that they are clearly visible to approaching vehicle driver from a distance of at least 100 m. They shall be mounted at a minimum height and lateral placement as that for delineators. These devices shall be bedded into the ground with adequate foundations as indicated in the drawings or in the relevant IRC Specifications or as directed by the Engineer. The orientation and location of the devices shall be as indicated in the drawings or in the relevant IRC Specifications or as directed by the Engineer.

805.4 Measurements for Payment

The measurement will be in numbers of 200 metre, kilometer and 51 kilometer distance indicator posts fixed at site, complete job as per these Specifications or as directed by the Engineer.

805.5 Rate

The Contract unit rate for hectometer/kilometer/51 kilometer distance measurement posts shall be payment in full compensation for furnishing all labour, materials, tools, equipment and making, painting and lettering and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

806 ROAD DELINEATORS

806.1 Scope

The work shall cover supplying and fixing roadway indicators, hazard markers and object markers. Roadway indicators shall be properly installed to indicate the horizontal alignment and vertical profile of the roadway so as to outline the vehicle path for safe driving. Hazard markers shall be installed immediately ahead of obstruction of vehicular path such as just before a narrow bridge. Object markers shall be erected where obstruction within the roadway starts such as channelising island in approaches to intersections.

806.2 The design, materials to be used and the location of the road delineators (roadway indicators, hazard markers and object markers) shall conform to Recommended Practice for Road Delineators, IRC:79, and to relevant drawings or as otherwise directed by the Engineer. The steel drums such as empty bitumen drums shall not be used as they could pose safety hazards. The delineators shall be retro-reflectorised as shown on the drawings or as directed by the Engineer. The reflectors on the delineators shall be of retro-reflective sheeting with encapsulated lens and with the visibility of 300 m under clear weather conditions, when illuminated by the upper beam of the car headlights.

806.3 Installation

The delineators shall be so installed that their posts do not change their orientation and the reflectorised faces are always perpendicular to the direction of travel.

806.4 Measurement for Payments

The measurement shall be made in number of delineators supplied and fixed at site.

806.5 Rates

The Contract unit rates of delineators shall be payment in full compensation for furnishing all labour, materials, tools, equipment including incidental costs necessary to complete the work to these Specifications.

807 BOUNDARY STONES

807.1 Scope

The work shall cover supply and fixing boundary stones as per designs and Specifications given in IRC:25 Type Designs for Boundary Stones" and at locations indicated in the drawings or as directed by the Engineer. The material to be used shall conform to IRC:25.

807.2 Measurements for Payment

The measurement shall be made in numbers of boundary stones supplied and fixed at site.

807.3 Rate

The Contract unit rate for boundary stones shall be full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and, fixing and all other incidental costs necessary to complete the work to these Specifications.

808 FENCING

808.1 Scope

The work shall cover supply and installation of chain link fencing or barbed wire fencing with its fixing on GI pipe posts or RCC posts and providing necessary stays and entry gates as shown in the drawing(s) and/or as directed by the Engineer.

808.2 The GI posts shall conform to IS:1239. The GI pipe posts shall be embedded in concrete to a sufficient depth below ground as indicated in the drawings. The steel shall be fabricated and painted to conform to Section 1900 of these Specifications.

808.3 The chain link fencing shall conform to ASTM F 1553-06. They shall be firmly secured to the posts such that the whole fencing remains intact.

808.4 Entry gate(s) shall be made of GI pipes or other metal as per the design shown in the drawing(s).

808.5 The concrete in R.C.C. posts shall conform to M 25 grade or as indicated in the drawings. The requirements of Section 1700 shall govern. Steel for reinforcement shall meet the requirements of Section 1600. The barbed wire fencing shall be galvanised steel barbed wire conforming to 18:278-1978.

808.6 Measurement for Payment

The measurement shall be in running metre of fencing including the entry gates.

808.7 Rate

The Contract unit rate for fencing shall be payment in full compensation for furnishing all labour, materials, tools, equipment for fabrication and fixing at site and

all other incidental costs necessary to complete the work to these Specifications.

809 TUBULAR STEEL RAILING

809.1 Scope

The work shall cover supply, fixing and erecting tubular steel railings as shown on the drawings and/or as directed by the Engineer.

809.2 The railing shall be of tubular steel in conformance to IS:1239 the fabrication and painting except for the final coat shall be completed before dispatch to the site. Prior to the painting, all surfaces shall be grit blasted to the satisfaction of the Engineer and pickled. The priming coat of paint shall be applied as soon as the steel has dried.

809.3 The posts shall be vertical and of the type as shown in the drawing with a tolerance not exceeding 6 mm in a length of 3 m. The railing shall be erected true to line and grade.

809.4 Measurement for Payment

The railing shall be measured in linear metre from end to end along the face of the railing; including end and intermediate posts, with no deduction for gaps as shown on the drawings.

809.5 Rate

The Contract unit rate for Tubular Steel Railing shall be payment in full compensation for furnishing all labour, materials, tools, equipment and plant required for fabrication, connection, oiling, painting, temporary erection, inspection, test and final erection at site and all other incidental costs necessary to complete the work to these Specifications.

810 STRUCTURAL STEEL RAILING

810.1 Scope

The work shall cover supply, fixing and erecting structural steel railings as shown in the drawings and/or as directed by the Engineer.

810.2 Materials

The structural sections such as angles, flats, rectangular hollow sections etc. shall conform to Section 1900. They shall be painted or galvanised as specified in the Contract.

810.3 Measurement for Payment

The railing shall be measured in linear metre including end and intermediate posts.

810.4 Rate

The contract unit rate for railing shall be payment in full compensation for furnishing materials; labour, tools and equipment required for fabrication, connection, oiling, painting, galvanising, erection, test and all other incidentals necessary to complete the work to these Specifications.

811 CRASH BARRIERS

811.1 Scope

The work shall consist of construction, provision and installation of crash barriers at locations as shown in the drawing or as directed by the Engineer. The type of the crash barrier shall be as specified in the Contract.

811.2 Concrete Crash Barrier

811.2.1 Materials

811.2.1.1 All materials shall conform to Section 1000 Materials for Structures as applicable, and relevant Clauses in Section 1600 shall govern the steel reinforcement.

811.2.1.2 The minimum grade of concrete shall be M25.

811.2.2 Construction Operations

811.2.2.1 The concrete barriers shall be either (i) precast or (ii) constructed by the "cast-in-place with fixed forms" method or the "extrusion or slip form" method or a combination thereof at the Contractor's option with the approval of the Engineer. Where "extrusion or slip form" method is adopted full details of the method and literature shall be furnished.

811.2.2.2 The concrete barrier may be precast in lengths upto 6 m depending upon the feasibility of transport and lifting arrangements. Longitudinal roadside concrete barrier shall be placed on adequate bedding as detailed in the drawing. The top and exposed faces of the barriers shall conform to the specified tolerances, as defined in Clause 810.2.2.3, when tested with 3 m straight edge, laid on the surface.

An expansion joint with pre-moulded asphalt filler board shall be provided at the junctions of crash barrier on structure and crash barrier on the fill. The crash barrier on the fill shall be constructed in pieces of length not exceeding 20 m, with pre-moulded asphalt filler board joints.

Backfilling to the concrete barriers shall be compacted in layers to the compaction of the surrounding earthwork.

811.2.2.3 Tolerance

The overall horizontal alignment of rails shall not depart from the road alignment by more than ± 30 mm, nor deviate in any two successive lengths from straight by more than 6 mm and the faces shall not vary more than 12 mm from the edge of a 3 m straight edge. Barriers shall be at the specified height as shown in the plans above the edge of the nearest adjacent carriageway or shoulder, within a tolerance of ± 30 mm.

811.2.3 End Treatment

The road side concrete barrier shall be provided with an end treatment by tapering the height of terminating end within a length of 8 m to 9 m. Median crash barrier shall be terminated sufficiently away from the median opening. It shall be provided with an end treatment, which shall be obtained by tapering the height of terminating end of the median barrier within a length of 8 m to 9m.

811.2.4 Measurement for Payment

All barriers shall be measured by linear metres of completed and accepted length in place, corresponding end to end along the face of concrete barriers including approach and departure ends.

811.2.5 Rate

The Contract unit rate shall include full compensation for furnishing all labour, materials including steel for reinforcement tools, equipment and incidental costs necessary for doing all the work involved in constructing the concrete barrier complete in place in all respects as per these Specifications.

811.3 Metal Beam Crash Barrier

811.3.1 Materials

811.3.1.1 Metal beam rail shall be corrugated sheet steel beams of the class, type, section and thickness indicated on the drawings. Railing posts shall be made of steel of the section, weight and length as shown on the drawings. All complete steel rail elements terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanized. All elements of the railing shall be free from abrasions, rough or sharp edges and shall not be kinked, twisted or bent.

811.3.1.2 The "W" beam type safety barrier shall consist of a steel post and a 3 mm thick "W" beam rail element. The steel post and the blocking out spacer shall both be channel section of 75 mm x150 mm & size 5 mm thick. The rail shall be 70 cm above the ground level and posts shall be spaced 2 m center-to-center. Double "W" beam barrier shall be as indicated in IRC:5-1998.

The thrie beam safety barrier shall have posts and spacers similar to the ones mentioned above for "W" beam type. The rail shall be placed at 85 cm above the ground level.

The "W" beam, the thrie beam, the posts, spacers and fasteners for steel barriers shall be galvanized by hot dip process (zinc coated, 0.55 kg per square metre; minimum single spot) unless otherwise specified. The galvanizing on all other steel parts shall conform to the relevant IS Specifications. All fittings (bolts, nuts, washers) shall conform to the IS:1367 and IS:1364. All galvanizing shall be done after fabrication.

811.3.1.3 Concrete for bedding and anchor assembly shall conform to Section 1700 of these Specifications..

811.3.2 Construction Operations

811.3.2.1 The line and grade of railing shall be true to that shown on the plans. The railing shall be carefully adjusted prior to fixing in place, to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment.

811.3.2.2 Unless otherwise specified on the drawing, railing steel posts shall be given one shop coat of paint (primer) and three coats of paint on structural steel after erection, if the sections are not galvanized. Any part of assembly below ground shall be painted with

three coats of red lead paint.

- 811.3.2.3 Splices and end connections shall be of the type and designs specified or shown on the plans and shall be of such strength as to develop full design strength of the rail elements.

811.3.3 Installation of Posts

- 811.3.3.1 Holes shall be dug or drilled to the depth indicated on the plans or posts may be driven by approved methods and equipment, provided these are erected in proper position and are free from distortion and burring or any other damage.
- 811.3.3.2 All post holes that are dug or drilled shall of such size as will permit proper setting of the posts and allow sufficient room for backfilling and tapping.
- 811.3.3.3 Holes shall be back filled with selected earth or stable materials in layers not exceeding 100 mm thickness and each layer shall be thoroughly tamped and rammed. When backfilling and tamping are completed, the posts or anchors shall be held securely in place.
- 811.3.3.4 Post holes that are drilled in rock and holes for anchor posts shall be backfilled with concrete.
- 811.3.3.5 Posts for metal beam guardrail on bridges shall be bolted to the structure as detailed on the plans. The anchor bolts shall be set to proper location and elevation with templates and carefully checked.

811.3.4 Erection

- 811.3.4.1 All guard rail anchors shall be set and attachments made and placed as indicated on the plans or as directed by the Engineer.
- 811.3.4.2 All bolts or clips used for fastening the guardrail or fittings to the posts shall be drawn up tightly. Each bolt shall have sufficient length to extend at least 6 mm through and beyond the full nut, except where such extensions might interfere with or endanger traffic in which case the bolts shall be cut off flush with the nut.
- 811.3.4.3 All railings shall be erected, drawn and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

811.3.5 End Treatment for Steel Barrier

- 811.3.5.1 End treatments shall form an integral part of safety barriers which should not spear, vault or roll a vehicle for head-on or angled impacts. The two end treatments recommended for steel barriers are "Turned-down-guardrail" and "Anchored in back slope", as shown on the drawings or as directed by the Engineer.

811.3.6 Tolerance

The posts shall be vertical with a tolerance not exceeding 6 mm in a length of 3 m. The railing barrier shall be erected true to line and grade.

811.3.7 Measurements for Payment

- 811.3.7.1 Metal beam railing barriers will be measured by linear metre of completed length as

per plans and accepted in place. Terminals/anchors of various types shall be paid for by numbers.

811.3.7.2 Furnishing and placing anchor bolts and/or devices for guard rail posts on bridges shall be considered incidental to the construction and the costs thereof shall be included in the price for other items of construction.

811.3.7.3 No measurement for payment will be made for excavation or backfilling performed in connection with this construction.

811.3.8 Rate

The Contract unit rate shall include full compensation for furnishing of labour, materials, tools, equipments and incidental costs necessary for doing all the work involved in constructing the metal beam railing barrier complete in place in all respects as per these Specifications.

811.4 Wire Rope Crash Barrier

811.4.1 Scope

The work shall consist of providing wire rope safety barriers as per designs provided by the supplier or as shown in the drawings.

811.4.2 Materials and Design

The wire ropes shall be galvanised steel wire, supported by galvanised steel posts at spacing, indicated in the drawings. The supplier shall provide calculations in support of the structural details to establish the stability of the barrier against an impact of a heavy commercial vehicle of a gross weight of 36 T, or any weight specified in the Contract.

811.4.3 Measurement for Payment

The wire rope crash barrier shall be measured in linear material including and anchors.

811.4.4 Rate

The Contract unit rate shall include the supply of materials, labour, fittings, installation and anchors for the wire rope barriers.

812 ROAD TRAFFIC SIGNALS

812.1 Scope

The work shall cover supply and installation of Road Traffic Signals.

The traffic signal, its configuration, size and location shall be in accordance with IRC:93 and IS:7537 and as shown in the drawings or as directed by the Engineer. Prior to installation of signals, the Contractor shall submit to the Engineer, for approval, detailed proposals showing the signal type, sizes, paint and structural details of the signal posts including control system.

812.2 The traffic signals shall have a complete electronic mechanism for controlling the

operation of traffic with an auxiliary manual controller. The time plan of signals shall be as per drawing and shall be modified as directed by the Engineer.

812.3 Materials

The various materials and fabrication thereof shall conform to the following

812.3.1 Signal Foundation

The signal foundation shall be constructed as per Specifications given in Clause 13 of IRC:93 or as shown in the drawings.

812.3.2 Construction Requirements

The construction requirements for post, signal head assembly, signal head, optical system, lamp and holder, visor, post, supports for overhead mounted signals, equipment housing, locks, inter-connecting cables, earthing, mains termination, controller electrical components, etc. shall conform to IS:7537 unless otherwise stated in IRC:93. The post shall be painted and protected as per Clause 3.7 of IS:7537.

812.3.3 Optical Requirements

The shape of all signal lenses shall be circular and shall be of specified colour and size and as shown in the drawing. Quality of lenses, arrangements of lenses, illuminations, visibility and shielding of signals shall be as per relevant Clauses of IRC:93 and IS:7537.

812.4 Tests

Tests shall be carried out on all components of traffic signals including tests on complete system for its performance as per relevant Clauses of IRC:93 and IS:7537.

812.5 Maintenance of Traffic Signals

It shall be the responsibility of the Contractor to provide for maintenance of the signal section system throughout the warranty period for at least five (5) years after installation and as per Clause 18 of IRC: 93.

812.6 Measurement for Payment

The measurement for traffic signalization system shall be by unit for complete work as specified and as per drawing for complete road junction.

812.7 Rate

The Contract unit rate for the traffic signalization system as a whole shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying, fixing at site, testing and maintenance throughout warranty period and all other incidental costs necessary to complete and maintain the work to these Specifications.

813 TRAFFIC CONTROL AND SAFETY DEVICES IN CONSTRUCTION ZONE

813.1 Scope

The work shall cover supply and installation at site. Traffic Control Devices in the construction zone comprising of signs delineators, traffic cones, drums, barricades, longitudinal barriers, warning tapes, flagmen, reflective jackets, headgears.

813.2 Signs

Traffic signs shall be in accordance with IRC:67 and in accordance with IRC:SP:55. Its material and other requirements shall be in accordance with Clause 801 of these Specifications.

813.3 Delineators

Delineators in constructions zone are in form of vertical posts, cones, traffic cylinders, tapes, drums etc. Vertical posts shall be in accordance with the provisions contained in IRC:79.

813.4 Traffic Cones

813.4.1 Traffic cones may be of height 500 mm, 750 mm and 1000 mm, and 300 to 500 mm in diameter or in a square shape. They shall be of brilliant red/orange/yellow, ultraviolet stabilized colour for maximum visibility and fade resistance under all weather conditions and ambient working temperature of -30°C to +140°C. The material shall be Linear Low Density Polyethylene (LLDP), plastic or rubber so that there is no damage to the vehicle when they are stuck. Cone and base are to be of one continuous layer to prevent tearing and base separation They should be non-crushable/flexible/tear resistant and UV stabilized and made from non-fading colours. They should return to their original shape in just 20 seconds after being crushed. The bases of cones shall be loaded with ballast (but they should not present a hazard if the cons are inadvertently struck) or anchored to check their being blown away. Their base should be designed for easy stacking without sticking. They may have retro-reflective white band and mounted flashing warning light for enhanced night visibility. All traffic cons shall conform to 88:873 (part 8) Catalogue A and the provisional European Standard EN 13422.

813.4.2 The measurement shall be for each piece and payment for each piece.

813.5 Drums

813.5.1 The drums shall be of size 800 mm to 1000 mm in height and 300 mm in diameter. They shall be constructed of lightweight, flexible, and deformable materials of LLDP or plastic so that no damage is caused to the vehicle when stuck. Steel drums shall not be used. They may be of bright red, yellow or white colours. They should be portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but would remain in place for a prolonged period. The markings on drums shall be horizontal, circumferential, alternative orange and white retro-reflective stripes 100 to 150 mm wide. Each drum shall have a minimum of two orange and two white stripes. Any non-retro reflective spaces between the horizontal orange and white stripes shall not exceed 50 mm wide. Drums shall have closed tops that will not allow collection of roadwork or other debris. When they are used in regions susceptible to freezing, they should have drainage holes in the bottom so that water will not accumulate and freeze, causing a hazard if struck by a motorist. Ballast shall not be placed on top of drum.

813.5.2 The measurement shall be for each piece and payment for each piece, for providing and maintenance at site as per the direction of the Engineer.

813.6 Barricades

The barricades may be portable or permanent. Barricades may be of wooden, metal or other suitable material panels. They shall be stable under adverse weather conditions and appear significant but not to cause damage to the vehicle if they are stuck. They can be classified in 3 types, namely Type-1, Type-II and type-III. Type-1 and Type-II are portable and Type-III permanent. Because of their vulnerable position and the hazard they could create, they should be constructed of lightweight material and should have no rigid stay bracing for A-frame designs.

813.6.1 Type-1 and Type II Barricade

The rail/panel length shall be 2000 mm to 2500 mm for Type I and 1000 mm to 1200 mm for Type II barricade. The width of rails shall be 200 mm to 300 mm. The rails shall be painted in alternate yellow and white stripes of 150 mm width each, sloping away at an angle of 45° in the direction of traffic. The support shall be on a "A-Configuration" or otherwise at the top to permit convenient folding and staking for transportation. Their stability shall be improved by ballasting. On highways or in other situations where barricades may be susceptible to overturning in the wind sandbags shall be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

813.6.2 Type-III Barricade

Type-III is the permanent type and may be made of wood, metal or other suitable material. The typical configuration shall include 3 or more panels/rails, of minimum 1000 mm length (maximum length as per site requirement) and 300 mm width each, painted with alternate yellow and white stripe of 150 mm width sloping at an angle of 45°. They shall be supported and secured on 2 or more vertical supports of same material. On highways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

813.6.3 Application

813.6.3.1 Type I or Type II barricades shall be used in situations where traffic is maintained through the temporary traffic control zone. They may be used singly or in groups to mark a specific condition, or they may be used in a series for channelizing traffic. Type I barricades normally would be used on conventional roads or urban streets and arterials. Type II barricades have more retro-reflective area and are intended for use on highways and expressways or other high-speed roadways.

813.6.3.2 Type III barricades be used for road closure and may extend completely across a roadway or from kerb to kerb. Where provision is made for access of authorized equipment and vehicles, the responsibility should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic,

the Type III barricade should not be extended completely across a roadway. A sign with the appropriate legend concerning permissible use by local traffic shall be mounted.

Signs may be erected on barricades, particularly those of the fixed type, that offer a most advantageous facility for this purpose. The ROAD CLOSED and DETOUR or ARROW signs, and the large arrow warning signs, for example, can be mounted effectively on or above the barricade that closes the roadway.

813.7 Longitudinal Safety Barriers

813.7.1 Longitudinal channelising barricades are light weight channelising devices that can be used singly as Type-I, II or III barricades, or connected so that they are highly visible and have good target value. They should be interlocked to delineate or channelise the traffic flow and mark the work zone. The inter-locking barricade wall should not have gaps that allow pedestrians or vehicles to stray from the channelising path. Longitudinal channelising barricades are located adjacent to traffic and therefore, are subject to impact by errant vehicles. Because of their vulnerable positions, longitudinal channelising barricades should be constructed of lightweight materials and be crash worthy. They shall be of high density polyethylene, non-fading, and high impact and U.V. resistant. They shall be of orange, white or custom colours. Their size should be minimum 1500 mm in length, 1000 mm in height, 600 mm in width. They could be filled with water through an aperture on the top and emptied by removing a plug at the base.

On roads with low speed traffic, GI sheets material could be considered for longitudinal barricades. They shall be firmly secured to vertical support system with no sharp edges to pose any hazard when struck. Their configuration shall be as per the drawing or as directed by the Engineer.

813.7.2 Measurement shall be per running metre of longitudinal barrier and payment for the running metre of complete job of providing, installation and maintenance at site as per the drawing/direction of the Engineer.

813.8 Flagman

813.8.1 The flagmen or flaggers shall be deployed where:

- Workers or equipment intermittently block an unprotected traffic lane,
- one lane is used for two directions of traffic,
- It is considered necessary to guide, warn or control traffic is considered necessary.

The flagman should be alert, intelligent and capable to effectively perform the assigned duties. Flagman shall be provided with hand signalling devices such as flags and sign paddles. Flagmen must be provided with and must wear warning garments, safety headgear, footwear and gloves for their protection and for conspicuity, while flagging. Warning garments worn at night must be of reflective material. Flags for signalling shall be minimum 600 mm x 600 mm and made of good red cloth and securely fastened to a staff of approximately of 1 m in length. Sign paddles should be at least 600 mm wide provided with a rigid handle. The background colour of STOP should be red and its shape shall be octagonal conforming to IRC:67. The word

STOP would be in white colour. Background of SLOW sign should be yellow with black letters and borders.

813.9 Reflective Clothings

- 813.9.1 In the work zones and construction sites, all the workers, supervisor and inspecting officers shall wear high visibility fluorescent clothings with retro-reflective material, so that their presence is conspicuous from a distance of 300 m. Clothings may be in form of vests, T-shirts, jackets, pants and raincoats etc., depending upon weather conditions and ease of usage. They shall be of bright colours of fluorescent red-orange or fluorescent yellow-green.
- 813.9.2 The reflective clothing's shall have reflective bands of width appropriate for the garments viz. vests, T-shirts, jackets, pants and raincoats. It shall have 360° visibility with at least one retro-reflective band encircling the torso, There shall be appropriate separation distances of vertical and horizontal bands placed on torso, sleeves and trouser areas. The garment shall be free of roughness and sharp edges so as not to cause excessive irritation and the wearer should get the best possible degree of comfort and protection.
- 813.9.3 The reflective clothing shall meet the requirements of standards given in IS:15809-2008 or EN 471:2003 The material shall be tested for colour and luminance, colour fastness with cracking, perspiration, laundering and UV light exposure. The material shall meet the requirements of brightness after rainfall performance; temperature variation, abrasion resistance, flexing, cold folding and variation in temperature.
- 813.9.4 Measurement shall be for the unit piece of clothing and payment for providing and maintaining at site as per direction of the Engineer.

813.10 Personal Protection Equipment for Workers

All the workers, exposed to moving roadway traffic or equipment in road construction zones shall wear high-visibility safety apparel, headgear, boots, gloves and other protective gears for their protection. The safety apparel shall be in accordance with Clause 813.9. The safety headgear or protective helmet shall protect the wearer against falling objects and possible serious injury; It shall address requirements of shock absorption, resistance to penetration, flame resistance, chin strap anchorages, comfortable wearing and shall meet the requirements of IS:2925 or EN 397. The safety shoes or boots shall provide personal protection from any possible hazard posed by the activity being done and provide comfortable wearing without giving any hindrance in the expected tasks. The work gloves shall provide protection against any personal injury that could be caused by the activities to be performed and comfort in wearing without giving any hindrance in the expected tasks. If the worker is to be exposed to dust in the Work zone, he shall have respiratory protection by dust mask meeting the requirements of IS:9473-2008. Depending upon the task, workers engaged in welding operations shall have eye protection through passive welding sheet meeting the requirements of EN 175 or auto darkening sheet meeting the requirement of EN 379/EN 169.

813.11 Measurement

The traffic control device of providing traffic signs shall be measured in number. Traffic control devices like barriers and delineators and supply offlagman shall be measured in number and days for which they are used unless specified otherwise in the Contract. Other traffic control devices such as drums, cones, warning tapes, reflective jackets, headgears for workmen shall be considered incidental to the work.

813.12 Rate

Rate for providing traffic signs shall be inclusive of supply of materials, fabrication, installation and maintenance of signs. The rate for provision of barriers and delineators shall be on a rental basis per number-days. The rate for supply of flagmen shall be full wages including their reflective jackets and headgear per man-days of deployment.

814 TRAFFIC IMPACT ATTENUATORS

814.1 Scope

The work shall cover configuration, furnishing and installing traffic impact attenuation devices at hazardous locations (for example gore areas between diverging roadways) conforming to the details shown in the drawings/plans or as directed by the Engineer; so as to act as energy absorbers. The traffic impact attenuators or crash cushions shall be installed for speeds greater than 50 kph. They may be composed of sand barrels or of 'w'-beam fender panels supported by diaphragm with trigger mechanism.

814.2 Sand Filled Impact Attenuators

814.2.1 The system shall consist of a group or series of free standing plastic barrels configured in increasing weights from the impact point towards the object. The array shall be designed to transfer the vehicle's momentum to the increasing masses of sand in the barrels and to provide a gradual deceleration. Each barrel is to be designed with a specific weight of unbagged sand to absorb the energy of an errant vehicle. The lighter barrels shall be placed near the front of arrays to gradually slow the smaller vehicles. Heavier barrels shall be placed further back in the array to slow the larger vehicles. The standard module weights are 90 kg, 180 kg, 315 kg, 640 kg and 950 kg, as recommended by MSHTO. The axis of symmetry of the arrays should be directed along the most likely direction. Approach for an errant vehicle for gore areas could be back towards the inter-section of the edges of pavement. Obstacles in narrow median should be shielded on both ends and the modules placed on the ends (to shield opposite direction traffic) should be placed flushed with downstream edge of the obstacle to avoid wrong way hits. The modules should be placed on a concrete or asphalt surface with maximum slope of 5 percent in any direction. Each barrel's location and weight of sand should be carefully spray painted on the surface at the position that will be covered by the barrel to ensure that the array will be correctly reconstructed after an accident.

814.2.2 The total length and width of the array shall be designed depending upon the expected speed of approaching vehicle. The typical lay out for approach speed of 100 kph would have total length of 10m, width of 2.5 m accommodating 14 barrels arranged in 9 rows with one barrel in first 4 rows and 2 barrels in next 5 rows. The contractor shall furnish a copy of the manufacturer's installation instructions for whatever particular brand of sand-filled impact attenuator is to be used. The sand-filled impact attenuator arrays shall be inspected to ensure that the array is set up as shown in the standard plans and filled in accordance with the manufacturer's recommendations. Sand barrels are essentially one-hit systems requiring complete replacement of impacted barrels. Their use, therefore, is suitable at sites where impact frequency is expected to be low. The arrangement shall be first designed and the layout drawing got approved by the Engineer.

814.3 Proprietary Attenuator System

The Proprietary Attenuator Systems essentially comprise a series of w- beam fender panels supported by diaphragms with a trigger mechanism at nose, which, when hit, releases a 'front assembly' to absorb the energy of impact. When impacted, the system shall telescope rearward to absorb the energy so as to bring the errant vehicle to a controlled stop. The refurbishment shall involve the replacement of damaged unit with repair done, off site. The contractor/supplier of such system shall furnish the certificate that the system to be installed has been tested in accordance with the NCHRP 350 and performs effectively at design speeds up to 100 kmph.

814.4 Measurement and Payment

The traffic impact attenuator system shall be measured and payment made for design and installation of the system as complete job at each location.

815 SEMI AUTOMATIC TOLL COLLECTION SYSTEM

815.1 Scope

The work shall cover supply and installation of Integrated Semi-Automatic Toll Collection System having the following main subsystems:

- i) Automatic Vehicle Counter cum Classifier (AVCC)
- ii) Automatic Boom Barrier
- iii) Contactless Smart Card Systems
- iv) Ticket Printer
- v) User Fare Display unit
- vi) Close Circuit Television System (CCTV)
- vii) Lane Controller
- viii) Traffic Light System
- ix) Intercom System
- x) Over Head Lane Signs
- xi) Integrated Toll Management Software

All equipment shall have built in or external surge protection devices.

815.2 AVCC System

815.2.1 General

The AVCC system shall be able to distinguish between the categories of vehicles

using the highway and as defined by the Ministry's Toll Rules. This class information shall be transmitted to the Lane Computer on completion of the post Automatic Vehicle Classification (AVC). The Lane Computer shall check that this information matches the classification entered by the toll collector. If there is a discrepancy between the two classifications, the Lane Camera shall be triggered to capture a digital image of the vehicle together with details of the class discrepancy message, transaction number with its date and time lane number and toll collector. The digital image and discrepancy information shall be communicated to the supervisory console for further processing by the toll supervision staff. In case of network or Lane computer failure, the AVCC system shall function independently and feed data directly to the Plaza Server and the system shall be able to detect the vehicle moving in wrong direction. The system shall also assist in auditing the toll collection operation. It shall be in modular unit with capability for various modules and functions to perform independently at different levels of toll collection operation. The Central AVCC data base system shall be part of this audit function. It shall be a standalone device with control access where the data cannot be changed or altered in any way. The reports from this system shall assist in identifying problems with operations, fraud or over/under collection of tolls. This central AVCC database System shall be able to operate independently of the Toll Lane System, even if the Toll Lane Controller is nonoperational. Any new technology, meeting the requirements specified in these specifications should not be excluded.

815.2.2 Technical Requirements

Each lane shall be equipped with an AVC controller (different from the lane controller) interface to classification sensors. The classification sensors can be any or combinations of the following types:

- i) Fibre-optic treadles
- ii) Laser classifiers
- iii) Optical height sensors
- iv) Optical axle counters
- v) Infrared 'Light curtains
- vi) Magnetic Sensors
- vii) Resistive Sensors

AVCC processing unit shall be a real-time processing unit, shall be the trigger source for Lane Camera system and shall have standby power supply capable of operations for a period of at least 4 hours. The AVC controller should be metallic, vandal-proof with IP 65 protection. It shall have System accuracy (calculated on a base of 10,000 vehicles):

- a) For vehicle counting - 99% minimum
- b) For vehicle classification - 98% minimum

815.3 Automatic Boom Barrier

815.3.1 General

The barriers are to be used to control the traffic through the lane. The operation of boom barrier shall be linked to the lane computer and shall allow the vehicle to pass through after a successful financial transaction. The system shall consist of a fixed housing and a movable arm. The boom shall be of 3000 mm length for a normal lane and more than 3500 mm for extra wide lane. The housing shall contain the motor and control units and shall be installed on the left side of the lane. The boom barrier should be electrically operated barrier gate for Toll Lane application. The barriers shall have presence detectors independent to the AVC system to prevent barrier arms coming down on vehicles while passing. This shall be in the form of infrared units, dedicated embedded loops or any other sensors. The finish of its housing may be Powder. Coated Orange, RAL 2000 and that of the boom with powder Coated White RAL 9010 with reflective strips. All housing and internal parts shall have rust and corrosion free metals or alloys of high strength with suitable epoxy coating as applicable. The Housing base frame shall be of Stainless Steel so as to protect the housing from rusting from the bottom.

815.3.2 Technical Requirement

The power supply shall be through 230+/-10%V AC, 50Hz with 100 percent duty cycle. Its Logic Control shall be with Technology to ensure that opening and closing timings remain constant under variation of wind and speed. It shall have smooth landing of boom without swaying at the end positions. The response time shall be 1.5 seconds, for boom length of upto 3000 mm and 2 sec. for boom length more than 3500 mm. The mean time before failure (MTBF) shall be 5 million cycles (1 Cycle= 1 open and close). It should be able to operate between the temperature range of -5°C to 55°C.

815.4 Lane Camera

815.4.1 General

The camera installed at convenient location shall be capable of capturing images of the following vehicles:

- a) In case of class discrepancy between the class detected by the AVC and that entered by the toll collector
- b) Exempt users
- c) Vehicles with Smart card
- d) All transaction of vehicle with special events
- e) Offending vehicles
- f) When the alarm footswitch is activated by the toll collector.

815.4.2 System Configuration

The camera should be installed at convenient location to capture images of the vehicles. It shall produce clear images of the front view along with the number plates of the vehicles even during night. The resolution of the images should be such that the registration number of the vehicles can be easily read. The camera should have waterproof housing with a hood to protect from direct sunlight. The protection shall be in accordance with IP65. The stand for the camera shall be made in steel tube that will not swing or twist under gutter speed of strong wind.

81.5.5 Smart Card System

815.5.1 Contactless Smart Card Readers/Writers

815.5.1.1 General

The Contactless Smart Card Readers/Writers are used for managing electronic Toll collection in conjunction with a compatible Contactless Smart Card. The Contactless Smart Card Readers/Writer is linked to a micro-controller or a PC which is typically the lane computer. It allows the vehicle to pass through after a successful financial transaction. Card reader/writer shall be "single-package" type, combining electronics and antenna in one package.

815.5.1.2 Installation Requirement

The Contactless Smart Card Readers/Writers shall be installed on the right side of all the lanes of the Toll Plaza. The orientation of the Contactless Smart Card Readers/Writers shall be wall mounting type, to be at a suitable height on the toll booth wall, to accommodate all types of vehicles e.g. separate readers for trucks/buses and cars/jeeps. This is to ensure that a successful Readers/Write' is achieved with a Contactless Smart Card. Readers/Writers'.

815.5.2 Technical Requirements

The reader shall have the ability to read the smart card from a distance, ranging from 0 cm to 10 cm with a transaction time of less than 0.5 seconds for read/write. Contactless Smart Card Readers/Writers shall be wall mounting type and all transactions shall- be secured with modern and industry standard cryptographic techniques or those based on DES/3DES mechanisms to resist fraud and to deter theft or misuse. The reader/writer shall conform to ISO Standards:14443A and shall be sealed to a NEMA4/IP65. It should have transmit frequency of 13.56 MHz. The operating temperature of the Smart Card Readers/Writer should be -5°C to +55°C and operating humidity of up to 95 percent non-condensing.

815.5.3 Contactless Smart Cards

815.5.3.1 General

The contactless Smart Card is used for storing money value for the purpose of Toll Collection in conjunction with a compatible Contactless Smart Card readers/writers. The Contactless Smart Card allows the Readers/Writers to increment/decrement user fee from the stored money value. It allows the vehicle to pass through after a successful financial transaction. The Contactless Smart Card, the card readers/writers shall be in a single technology configuration. The smart Card shall be able to store the money value in prepaid mode.

815.5.3.2 Technical Requirements

The card shall meet the ISO 14443A standards for contactless smart cards. The memory of the smart card shall be 1KB. It shall be warranted against defects in materials and workmanship for 3 years. The Operating Temperature of the Smart

Card should be -10°C to 60°C.

815.6 Close Circuit Television (CCTV) System

815.6.1 General

The System shall be provided to monitor the activities of toll collection booth operations in the toll plaza. It shall comprise Video Camera and Video Camera Housing at the toll Plaza and 106 cm LCD Monitor and Digital Video Recorder (DVR) at the control centre. The Video Cameras shall be conveniently mounted so that full view of the Toll Plaza and the booth operations are captured.

815.6.2 Technical Requirements

The Video Camera shall be of dome type to avoid pilferage, be resistant to vandalism and be weather-proof. The mounting and equipment housing shall be able to withstand adverse weather conditions. The camera shall provide a minimum of 520 TV lines horizontal resolution. The camera shall provide a useable picture at a minimum illumination of 0.02 Lux. The weighted signal to noise (SN) ratio shall be greater than 50 dB at 1.0 V p-p, 75 ohms. The Cameras shall have MTBF (Mean time between failure) of at least 50,000 hours of operation.

815.7 Digital Video Recorder (DVR)

The Digital recorder shall be stand alone and have the facility to record images on the hard disk and also on external recording devices such as DVD, Hard Disk etc. The digital video recorder shall have enough data storage capacity to store video of 15 days from all the cameras and shall have interface to archive the data on to the DVD/Tape for back-up. The DVR shall have sufficient video signal inputs to cater for all cameras. It shall have Capability alarm/event based recording and the facility for high speed searching based on inputs such as date, time, etc. The Digital recorder shall have functionality to display multiple video images simultaneously on a single Monitor/Screen.

815.8 Lane Controller

815.8.1 General

The Lane Controller shall be provided to control and monitor all the sub systems of the toll lane. It's all consist of CPU and power supply, Data Communication ports, Digital I/O port, Circuit breakers, Terminal blocks, Relays LAN port; IP 65 enclosure with high security locking mechanism. All the peripheral devices in the lane shall be hardwired to the Lane Controller.

815.8.2 Technical Requirements

The system shall be modular with Input / Output Card having adequate channels catering to interfacing of all the peripherals devices with a provision for adding extra two devices. The system shall be housed in a metallic enclosure and installed inside the toll booth. All the peripheral devices in the lane shall be hardwired to the Lane Controller.

815.9 User's Fare Display Unit

815.9.1 General

The Fare Display Unit shall be in the form of a variable message sign, controlled automatically by the lane computer, to indicate the category of the vehicle and the amount payable by the road user. The system shall be LED based. It shall be installed outside the booth, near the payment window so that the road user will have clear view of the fare payable.

815.9.2 Technical Requirements

- | | | |
|--------------------------|---|----------------|
| a) Power Supply | - | 220V/50 Hz AC |
| b) Communication | - | RS232 |
| c) Operating Temperature | - | 10°C to + 55°C |
| d) Protection | - | IP 65 |
| e) LED Reliability | - | 100,000 hrs |

815.10 Traffic Light System

815.10.1 General

LED based light signal, installed at the toll lane towards the exit side shall be connected to the lane controller. The traffic sign glowing red would indicate that the motorist has to stop and pay the user fee. After successful transactions, the traffic sign would turn green to indicate that the motorist can proceed. Traffic lights shall be installed on a pole of about 2 m above the road surface on the right side of each lane. The contractor shall decide the appropriate height taking into account other equipments to ensure clear/unobstructed visibility and control through lane controller. The system shall work in synchronization with the boom barrier and shall have in-built night dimming function.

815.10.2 Technical Requirements

- | | | |
|-----------------------------|---|---|
| a) Size of the display | - | Approx. 200 mm diameter with sun visor |
| b) LED | - | Industry standard, Red and Green |
| c) Housing | - | Corrosion resistant material |
| d) Environmental protection | - | IP 65 |
| e) Intensity | - | Day light visibility > 1000 mcd for Red,
>1600 mcd for Green |
| f) Operating temperature | - | 10°C to + 65°C. |

815.11 Lane Communication System

Voice communication installed in the toll booths shall provide "hands free" two-way verbal communication between the supervision staff in the toll control room and the toll collectors. The toll collector shall be able to attract the attention of the Supervisor in the control room by pressing a single button on the intercom slave unit in the toll booth. The equipment shall also have the facility to allow the supervision staff to monitor communication in the toll booth between the toll collector and the user or between any of the tollbooths without alerting the toll collector. The voice communication system shall operate independently of the Lane Computer system. It shall also be implemented in various rooms of the plaza building and at building access points. Two-way communications shall be possible as soon as the Supervisor responds by selecting the appropriate lane button on the Master Communication unit. One-way communication shall be possible from the Control Room intercom to all lanes simultaneously (broadcast).

815.12 Overhead Lane Signs (OHLS)

815.12.1 The overhead lane signs OHLS shall be mounted on the leading edge of the canopy covering the toll lanes above the centre of the lane to indicate to the User whether the toll lane is open or closed for the processing of vehicles. A red cross signal would indicate that the lane is closed, whilst a green arrow would indicate that the lane is open to traffic.

815.12.2 Technical Requirements

The OHLS shall be made of green and red LEOs. Signs shall be sufficiently bright and directed to indicate to a motorist approaching the toll plaza, at a distance of 250 m on a bright cloud free day that lanes are available for use. The cross and arrow aspects shall be larger than 300 mm. The sign shall be fitted with a sun-hood to screen the effect of the sunlight. The enclosure of the OHLS shall be constructed from a corrosion resistant material. The enclosure shall have an IP 65 rating and be ventilated to dissipate internal heat. The system shall have night dimming function.

815.13 UPS System

UPS system shall be supplied for individual lanes and plaza systems separately. Each UPS system shall be designed for 125 percent of the total connected load. The power supply to all electronic equipment (indoor and outdoor) shall be fed from UPS which shall have minimum 2 hours backup. The power budget calculation is to be submitted to the Engineer.

815.14 Violation Alarm

The siren operates in conjunction with a violation and acts as a warning device. The purpose of the siren is to alert the plaza staff of a run-through through the lane. Visual indication is via a strobe light. It shall meet the following requirements:

- | | | | |
|------|--------------------------|---|---------------|
| i) | Technology | - | Motor driven |
| ii) | Audible rating | - | 112 dB at 1 m |
| iii) | Hearing distance | - | 500m |
| iv) | Environmental Protection | - | IP 65 |

815:15 Computer Hardware

815.15.1 Plaza Server shall have following minimum Specification:

- 1) Intel Xeon 3.0 GHz or higher with Intel EM64T/1 MB Cache/800 MHz FSB
- 2) 2 GB ECC DDR2 RAM upgradeable to 12 GB
- 3) Dual Channel U320 SCSI Controller
- 4) 6x36 GB (10K rpm) HOD, Hot-pluggable, with RAID-S Support
- 5) CDRW - DVD Combo Drive
- 6) Dual Gigabit 10/100/1000 Ethernet
- 8) Redundant Power Supplies, Redundant Fans
- 9) Anti-virus preloaded
- 10) Server Management Software - with remote management features onboard
- 11) 20/40 GB OAT Drive
- 12) Certifications : ACP V1.0 8 Compliant PCI 2,2 Compliant, PXE Support, WOL support, Microsoft Windows 2000/2003, Linux, PCI-X1.0 Compliant
- 13) Operating Conditions: Operating Temperature Range: 0°C-50°C Relative Humidity: 20 percent - 90 percent, non-condensing
- 14) AC Voltage: 207VAC to 253VAC@ 47-63Hz

815.15.2 Bar Code Reader

The bar code reader shall be used to scan unique identification bar codes imprinted on media such as paper and plastic medium such as smart cards etc. The bar code reader shall be equipped with easily visible LEOs and audible beeps that indicate the scanner's operation status. The barcode reader shall have a rugged protective boot with an adjustable stand and be mounted to a countertop or be left free standing for handheld scanning. The barcode readers shall conform to IS:14700: Part 6: Sec 3; 2002. The bar code reader shall be IP 54 protected.

815.15.3 Receipt Printer

The receipt printer shall be a compact thermal printer able to print, as a minimum, toll payment receipts (text and graphics) and barcodes. The receipt printer shall use thermal fixed head technology. The print speed shall not be less than 150 mm/s for both text and graphic and at a minimum resolution of 203 dpi (8 dots/mm). It shall be able to support paper thickness of 75 - 80 GSM. The receipt printer shall support programmable English and Hindi fonts and graphics, including Barcodes of at least Code 128 format. The receipt printer shall have an automatic cutter with a self-sharpening ceramic rotary knife. The receipt printer shall be robust for use in a toll booth environment where there is heavy usage and possible dust and exhaust from vehicles. The auto cutter shall have a reliability of at least 1.5 million cuts. The receipt printer head shall have a Mean Cycle between Failure (MCBF) of at least 50 million print lines. The receipt printer shall have a Mean. Time between Failure (MTBF) of at least 360,000 hours. The receipt printer enclosure shall be IP54 rated.

815.15.4 Toll Management System (TMS)

The Toll Management System (TMS) shall be responsible for processing the data into information that will be used to verify toll transactions, provide toll collector control, cash-up and performance facilities, and shall include a host of management tools and reports for the effective administration of the toll operation. The TMS shall also assist in auditing the toll collection operation. It shall be a modular unit with the capability for various modules and functions to perform independently at different levels of the toll collection operation. The TMS shall have various customized reports to assist in managing the toll facility, and to provide management tools to assess toll revenues. The TMS shall have financial management and traffic analysis tools to assist the operator in planning operations. The contractor/supplier shall ensure that security updates and latest service packs, "patches" are loaded. Industry standard operating systems shall be utilized and all user licenses shall be provided. The database shall be an industry standard database and shall be supplied with all the latest service packs and patches, including user licenses.

815.15.5 Rates

The payment shall be made for design, configuration and commissioning of Semi-Automatic Toll Collection System as complete job at the location indicated in the Contract, and shall be in stages specified in the Contract.

816 ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

816.1 Scope

The work shall cover design, supply, installation, commissioning and/or operation and maintenance of Advance Traffic Management Systems (which is one of the components of Intelligent Transport Systems - ITS). The system would include outdoor equipment including emergency call boxes, variable message sign systems, meteorological data system, close circuit TV camera (CCTV) system, traffic counting and classification system and transmission system. The indoor equipment would comprise a large display board, central computer (with Network Management System - NMS), CCTV monitor system, call centre system or management of emergency call boxes housed in a control centre with uninterrupted power supply. Any new technology, meeting the requirements specified in these specifications should not be excluded. The systems shall meet following objectives:

- Smooth and uninterrupted traffic flow
- Enhance road safety
- Real time information and guidance to users
- Emergency assistance round the clock
- Alerts for abnormal road and weather conditions
- Reduced journey time and inconvenience

816.2 System Requirement

ATMS shall provide the following facilities to highway users:

- make emergency calls to Control Centre in case of accidents, breakdown, fire and ambulance.
- pre-warn the highway users about unusual condition on the road.

ATMS shall provide the following information/data to traffic managers for efficient and effective handling of traffic.

- information regarding location of any incident, incoming calls, help required and messages to be passed to third parties.
- Information regarding traffic congestion, speed and weather conditions.

ATMS shall provide the following controls to traffic managers:

- change the variable message signs from the Control Centre.
- mobilize the movement of ambulances, cranes & patrolling vehicles.

ATMS shall provide online recording and reviewing of the voice & visual information for record and analysis.

816.3 System Configuration

The ATMS shall have following sub-systems:

- i) Emergency Call Boxes
- ii) Mobile Communication System
- iii) Variable Message Signs system
- iv) Meteorological Data System
- v) Automatic Traffic Counter cum Classifier System
- vi) Video Surveillance System
- vii) Video Incident Detection System (VIDS)

816.4 Availability Requirements

The inability to perform any required function, the occurrence of unexpected action or degradation of performance below the specifications shall be considered as a failure. The Mean-time-between-failure (MTBF) shall be the average operating time accumulated by the total population of identical items between failures. The system supplier/contractor shall submit MTBF and MTIR figures. The ATMS shall have an overall system availability of better than 99 percent. The ATMS shall be considered unavailable if any of its function cannot be properly executed and when any of the following conditions persist for more than 8 hours on the entire stretch.

- i) Variable Message System Failure: No display/Improper Display of VMS or failure of their related transmission/control system which would render the VMS inoperative
- ii) Emergency Call System Failure: Failure of any three consecutive Call boxes or failure of their related transmission system which would render the call boxes inoperative.
- iii) ATCC Failure: Failure of more than one ATCC or failure of their related transmission system which would render the ATCC inoperative.
- iv) Met Failure: Failure of more than one Met or failure of their related

transmission system which would render the Met inoperative.

- v) Video Surveillance System Failure: Failure of more than two Video Cameras or failure of their related transmission/control system which would render the cameras inoperative.
- vi) Video Incident Detection System Failure: Failure of more than one Video Cameras or failure of their related transmission/control system which would render the cameras inoperative.
- vii) Display at Control Centre: Whenever Control Centre is unable to get display of messages initiated by the Control Centre in-charge.

In addition to the above the system shall be considered unavailable when failure of the integrated ATMS Software or its hardware persists for more than 8 hours.

816.5 Reliability Requirements

The supplier shall ensure that ATMS supplied shall comply with the following reliability requirements:

ATMS (Sub-Systems)	Mean Time Before Failure – MTBF
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Outdoor Equipment	15,000 hours
Transmission System Equipment	15,000 hours
Control Centre Equipment	15,000 hours
Power Supply Equipment	15,000 hours

816.6 Maintainability Requirements

The Mean-Time-to-Repair (MTTR) of the ATMS to full normal operation following a failure shall be less than 8 hours all inclusive.

816.7 System Safety Requirements , The ATMS is classified as a safety related system and a minimum of CENELEC standards EN50128 software integrity level 2 shall apply. All equipment must comply with and be installed in accordance with IEC 65, IEC 364. All metal enclosures shall be provided with an earthing terminal and earthing of all equipment shall be carried out in accordance with overall earthing policy.

816.8 Environmental/Climatic Requirements

816.8.1 Indoor Equipment

Temperature (Operating)	-	0°C to+ 50°C
Relative Humidity	-	up to 95% (non-condensing)

816.8.2 Outdoor Equipment

Temperature (Operating)	-	5°C to+ 60°C
Relative Humidity	-	up to 95% (non-condensing)

The system and the equipment used as a minimum shall meet the following climatic

and environmental requirements as specified in IS:9000:

Tests	Severities
Change of Temperature (Temp cycling) as per IS:9000 (part xiv/sec1)	i) Low Temp 0°C + 3°C ii) High Temp 60°C + 2°C Rate of cooling and heating 1°C/m iii) Duration for each cycle 3 hours iv) No of Cycles, 3
Damp heat (Cyclic) test as per IS: 9000 (part v/sec 2) variant 1	i) Upper Temp 40°C + 2°C ii) Lower Temp 25°C iii) One Cycle 12 h iv) Relative humidity 95 percent v) No. of Cycles 6
Vibration (Sinusoidal) test as per IS:9000	i) Freq. range 10Hz - 55 Hz ii) Vibration 0.35 mm Amplitude iii) Duration of 20 sweep cycles endurance for sweep (10Hz- 55 Hz) iv) No of axes 3 co-ordinate axis v) Duration at 30 min+1 min Resonant frequency

816.9 Emergency Call Box

816.9.1 General

The apparatus is a communication medium to be installed on the highway and to be used by the road users to make alarm call to the Control Centre in case of accidents and other emergency problems on the road or any incident. The Emergency Call Boxes shall be located in pairs on opposite sides of the highway. Main ECB unit (Master) shall be located on one side and the secondary unit (Slave) on the opposite side.

816.9.2 System Configuration

The Emergency phone shall comprise loud speaker, microphone, activation button, ringing tone to indicate progress of call when button is pressed, confidence tone to indicate call is still connected when on hold, recorded message in case the line is busy and LED indication during conversation. These components shall be provided in FRP (Fibre Reinforcement Plastic)/stainless steel/Aluminium Alloy housing.

816.9.3 General Requirements

The ECB shall be designed for hands free operation. It shall be identified by reflective guide sign placed approx. 10 m ahead of the ECB . It shall have a provision for mounting on a concrete base with cast-in bolts, nuts and washers and the whole shall be installed so as the persons using the instrument will normally be facing the oncoming traffic. The enclosure shall be equipped with retro-reflective sticker that is clearly visible at night. The sticker shall read 'SOS' along with a telephone symbol. It shall have provision for the instructions of operation to be written clearly on the outside surface in _two languages. Voice Logger Software shall be provided to handle and log all calls from the network. There shall be up to four programmable auto dial numbers associated with the push button. The ECB shall automatically dial subsequent numbers if the first number is busy or unavailable.

816.9.4 Technical Requirements

816.9.4.1 The ECBs shall work on DC supply and operate in full duplex mode. It shall be able to operate in a noise level of up to 95 db and suitably protected against external EMI ESI Interference through shielding/grounding. It shall have in-built programming port/feature for addressing. The same must be capable of being addressed using Laptop or Palmtops in fields. The ECB Central software shall use this address for identification of ECB. The ECB shall use latest components and a micro controller of adequate capacity to meet the system requirements. It shall have in-built fault diagnostics features for on-site maintenance and have extant protection against lightning. It shall be powered from the communication cable/ solar panel. The solar panel and battery shall be adequately rated to support the ECB working under idle conditions and a talk time of minimum 90 minutes over 3 days in succession under worst climatic conditions. At each location one ECB shall be Master and the other Slave. The master ECB shall be equipped with fibre optic interface, solarpanel, battery back-up and voice communication mechanism and shall also comply with all the requirements specified in this section for ECBs. The slave ECB shall be equipped at least with - activation button, vandal sensing mechanism, call progress indication LED, Microphone, Speakers, Handicapped operation activation - in a weather proof housing as detailed in these specifications. The system shall detect vandalism and give audio-visual alarm at the control centre. The ECB system shall have a product support guarantee of 10 years from the manufacturer. The ECB central system shall communicate with the Central Traffic Management System and all the events and alarms shall also be displayed and stored in the Central Traffic Management server. The ECBs shall meet the specification as per the following:

- i) Electromagnetic compatibility: be suitably protected against external EMI/ESI Interface through shielding/grounding.
- ii) Lightning Protection: to be suitably protected.
- iii) Drop and topple: BS:2011 or equivalent.
- iv) Enclosure: IP 65.

The equipment shall conform to all applicable electrical standards in India.

816.10 Mobile Radio Communication System

816.10.1 General

The mobile communication system shall be provided to establish voice communication on radio between the Control Centre and the emergency mobile vehicles such as ambulances, cranes and patrolling vehicles. The system shall comprise base station unit, repeater unit, mobile radio unit and control centre equipment. Its Base Station Unit shall comprise transmitter, receiver antenna switch, radio engineering terminal, radio data terminal, radio operator terminal and power supply. Its Repeater Unit shall comprise transmitter, receiver, antenna, repeater and power supply. Its Mobile Radio Unit shall comprise transmitter, receiver, antenna, control unit and power supply. The Control Centre Equipment shall have Network Management System.

816.10.2 General Requirements

The system shall cover the entire route. The system design shall be modular in concept. The system shall be compact and rugged in design having ease of maintenance and shall work satisfactorily under adverse conditions like storm, rain

and vandalism resistant. The system shall neither affect functioning of other telecom equipment installed adjacent or along it, nor get affected by the presence of other equipment/systems. The Mobile Radio shall have provision for mounting the mobile set on ambulances, cranes and patrolling vehicles. The repeater station equipment and antenna shall be installed at sub centres. Each mobile unit shall have a unique address code. The system equipment shall work on re-chargeable batteries with 24 hr back-up.

The control panel of mobile unit and base station unit shall have the following features:

- i) Power ON-OFF switch
- ii) Emergency calling button
- iii) Adjustment of loudspeaker volume
- iv) Digital display
- v) Functional buttons

816.10.3 Functional Requirements

The modulation shall be either frequency or phase type (FSK) and shall operate in semi- duplex mode. The equipment shall have provision to eliminate collision of data. It shall have facility to configure the network for individual, sub-group or broadcast mode of operation for both selective calling and group calling operation. All components used in the assembly of equipment shall be of industrial grade specification. The equipment shall conform to ETS European standards and shall be suitably protected through shielding/grounding against external EMI/ESI Interference, and shall be immune to RFI, ESD and lightning.

816.10.4 Technical Requirements

The system shall have the facility to connect mobile to mobile, mobile to controller and controller to mobile. The system shall have the facilities for waiting calls, holds calls and transfer calls. The system shall have a facility such that the Control Centre can select between the call modes of individual call, group/all-call and call to mobiles listed in the queue. The system shall use primary channels for calling from mobiles to the Control Centre and vice- versa whereas the secondary channels shall be used for mobile to mobile connection. The system shall have the facility to terminate the mobile to mobile connection under the following conditions:

- a) One of the two parties hangs up
- b) One of the two parties receives a call from the Control Centre c). The duration of the conversation exceeds 5 minutes limit.

In case of emergency, the system shall have the facility to receive alarm calls from mobile radio. The mobile radio shall be integrated with the Fibre Optic Communication system. The system shall use frequencies to be obtained by the contractor from WPC in the complete stretch as per scope. The system shall have the provision for communication on the PSTN Network. The system shall have suitable voting system to select the better signal at base stations as well as mobile units. The system shall have provision to handle calls from/to at least 20 mobile sets. The system shall have self-diagnostic features. The system shall be protected against any damage due to power supply fluctuations, transients and surges.

816.11 Variable Message Signs

816.11.1 Scope

The work shall cover supply and installation of Variable Message Signs (VMSs) which provide to road users the advance en-route traveller information of road conditions ahead in real time. The provisions contained in IRC:SP:85 shall be followed.

816.11.2 Fixed VMS

Fixed VMS shall be mounted on a sturdy and aesthetically pleasing gantry structure whereby the vertical clearance of at least 5.5 m is available from the road. Safety barriers shall be provided at gantry support column(s) for their protection and for safety of road users. The concrete pedestal for support column should be flushed with ground but in no case should protrude more than 1.5 m.

816.11.2.1 The minimum distance of VMS on expressways should be 1.5 km prior to / decision point and that for National Highways it should be 1 km. The signs should be visible from a distance of 250 m. It should not be located on a curve and on a highway sections having grade exceeding 4 percent.

816.11.2.2 There should be clear distance between existing sign and VMS. The minimum distance between road signs and VMS should be at least 250 m on expressways and 150 m on National Highways.

816.11.3 Portable VMS

816.11.3.1 Portable signs shall be mounted at the back of a truck or similar vehicle. The portable VMS signs mounted on a truck shall be powered by solar energy or battery and show the sign of 'men at work' and/or speed limits in the construction zone. They shall be so placed that they are effective. The placement must give adequate time to the motorists to react to the message and take corrective action. On Expressways and National Highways placement of these at 2 km prior to- the decision points should be done with repetition at every 500 m and 50 m prior to the point of decision. It should provide a sight distance of 200 m and should not interfere with other traffic control devices. If the portable VMS set-up and a message is not to be required for a period of next four hours or more, the sign panel should be turned away from the traffic, parallel to the road centre line. Non blank signs should be facing the drivers for an extended period.

816.11.3.2 Under no circumstances shall VMS be used for advertising of any kind. It would be in blank mode when traffic, roadway, environment or pavement conditions or public service announcements do not warrant the display of message or messages.

816.11.4 Technical Requirements

The design of the system shall be modular. The system shall use LEDs/high gain Tran reflective LCDs for outdoor full sunlight. The failure of one LED module should not affect the output of any other LED cluster. Its design shall be such that the display is legible from a distance of 300 m on Expressways and from 250 m on other highways.

The equipment will comply with the following:

i)	Overall Size Board	Length minimum 3000 mm Height minimum 1800 mm Depth 200 mm
ii)	Number of Display Lines	3
iii)	Number of Characters per line	15
iv)	Height of Characters	minimum 400 mm for English Alphabet and 380 mm for any other local script excluding vowel connotations.
v)	Language	Three languages (English, Hindi and Regional Language)
vi)	Contrast Ratio	> 30:1 perpendicular to the board face >10:1 at an angle of + 70° to perpendicular.
vii)	Memory	Capable of storing minimum 10 frames that can be triggered on receiving the tete-command.
viii)	Housing	Powder coated housing with IP55 or other equivalent international standard for protection easing against dust, sprayed water and winds.
ix)	Mounting	Pole mounted as gantry and or cantilever with vertical clearance of 5.5 m from the surface.
x)	Interface Standard	RS422 and RS485 interfaces with compatibility on Ethernet.
xi)	Special Features	Automatic diagnostic and reporting of failure/fault of arrays/rows.
xii)	Protection against EMI	Circuitry and wiring inside VMS to be protected against any kind of EMI interference
xiii)	Additional Features and humidity sensor	Incorporation of temperature sensor
xiv)	Luminous Intensity (LED)	> 3000 mcd
xv)	Life of Components of VMS	> 10 years

Elaborate Fault diagnostics shall be provided as per EN 12966 or other equivalent international standards. Each pixel shall be monitored and feed. back shall be provided for the health status. Minimum of following shall be provided:

- i) Power Failure at VMS
- ii) Processor PCB Failure
- iii) LED Cluster Failure
- iv) Loss of incoming message/data not properly received.
- v) Temperature monitoring.

The controller unit shall provide brightness control facility. Monitoring of ambient temperature of the housing. The controller shall be capable of automatically diagnosing and reporting component failure or any electronic fault. The controller shall be provided with a test port for local diagnostics via laptop. It shall be possible to perform fault diagnostics from the central control room via the software. The LED Clusters shall be mounted suitably for providing better viewing angle. Each display module shall have its own display interface to the Central processor. VMS shall be designed to comply with the following protocols:

NMCS2, MESSAGE CONTROL, TR2070D, NTCIP Version 2 or other equivalent international protocols.

816.11.5 Testing

The equipment shall be tested for functional requirements as below:

Messages shall be displayed using the central software and local terminal. The fault conditions shall be simulated. Messages/fault logs shall be checked for:

- a) LED FAULT
- b) Communication failure
- c) Power failure
- d) Brightness of Pixels.

816.11.6 Installation Requirements

The structure on which the VMS is mounted shall be sturdy and aesthetically looking and capable of bearing wind loads up to 200 kmph. The lowest hung part of the display board shall have vertical clearance of at least 5.5 m from the road level. It shall be provided with a walkway to allow at least six persons to carry out maintenance of the VMS without obstructing the carriageway.

816.12 Transmission System

816.12.1 General

The Transmission system provides connectivity between Control Centre and outdoor equipment such as Emergency Call Boxes, Variable Message Signs, Meteorological Data System, Video Cameras, Traffic Sensors, etc. The system shall comprise Cable System, Interface System and Optical Fibre Transmission System.

816.12.2 Cable System

The system shall comprise copper cable, Backbone Optical fibre cable (for connectivity between the sub-centers and main control centre) and auxiliary fibre optic cable for connectivity of the road side equipment to the sub-centre and Coaxial

cable. The cable system along with interface equipment shall work satisfactorily under adverse conditions like storm, etc. The Optical Fibre Cable system shall interconnect with the defined optical transmission sources and also if required with associated network devices for signal transmission without any impairment. A separate and independent (auxiliary) Optical Fibre Cable system shall be used for the transmission of video signals; data signals from the equipment locations to the sub-centers where copper cable has limitations for transmission of signal

All Optical Fibre Cable shall be of TEC (Govt. of India) approved design.

The Co-axial Cable System shall provide immediate interface to carry signals from CCTV/ VIDS Cameras located at strategic locations to the nearest sub centre. Optical Fibre Cable shall also be used with transmitters and receivers if the distance is large and high quality signal transmission and reception is not possible using co-axial system. The signals shall, without any impairment, be routed to the Control Centre via the sub-centers using the auxiliary Optical Fibre cable.

816.12.3 Interface System

Interface System shall comprise Sensor interface equipment, Optical fibre cable interface equipment and Control Centre interface equipment. The Interface System shall cover the Copper Cable, Co-axial Cable and Optical Fibre Cable System and transmit and process the composite signals to achieve the desired reliability/availability requirement. The Interface sub-systems shall be capable of handling the composite audio, video and data signals at various interface levels and process them. The Interface sub-systems shall be designed optimally at/ various levels i.e. from the individual sub-systems level to integrator through Control Centre.

816.12.4 OFC Transmission System

The system shall comprise optical line terminals, Interface cards and network management. The Backbone Optical Fibre Cable System shall interconnect the sub-centre/integrators and the Control Centre. The Optical Fibre Cable system shall interconnect with the defined optical transmission sources and also if required with associated network devices for signal transmission without any impairment. The backbone communication of Cable system shall be used only to interconnect the sub-centers to the main control centre. This cable shall be terminated only at the sub-centres and main control centre. It shall not be allowed to interface any other sub-systems in the field to this cable or any spare cores in the cable directly or through branching. A separate and independent (auxiliary) Optical Fibre Cable system shall be used for the transmission of video signals, data signals from the equipment locations to the sub-centers where copper cable has limitations for transmission of signals. This would be finalized during approval of detailed design by the successful bidder. All Optical Fibre Cable shall be of TEC (Govt. of India) approved design.

816.12.5 Power Supply System

The Power Supply System shall support the requirements of individual sub-systems. The Power Supply System proposed for individual sub-systems shall take into account the overall availability/reliability requirements. The Power Supply System design shall take into consideration local power availability, temperature and other climatic variations, and easy maintainability. A 230 VAC, 50 Hz single phase power supply shall be used. The equipment components shall have adequate surge and lightning protection.

816.13 Meteorological Data System

816.13.1 General

The Meteorological Data System shall consist of wind sensors for monitoring wind speed and direction, visibility sensors for detection of visibility changes resulting from fog or dust storm, atmospheric sensors to measure air temperature and humidity and road condition sensor to read road surface temperature. The system configuration shall therefore comprise thermocouple/dynamometer, humidity meter, anemometer and visibility meter.

816.13.2. Technical Requirements

The Meteorological Data System shall communicate the measurement to the Control Center. It shall be compact, rugged in design and having ease of maintenance and shall be capable of detecting and keeping track of the surface temperature of the Highway surface and initiate appropriate alarms at the Control Centre.

The Met Sensor shall meet following requirements

Relative Humidity Sensor

Range	-	1100%
Minimum Accuracy	-	±2% RH
Resolution	-	0.1%
Temperature Range	-	5°C to +60°C
Sensor Mechanism	-	The sensor shall be adequately protected against dust/pollution and shall provide a linear output voltage for 0-100% humidity

Air Temperature Sensor

Range	-	30°C to +70°C
Sensing Element	-	should provide a linear output for the entire range of temperature
Resolution	-	0.1% of range
Accuracy	-	±0.3% of range
Visibility Sensor Range	-	50 to 1500 m
Wave length	-	880 mm
Sensor Type	-	Infrared sensor, source and detector
Accuracy	-	±15%

Wind Direction Sensor- Less than 0.3 m/s Threshold Speed

Accuracy	-	Better than ±5%
Damping ratio	-	0.7
Wind Seed Sensor Range	-	Up to 79 m/s
Threshold Speed	-	Less than 0.3 m/s
Accuracy	-	±2%
Output Signals	-	Average Wind/Average Gust

Road Condition Sensor

Temperature Sensor Range	-	-100c to +60°C
Resolution	-	0.1°C
Wet/Dry Sensor Output	-	ON/OFF

816.13.3 Data Acquisition Controller

The Data Acquisition Controller shall meet the following requirements:

- i) Be suitable for all the supplied sensors,
- ii) Have appropriate number and type of inputs in order to service all the sensors,
- iii) Incorporate an LCD display to allow local monitoring of the data,
- iv) Have a memory backup (up to 7 days) to retain data locally in case of communication failure.

816.14 Automatic Traffic Counter-cum-Classifier

816.14.1 General

This system shall be provided for identifying and recording all types of vehicles on the highway for effective monitoring and data collection at Control Centre. Besides, the system shall be capable of classifying any other vehicle category as per user needs. Vehicle classification should be user selectable based on length of vehicle and/or detuning of the loop inductivity. The system shall be robust and be capable of operating with minimum maintenance. The system shall interface with the ATMS/ATMS Software for central monitoring. The indicative classification of common vehicles in India, based on wheel base, is as given below.

	Type of Vehicle	Probable Range of Wheel Base (mm)
1)	Two Wheelers (Motorised) Scooters, Mopeds, Motor Cycle	0-1350
2)	Three Wheelers (Auto/Tempo)	1400-1800
3)	Four Wheelers Cars, jeeps, vans etc.	1801-2675
4)	Light Motor Vehicles	2690-3400
5)	Trucks/Buses	3401-5600
6)	MultiAxle Vehicles	5000-18000

Vehicle Classification should be user selectable based on length of vehicle and number of axles. The system shall have the capability of accommodating multiple installations through installation of detector /sensors which can be left permanently in place and connected as required to the recording device when traffic counts are made at that particular location. It shall also be capable of taking inputs from portable sensors and should be modular in design. The system shall have capability of interfacing with the integrators for central monitoring. It shall have suitable interface for transmitting information from ATCC System to the Control Centre.

816.14.2 Technical Requirements

816.14.2.1 Sensors

The sensors should be a combination of piezo-electric sensors and inductive loops, enabling counting/classification of up to 4-lane traffic (expandable to atleast 6-lane traffic) with user set time periods.

816.14.2.2 Electronics

Vehicle counting/classification interval shall be programmable from one minute to 1440 minutes (24 hours) and system should accept user programmable recording intervals to count and classify during a 24 hour period. The system should be able to count and classify vehicle by each lane.

816.14.2.3 Data Collection

The system shall be capable of sending data to the ATMS/ATMS Software which shall enable the ATMS/ATMS Software to classify the vehicles, detect average speed per lane, vehicle occupancy and headway as a minimum. Data collection shall be by RS232, RS422 or RS485 interface or IP connection. The system shall be capable of recording, for later analysis, on an individual vehicle basis, time/date, speed, direction." Number of axles axle spacing, and site identification. .

816.14.2.4 Data Storage

The system should be able to record and store vehicle data for a period of at least two weeks with daily traffic volumes of up to 10,000 vehicles.

816.14.2.5 Operating Language

English

816.14.2.6 System Accuracy

The accuracy of the system in recording speeds and headways/gaps shall as per Table 800-15.

816.14.2.7 Data Retrieval

The system should have the capability of data retrieval, direct data transfer through a serial link to computer, Leased line/GSM/CDMA.

816.14.2.8 Software

Software and manuals to analyze the data from output of vehicle counts, classification speeds and headways shall be provided. Capability of graphic/tabular presentation of analyzed data shall also be offered.

Table 800-15: System Accuracy Requirements

Parameter	Accuracy	Conditions
Average Speed	10 percent	There are at least 25 vehicles in the group, individual vehicle speeds are between 10 kmph and 195 kmph and the vehicles conform to normal highway driving behaviour.
Average Headway	10 percent	There are at least 25 vehicles in the group, individual vehicle speeds are between 10 kmph and 195 kmph, individual vehicle head-ways are between 1 and 10 seconds and the vehicles conform to normal highway driving behaviour.
Flows	5 percent	There are at least 100 vehicles of each category in group and vehicles conform to normal highway driving behaviour.
Occupancy	10 percent	There are at least 25 vehicles in the group, individual vehicle speeds are between 10 kmph and 195 kmph, individual vehicle headways are between 1 and 10 seconds and the vehicles conform to normal highway driving behaviour.

816.14.2.9 Mode of Operation

This will be user programmable up to at least 12 speed and 15 vehicle class bins, of vehicles operating in India (user specified). System capability in this regard may be indicated. Counter shall also bin simultaneously in speed, axle and count or any combination of the three,

816.14.2.10 Capability

The system shall have capability of recording vehicle counting and classification, speed, headway at set interval of 1-10 minutes.

816.15 Video Surveillance System**816.15.1 General**

The System shall be provided to monitor the movement of vehicles on the highway. System configuration shall comprise video camera, video camera housing, pan and tilt heads, optical transmission units for video and data (if required) and mounting poles at camera locations. The Control centre configuration shall comprise monitors for individual cameras, matrix switcher, multiplexer and digital video recorder with suitable interface for the integrated highway package and optical interface units to the backbone communication system wherever required (where the video and data cannot be transported from camera location to the Sub-centre on co-axial cable). The Video Camera location shall be easily identifiable. The Video Camera shall be of dome type to avoid pilferage, be resistant to vandalism and weather-proof. The mounting and equipment housing shall be able to withstand adverse weather conditions and the Video Camera shall be capable of working satisfactorily under worst weather conditions. The Video Camera and associated units shall be water ingress and dust proof. The Video Camera mounting shall have easy accessibility for maintenance purposes.

816.15.2 Technical Requirements

816.15.2.1 The Video Camera shall meet the following minimum technical as requirements:

- | | | |
|--------------------------|---|--|
| a) Image Sensor | - | ¼ CCQ with 22 X optical zoom |
| b) Active Pixels | - | 7 2(H)x582(V) |
| c) Horizontal Resolution | - | Minimum 470 lines |
| d) Sensitivity | - | 0.02 lux@ 1/1.5 Second shutter speed |
| e) Focus | - | Automatic (with manual override/preset facility) |
| f) Signal to Noise | - | >50 dB |
| g) AGC | - | Automatic with manual override |
| h) White Balance | - | Automatic with manual override |
| i) Auto Shutter | - | Yes |
| j) Signal Format | - | NTSC/PAL |

816.15.2.2 The video camera shall have angular travel as below:

- | | | |
|---------------|---|---------------------|
| Horizontal | - | 360° continuous pan |
| Vertical Tilt | - | +2°.tO -92° |

The Video Camera shall have speed as below:

Manual Speed

- | | | |
|------|---|---------------------------------|
| Pan | - | 1/10° to 80°/second {Variable} |
| Tilt | - | 1/10°. to 40°/second {Variable} |

Preset Speed

- | | | |
|------|---|-------------|
| Pan | - | 250°/second |
| Tilt | - | 200°/second |

816.15.2.3 The dome drive shall have 40 presets with labels and shall have an accuracy of +/- 0.25° preset accuracy. It shall have built-in protection against power Line Surge and Lightning and provision for Onscreen-compass and Tilt display, integral, auto sensing multi- protocol receiver/drive and provision for Auto-flip dome rotation. There shall be programmable limit stops for Auto/random/frame scan modes. The Video Camera shall be connected to the control centre/sub-centre through co-axial cable• and data cable/optical fibre cable as per the site requirement and shall have remotely selectable operating modes and shall be operated from the Control Centre. The video images from camera shall be transmitted in real time. The video image shall be made available at the control centre without any distortion or / loss of information. The video camera system shall have the .facility for zone blanking, auto identification of zones when the pan movement of camera is active and infra-red compatibility for night operation.

816.16 Video Incident Detection System

816.16.1 The system shall be an intelligent image detection system using CCTV cameras. The cameras shall have inbuilt intelligence to ascertain when the image has meaningfully deviated from the Standard Image originally recorded. On sensing the incident, the system shall automatically start recording the image at the control centre.

816.16.2 The Incident Detection system shall capable of the following:

- a) Measurement of traffic flow speed between 0 and 150 km/hr for up to 6-lanes
- b) Detection of vehicles driving in wrong direction
- c) Automatic detection of 5 types of traffic flow: normal, dense, delayed, congested, and stop and go
- d) Detection of stopped vehicles, within 10 sees and for up to 16 detection zones.
- e) Monitor Zone occupancy of the detection area
- f) Detection of deceleration g) Detection of fog/smoke

816.16.3 Alarms for following events:

- a) Queue
- b) Stop
- c) Inverse direction
- d) Speed drop
- e) Fog/smoke
- f) No video signal
- g) Error

816.17 Control Centre

816.17.1 General

The Control Centre shall accommodate following equipment and software :

- i) Central Computer Server (with integrated ATMS/ATMS Software)
- ii) Emergency call management system equipment and software
- iii) CCTV Console and other Equipment
- iv) Mobile radio operator and configuration equipment and software
- v) Video incident detection system console and other equipment
- vi) Backbone communication equipment and NMS for the same.
- vii) Large Display Board
- viii) Printer
- ix) Uninterrupted Power Supply with supply system and back up
- x) Power supply equipment.

816.17.2 Emergency Call Management

Emergency Call Management system located at the Control Centre shall carry out the following functions:

- i) Attend to incoming calls from ECB's using a PC based console, and navigate the highway section under supervision using graphical representation of the network which shall be displayed on the PC monitor.
- ii) Provide audible and visual alert on the screen for any incoming calls from the Emergency call boxes. Colour of the icon representing the Call boxes on the

- graphical map shall change indicating the states of call box (phone) healthy, call box (phone) faulty, incoming call, conversation in progress and call on hold.
- iii) Provide for call waiting signal to the ECB and put the call on queue in case of several calls at the same time.
 - iv) Create log and record all conversations from and to the Control Centre from the ECBs.
 - v) Further the system shall automatically check periodically (the interval of which shall be operator selectable) the health of phones and generate an audio visual alarm in case of faults.
 - vi) The system shall generate a unique call number for each and every call and allow the operator to provide annotation.
 - vii) There shall be one Emergency Call Manager's terminal easily expandable to more operator stations by connecting more operator terminals.
 - viii) Holding of any call by the operator.
 - ix) Terminating any call by the operator.
 - x) Seamless configuration on addition/deletion of ECBs on the network.
 - xi) Database generation, display on the monitor and logging of all parameters of call progress.
 - xii) Recording of communication between the operator and road users.
 - xiii) Audio visual alarm in case of vandalism.
 - xiv) Audio visual alert in case of operation by handicapped.

816.17.3 Integrated ATMS Software

The ATMS software shall manage the following on a single server platform:

- a) Emergency Communication System
- b) Variable Message Signs System
- c) Meteorological Data System
- d) Automatic Traffic Counter cum Classifier System
- e) Video incident Detection System
- f) CCTV Surveillance System.

816.17.4 System Architecture

816.17.4.1 Hardware for Central Server

The system shall run on a powerful dual-processor server with RAID facilities to provide continuity of hard disk 'storage. Storage capacity should be large and comfortably sufficient to cater for the demands of a modern traffic management system. The system shall have client-server architecture so that multiple users may access the system simultaneously.

Minimum hardware specification shall be as follows:

- a) Server from reputed company
- b) Dual Core 2.2 GHz Processor or Higher
- c) Hard Disc: 5* 146 (RAID 5 Support)
- d) 4Gb RAM or higher
- e) Operating system: Industry standard
- f) The database: Industry standard
- g) Tape drive for backup/archive
- h) Facility for remote diagnosis and support.

816.17.4.2

Hardware for Work Stations/Operator Console

The workstations shall have the following specifications:

- a) Pentium IV 2.0 GHz b) 512Mb RAM
- c) 80GB; Hard Drive d) 19" TFT monitor

816.17.5

System Software

The System software shall run on industry standard Server platform incorporating either MS Windows or Linux operating system in a client server mode. All the above subsystems shall be displayed and managed by the Supervisor which will show the status of all the above subsystems simultaneously as graphic symbols/icons. The graphic operator interface shall be menu driven for ease of operation. The operator shall be able to configure, set values, commands, perform database operations, reports, archive using these menus. The Integrated ATMS software shall monitor and record online all data from ATCC, Met Sensors, VMS, Traffic control system, CCTV, VIDS and ECBs. It shall be possible to configure the sub- systems as well as add/delete components of the system such as ECB, VMS, MET sensor, ATCC, VIOS, and CCTV in the ATMS software online seamlessly.

The Integrated ATMS Software shall also have following features:

- i) The system server shall be configured so as to minimize the risk of data loss in the event of system failure of power loss. It shall support client terminals operating on a LAN, WAN or remote connection. Access to the database and client terminals shall be username and password controlled. Access level shall be determined by the system supervisor and shall range from "read only" to full edit/supervisor rights. The system shall not bypass/violate access rights setup on slave systems. It shall not be possible to send shut down or "Kill" commands from the database management system.
- ii) For system monitoring it shall be possible to configure a view only user with access to the map and embedded/linked data only. Such a terminal could be used by police, highway engineers, emergency services, etc. It shall be possible to relay urgent faults / incidents / System alarms (supervisor configurable) to remote operators/staff via an SMS message for any requirements in future.
- iii) The system shall have proven and modular Web interfaces. It should be possible to integrate the same if required in future for providing highway information such as (CTV images, traffic flow, journey time, etc., to the general public via internet web pages.
- iv) The system shall have proven and modular interfaces to automatic license plate recognition system. It shall be possible to integrate the same in future if required.

816.17.6

System Functions

816.17.6.1

Sub-system Monitoring and Control

The System software shall monitor and control ATMS sub-systems as below:

- i) It shall monitor and record online all data from Meteorological Data System installed on the highway. The data shall be updated every five minutes.
- ii) It shall monitor and record online all data from the ATCC. The system shall provide the user with the information/display of traffic flow conditions on the MAP. The data shall be updated every one minute.
- iii) It shall monitor health of the Emergency telephones on a continuous basis.
- iv) It shall monitor and control the variable message signs. The operator shall be able to generate new messages for signs. The system shall react intelligently and automatically to the highway conditions and set up suitable messages on

the VMS. It shall also be possible to schedule the pre-defined messages to be displayed on the VMS. The display period shall be operator selectable. The priorities of the messages shall also be operator selectable.

- v) The System software shall provide information regarding incidents (VIDS) and store/archive them for future use.
- vi) The system shall interface with intelligent traffic control systems for traffic control and monitoring specially at interchanges and access points.
- vii) The system shall interface to CCTV system to select cameras for display and control of images.
- viii) The system shall process above referred data acquired through above system for decision taking, display information on respective VDU monitors and central Large Display Board.
- ix) Provide continuously clear and comprehensive displays and print log of events.
- x) Access to historical data files of ATMS.
- xi) Execution of operator commands with access code security.
- xii) Generation of reports at specified times (operator selectable)
- xiii) System timekeeping.
- xiv) Connectivity and data transfer to other control centers if required

816.17.6.2 Graphic User Interface (GUI)

The GUI for the system shall be map based and menu driven. The changes commands/ menu shall be simple to be executed by the operator. There shall be a screen depicting the map of the highway along with other equipment installed on the route. The highway map shall be capable of displaying an overview level showing the whole area covered by the system. It shall then be possible with no loss of definition, to zoom to a detailed map. It shall be possible to display both static and dynamic data on the Map. Two level of mapping shall be supported as a minimum:

- 1) Highway Overview.
- 2) Highway section wise detailed view.

Icons shall be placed on the map to identify different equipment types. Both shall be automatically tagged with grid reference data to allow them to appear in the correct relative positions at both levels of map. Positioning the mouse pointer over an icon or poly-line shall display the corresponding equipment status information.

For poly-lines representing route data, the user shall be able to configure a number of thresholds for the different data types available. An example would be congestion for links where up to X% percentage thresholds can be defined. Each threshold shall be represented by a distinct colour or changed shapes. The map shall use this scheme to display the poly- lines based on comparisons with the current real-time data.

The user shall have the ability to configure the map view to display the data layers of choice; for example to show Met Sensor only or ATCC together with current incidents.

It shall be possible for the operator to place icons or "active" symbols on the map to represent

- a) Access control/ramp metering system
- b) Traffic control system
- c) Variable Message signs
- d) CCTV cameras
- e) Incidents such as Accident, Roadworks, Event, Diversion, Breakdown and Road closure
- f) Strategy
- g) Weather station data
- h) Flow, speed classification information
- i) User defined fields

Icons will be either active or non-active. Active icons will link to the associated system and show their current status change of state (colour or flash) and by displaying detailed information triggered user action.

816.17.7 Database Management

The database used by the ATMS software shall be an industry standard database like

ORACLE, SQL, dbase etc. The system shall have facility to perform certain selected database operations only by authorized users.

816.17.7.1 Data Presentation and Storage

The presentation of data shall reflect the use of the system as a real time tool for the operator to monitor and control the highway. It shall be possible to present current data (day) in comparison with profile data or date comparison (same day last year). It shall be possible to create predictive traffic data and trends. The data shall be stored in the system in a format to present weekly and monthly average for congestion and summary flow for weeks and months. The system shall store at least 12 months of data. Older data may be archived. However, the system shall provide tools for the retrieval, manipulation and presentation of data. Data store shall be clearly marked with an indicator to show day or period type e.g. normal, holiday, weekly off; by reference to the system calendar. It shall be possible to export data to an external system for further analysis. Transfer shall be available in .xls, csv or any standard formats. It shall be possible to display data or combinations of data in graphical manner and to print graphs, e.g., Graphs of current, profile, historic, and combinations for

- a) Flow
- b) Occupancy
- c) Congestion

816.17.7.2 Archive and Restore

This facility shall allow the archiving of the database to a tape/External HD/DVD. The data archived shall then be deleted from the database. Data may only be archived when it is more than two years old. Only one archive request may be outstanding at a time. Once archived, part or all of the data may be restored by copying from the tape back onto the system, where it remains for 30 days. Only one restore request may be outstanding at a time.

It shall be possible to define a series of notification levels which will raise an alarm when the disk space reaches a specified limit. This is used to alert an operator to the need to archive data.

816.17.7.3 Database Back-up

The system management procedures for producing daily and weekly back-ups shall not need any operator intervention.

816.17.7.4 Reports

The system shall have detailed reports for:

- a) Status reports for the sub-systems (alarms, faults etc.)
- b) Detailed traffic reports-speed, count, occupancy etc.
- c) Detailed weather report for all variables from weather sensor
- d) Detailed report of emergency call.

816.17.7.5 Timetable and Calendar

The system shall have a time Table facility. The time table shall allow commands by day of the week, time of day, day type, The system calendar shall allow days to be marked as normal, holiday, weekly off, etc.

816.17.7.6 System Log

The system shall retain a log of all events, alarms, timetable actions, and operator actions (together with operator username). In addition to system generated events the operators shall have facilities to enter events or incidents into the log. It shall be possible to search the log by time/date, event type, operator user name, strategy, location.

The log facility shall provide the means to:

- a) Record all important events that occur in the operation of the integrated highway management system, both manual and automatic View and manage the status of alarm events,
- b) Collect and collate incident information from both manual and automatic sources,
- c) Allow the user to record routine operational messages,
- d) View all changes and actions taken on the ATMS,
- e) Record and view useful contact names and other details.

816.17.7.7 Asset Management

- a) The system shall incorporate a facility to store records of assets for ATMS.
- b) The asset register shall store data relating to location, type, and number of equipments as well as electricity ratings.

816.17.7.8 User Management

This facility shall provide the means to make user access to ATMS secure. Only the system administrator(s) shall have access to this facility and will set up details for other users. Each user shall have a username that needs to be configured so that it matches a PC log-in. Hence logging on to the PC will automatically mean that access to ATMS is available for the chosen users. Each user can also be configured to have access to none, some or all of the ATMS facilities.

816.17.8 Operator Interface and Control

816.17.8.1 Fault and Alarm Management

Fault and Alarm Monitoring (FAM) for ATMS shall have following features:

- a) The FAM system shall be provided with the capabilities to monitor system alarm status on a real-time basis.
- b) The FAM system shall have the ability to store alarms in the database for future enquiries, and to access the fault alarm history database for retrieval of alarm data in the alarm history memory.
- c) All ATMS controlled equipment as well as VMS display boards shall be provided with fault monitoring and reporting to the FAM system.

816.17.8.2 Alarm Handling

- a) The following alarm conditions shall be provided to the FAM system as a minimum:
 - i) Loss of communication link
 - ii) Loss of the entire ATMS facilities at a location
 - iii) Loss of interface link with the ECB
 - iv) Alarm from MET Sensor-Air Temperature, Visibility, Humidity, Road Surface temperature, Road Surface wet/dry, Wind Speed, wind direction etc.
 - v) VMS Faults e.g. Communication Fault, LED Fault, Data parity fault, Power supply fault, Protocol polling fault to I/O Device, etc.
 - vi) ATCC faults e.g. Sensor fault, communication link-failure etc.
 - vii) CCTV faults
 - viii) Traffic control system faults-Lamp LED Fault, Sensor fault, communication link failure, etc. ix) Power supply unit failure
 - x) Automatic Message priority conflict.
- b) All failure alarms shall be stamped with time and date.
- c) All failure alarms shall remain on the active alarm display list until they have been acknowledged by the operator on the FAM system via the management workstation.
- d) All alarms removed from the active alarm display list shall automatically be inserted into the alarm history database when they occur.
- e) The alarm history database shall be provided with sufficient storage capacity to store the anticipated alarms for a period of at least four weeks without carrying out any housekeeping function.

816.17.8.3 Alarm Displays

- a) Alarms shall be displayed on the workstation via a detailed full screen alarm browser application.
- b) The alarm Display shall provide as a minimum the following general capabilities and characteristics for the ABA for alarm display list and alarm history:
 - i) A colour coding scheme indicating the alarm severity according to the alarm classifications.
 - ii) The display of the alarms with their associated time stamps.
 - iii) Scrolling capabilities to enable the operator to view more alarms that can be displayed on one single screen.
 - iv) The facilities to acknowledge alarms.
 - v) The facilities to clear alarms from the display.

816.17.8.4 Fault Diagnostics

The faultdiagnostics system shall perform the following diagnostics features as a minimum.

- i) Detect the alarm conditions as listed in Clause 815.17.7.2.
- ii) All fault status information and associated equipment test results shall be presented to the workstation immediately after the alarms are triggered.

816.17.8.5 Failure Modes

When power is restored following a power failure to the system, the system shall perform all necessary self-testing processes and then resume functioning fully in the same configuration as before the shutdown. This shall be completed automatically within 5 minutes of power restoration.

816.17.9 Back Bone Communication System

The backbone communication system shall connect the sub-centers with the Control Centre. The auxiliary Optical Fibre communication system shall provide connectivity for peripheral systems like ATCC, CCTV, mobile radio, emergency call management system, VIOS, Traffic Control System, Mobile Radio and LAN interface for Tolling Systems to the Control Centre. There shall be a node for the backbone communication system at every sub-centre and the Control Centre. The network management system (NMS) shall be located at main control centre. It shall however be possible to connect the NMS at any sub-center location which houses a communication node. The NMS shall be installed on a PC.

816.17.10 Large Display Board

816.17.10.1 Functions

- a) The device shall be used for monitoring the traffic through CCTV/ VIDS to display the ATMS Graphical User Interface (GUI). The large display board shall be displayed on the wall of the Control Centre. The Application software shall consist of a built-in• module for display board.
- b) It shall be possible to create customized data acquisition screen and drag icons by simple click of the mouse.
- c) It shall be possible to create backgrounds using scanned photographs, maps one-line diagrams, engineering drawings, etc., using popular graphic or engineering applications.
- d) It shall be possible to create new process diagrams that represent various sections of the highway at different levels of levels of details using the package.

816.17.10.2 Equipment

The Large Display Board shall be highly reliable for installation and round the clock operation in the Control Centre. The Display Board shall be driven by the Central Computer using the main console. The design of the Display Board system shall be modular and expandable. The Display Board shall use high gain trans-reflective LCDs for ambient indoors. The Board shall meet the following specifications:

i)	Overall board size	Length minimum 3000 mm Height minimum 1200 mm
ii)	Display	Graphic
iii)	Contrast Ratio	minimum 1000:1
iv)	Housing	Structure coated housing with IP54 protection casing against dust, sprayed water
vii)	Interface Standard	RS 422, RS 485 (Ethernet compatible)
viii)	Special Features	Automatic diagnostics and failure reporting

816.17.11 Uninterrupted Power Supply

816.17.11.1 Functions

The uninterrupted power supply shall be installed at the Control Centre for providing clean uninterrupted power supply to all the operational Equipment at the centre. The uninterrupted power supply shall be capable of providing full load for the operational equipment for a minimum period of 60 minutes. The Control Centre shall be powered from 230V AC from the State Electricity Board (SEB) supply. Any loss of AC power to the Control Centre from the SEB shall not cause loss of any data on the computers or any resetting of system parameters. The following requirements will be met:

Features

Rating	To meet the load requirement
Input Voltage	230 V AC (+10% to -15%)
Input Frequency	50 HZ \pm 10%
Inverter Type	High frequency switching sinusoidal multiple. Pulse
Output Voltage	230V
Output Frequency	Free running 50 Hz \pm 0.1% Tracking bypass \pm 2%
Output Voltage Waveform	Sinusoidal
Output Voltage Regulation	Better than \pm 1% for simultaneous variation of no. to full load and input Voltage to any extremes. \pm
Total harmonic distortion	<5%
Inverter efficiency	>87%
Transmit Response	for 100% step load Dip-Typical 5% max. <8% Peak-Typical 5% max. <8% Recovery to normal up to 60 msec. i.e. 3 cycles.
Overload capacity	125% for 10 msec. 800% on static bypass for 10 msec.
Audible indication	<55 dBA at 1 meter distance for

- i) Mains OK
- ii) Inverter OK
- iii) Overload
- iv) On battery
- v) Low battery
- vi) Inverter trip

Four extra LED indications shall be available with automatic bi-directional static switch for

- i) By pass OK
- ii) Load on inverter
- iii) Load on By Pass
- iv) By Pass frequency out of range
- v) Metering for voltage, frequency and current
- vi) Battery capacity required for minimum 1-hour back up at full load.

816.18 Warranty

The Contractor/Supplier of the Advanced Traffic Management Systems (ATMS) shall furnish the Warranty/Guarantee for successful commissioning and operation of ATMS for a minimum period of 5 years. He shall also furnish the certificate that there is no proprietary item and that the Systems shall be interoperable. All components and equipments shall be tested for commissioning. The documents with regard to design, technical details, installation details, testing and commissioning, details of fault diagnostics, operation and maintenance manuals and reports shall be submitted to the Engineer by the Contractor/Supplier.

816.19 Payment

The payment shall be made for design, configuration, installation and commissioning the ATMS, as complete job on the identified stretch of highway, as specified in the Contract or as per directions of the Engineer.

900

For Quality control for Road works

901. GENERAL

- 901.1.** All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirements of these specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out all required tests and Quality Control work piper Specifications and/or as directed by the Engineer. The internal layout of the laboratory shall be as per Clause 121 and/or as directed by the Engineer. The list of equipment and the facilities to be provided shall be got approved from the Engineer in advance.
- 901.2.** The Contractor's laboratory should be manned by a qualified Materials Engineer/Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.
- 901.3.** The Contractor shall carry out quality control tests on the materials and work to the frequency stipulated in subsequent paragraphs. In me absence of clear indications about method and or frequency of tests for any item, the instructions of the Engineer shall be followed.
- 901.4.** For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer (by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth here in under. Additional tests may also, fee conducted where, in the opinion of the Engineer, need for such tests exists.
- 901.5.** The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests required by the Engineer from time to time. This may include provision of labour, attendants, assistance in packing and despatching and any other assistance considered necessary in connection with the tests.
- 901.6.** For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall lie done after obtaining permission from the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.
- 901.7.** The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer during inspection. Works falling short of quality shall be rectified/redone by the Contractor at Ws own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.
- 901.8.** The cost of laboratory building including services, essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same. If, however, there is a sep; rate item in the Bill of Quantities for setting up of a laboratory and installing testing equipment, such work shall be paid for separately.
- 901.9.** For testing of samples of soils/soil mixes, granular materials, and mixes, bituminous materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied to the Engineer by the Contractor at his own cost.
- 901.10.** For cement, bitumen, mild steel, and similar other materials where essential tests are to be carried out at the manufacturer's plants or at laboratories other than the site laboratory,

the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also” furnish the test certificates to the Engineer.

901.11. For testing of cement concrete at site during construction, arrangements for supply of samples, sampling, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests specified in the Handbook of Quality Control for Construction of Roads and Runways (IRC :SP 11) and relevant IS Codes or relevant clauses of these Specifications, the cost of which shall be borne by the Contractor.

901.12. The method of sampling and testing of materials shall be as required by the “Handbook of Quality Control for Construction of Roads and Runways” (IRC : SP: 11), and these MOST Specifications. Where they are contradicting, the provision in these Specifications shall be followed, Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor.

901.13. The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period. Similarly, the supply of aggregates for construction of road pavement shall be from quarries approved by the Engineer. Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

901.14. Defective Materials

All materials which the Engineer/his representative has determined as not conforming to the requirements of the Contract shall be rejected whether in place or not; they shall be removed immediately from the site as directed. Materials, which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any order of the Engineer/his representative, given under this Clause, the Engineer/his representative shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

901.15. Imported Materials

At the time of submission of tenders, the Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor’s responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/ finished products are not covered by the Specifications in the Contract, the details of Specifications proposed to be followed and the testing procedure as well as laboratories/ establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified to the lot of materials shall be furnished at the Contractor’s cost.

902. CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

902.1. General

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after:

902.2. Horizontal Alignment

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 10 mm there from. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 25 mm.

902.3. Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 900-1.

TABLE 900-T. TOLERANCES IN SURFACE LEVELS

1)	Subgrade	±20mm
2)	Sub-base a) Flexible pavement b) Concrete pavement	±10mm ±6mm
3)	Base-course for flexible pavement a). Bituminous Base/Binder course b) Granular i) Machine laid ii) Manually laid	±6mm ±10mm ±15mm
4)	Wearing course for flexible pavement a) Machine laid b) Manually laid	±6mm ±10mm
5)	Cement concrete pavement	±5mm

* This may not exceed - 8 mm at 0 - 30 cm from the edges.

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than 6mm for flexible pavements and 5 mm for concrete pavements.

For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of the surface levels shall be taken on , a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the. compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

902.4. Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straight-edge as desired by the Engineer at the middle of each traffic lane along a line parallel to the centre line of the road.

The maximum permitted number of surface irregularities shall be as per Table 900-2.

TABLE 900-2. MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES

	Surfaces of Carriageways and Paved Shoulders				Surfaces of Laybys, Service Areas and all Bituminous "Base Courses			
Irregularity	4mm		7mm		4mm		7mm	
Length (m)	300	75	300	75	300	75	300	75
Number of Surface Irregularities on National Highways/ Expressways*	15	9	2	1	40	18	4	2
Number of Surface Irregularities on Roads of lower Category*	40	18	4	2	60	27	6	3

•Category of each section of road as described in the Contract

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous and cement concrete)	3mm
for bituminous base courses	6mm
for granular sub-base/base courses	8mm
for sub-bases under concrete pavements	10mm
for subgrade	15mm

902.5. Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

- (i) **Subgrade:** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305.
- (ii) **Granular Sub-base:** Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401.
- (iii) **Lime/Cement Stabilized Soil Sub-base:** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.
For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm supplemented with freshly mixed materials as necessary and recompacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.
- (iv) **Water Bound Macadam/Wet Mix Macadam Sub-base/Base:** Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 404. This shall also apply to wet mix macadam to Clause 406.
- (v) **Bituminous Constructions:** For bituminous construction oilier than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat if needed and recompacting to specifications.

Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less than 3-5 m in width.

- (vi) **Dry Lean Concrete Sub-base/Rolled Cement Concrete:** The defective length of the course shall be removed to full depth and replaced with material conforming to Clauses 601 or 603, as applicable. The area treated shall be at least 3 m long, not less than 1 lane wide and extend to the full depth. Before relaying the course, the disturbed subgrade or layer below shall be corrected by levelling, watering and compacting.
- (vii) **Cement concrete pavement:** The defective areas having surface irregularity exceeding 3 mm but not greater than 6 mm may be rectified by bump cutting or scrubbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. If high areas in excess 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed at the Contractor's expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances shall be demolished and reconstructed at the Contractor's expense.

903. QUALITY CONTROL TESTS DURING CONSTRUCTION

903.1. General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the preceding Clauses.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

903.2. Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

903.2.1. Borrow material : Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out:

- (a) **Sand Content [IS: 2720 (Part-4)] :** 2 tests per 3000 cubic metres of soil.
- (b) **Plasticity Test [IS:2720 (Part-5)] :** Each type to be tested, 2 tests per 3000 cub. metres of soil.
- (c) **Density Test [IS:2720 (Part-8)]:** Each soil type to be tested. 2 tests per 3000 cubic metres of soil.
- (d) **Deleterious Content Test [IS:2720 (Part-27)] :** As and when required by the Engineer.
- (e) **Moisture Content Test [IS :2720 (Part-2)] :** One test for every 250 cubic metres

of soil.

- (f) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [IS : 2720 (Part-16)]: One CBR test for every 3000 cu. m. at least or closer as and when required by the Engineer.

903.2.2. Compaction Control: Control shall be exercised on each layer by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

$$\left[1.65 - \frac{1.65}{(No.ofSamples)^{0.5}} \right] \text{times the standard deviation}$$

However, for earthwork in shoulders (earthen) and in the subgrade, at least one density measurement shall be taken for every 500 square metres for the compacted area provided further that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

903.2.3. Cut formation : Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903.2.2.

903.3. Tests on Sub-bases and Bases (excluding bitumen bound bases)

The tests and their frequencies for the different types of bases and sub-bases shall be as given in Table 900-3. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2.2.

903.3.1. Acceptance criteria: The acceptance criteria for tests on the strength of cement/lime stabilised soil and distribution of stabiliser content shall be subject to the condition that the mean value is not less than the specified value plus:

$$\left[1.65 - \frac{1.65}{(No.ofSamples)^{0.5}} \right] \text{times the standard deviation}$$

TABLE 900-3. CONTROL TESTS AND THEIR MINIMUM FREQUENCY FOR SUB-BASES AND BASES (EXCLUDING BITUMEN BOUND BASES)

s. No.	Type of Construction	Test	Frequency (min.)
1)	Granular	i) Gradation ii) Atterberg limits iii) Moisture content prior to compaction iv) Density of compacted layer v) Deleterious constituents vi) CBR	One test per 400 cu.m One test per 400 cu.m One test per 400 cu.m One test per 1000 sq.m As required As required
2}	Lime/Cement	i) Quality of lime/ cement	One test for each consignment subject to a minimum of one test per 5 tonnes

s. No.	Type of Construction	Test	Frequency (min.)
	Stabilised Soil Sub-base	ii} Lime/Cement content iii} Degree of pulverization iv) CBR or Unconfined Compressive Strength test on a set of 3 specimens v} Moisture content prior to compaction vi} Density of compacted layer vii) Deleterious constituents	Regularly, through procedural checks Periodically as considered necessary As required One set of two tests per 500 sq.m One set of two tests per 500 sq.m As required
3)	Water Bound Macadam	i) Aggregate Impact Value ii) Grading of aggregate iii) Combined Flakiness and Elongation Indices iv) Atterberg limits of binding material v) Atterberg limits of screenings	One test per 1000 cu.m of aggregate One test per 250 cu.m One test per 500 cu.m of aggregate One test per 50 cu.m of binding material One test per 100 cu.m of aggregate
4)	Wet Mix Macadam	i) Aggregate Impact Value ii) Grading of aggregate iii) Combined Flakiness and Elongation Indices iv} Atterberg limits of portion of aggregate passing 425 micron sieve v) Density of compacted layer	One test per 1000 cu.m of aggregate One test per 200 cu.m of aggregate One test per 500 cu.m of aggregate One test per 200 cu.m of aggregate One set of three tests per 1000 sq.m

903.4. Tests on Bituminous Construction

903.4.1. Tests and frequency : The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4". The Engineer may direct additional testing as required.

903.4.2. Acceptance criteria : The acceptance criteria for tests on density and Marshall stability shall be subject to the condition that the mean value is not less than the specified value plus :

$$\left[1.65 - \frac{1.65}{(No.ofSamples)^{0.5}} \right] \text{times the standard deviation}$$

TABLE 900-4. CONTROL TESTS FOR BITUMINOUS WORKS AND THEIR MINIMUM FREQUENCY

Sr. No.	Type of Construction	Test	Frequency {min.}
1)	Prime Coat/Tack Coat/Fog Spray	i) Quality of binder ii) Binder temperature for application iii) Rate of spread of Binder	Number of samples per lot and tests as per IS:73, IS:217 and IS:8887 as applicable At regular close intervals
2)	Seal Coat/Surface Dressing	i) Quality of Binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value of aggregates (Immersion Tray Test) v) Water absorption of aggregate vi) Water sensitivity of mix vii) Grading of aggregate viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) ix) Polished stone value (not applicable for SAM/SAMD)	Same as mentioned under Serial No.1 One test per 200 cu.m of each source and whenever there is change in the quality of aggregate One test per 100 cu.m of aggregate for each source and whenever there is change in the quality of aggregate One test of each source and whenever there is change in the quality of aggregate -do- -do- Two tests per day One test for each source and whenever there is change in the quality of aggregate -do- At regular intervals
3)	Open-graded Premix Surfacing/Close-graded Premix Surfacing	i) Quality of binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value v) Water absorption of aggregates	i) Same as mentioned under Serial No. 1 ii) Same as mentioned under Serial No. 2 iii) Same as mentioned under Serial No. 2 iv) Same as mentioned under Serial No. 2

Sr. No.	Type of Construction	Test	Frequency {min.}
		viii) Soundness(Magnesium Sulphate and Sodium Sulphate) ix) Polished stone value x) Temperature of binder at application xi) Binder content xii) Percentage of fractured faces	viii) Same as mentioned under Serial No. 2 ix) Same as mentioned under Serial No. 2 At regular interval x) Two tests per day per plant xi) Same as mentioned under Serial No. 2
4)	Bituminous Macadam	i) Quality of binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value v) Water absorption of aggregates vi) Water Sensitivity of mix vii) Grading of aggregates viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) ix) Percentage of fractured faces x) Binder content xi) Control of temperature of binder and aggregate for mix and of the mix	i) Same as mentioned under Serial No. 1 ii) Same as mentioned under Serial No. 2 iii) One test per 350 cu.m for each source iv) Same as mentioned under Serial No. 2 v) Same as mentioned under Serial No. 2 vi) Same as mentioned under Serial No. 2 vii) Same as mentioned under Serial No. 2 viii) Same as mentioned under Serial No. 2 ix) Same as mentioned under Serial No. 2
5)	Dense Bituminous Macadam/Bituminous Concrete	i) Quality of binder ii) Aggregate Impact Value/ Los Angeles Abrasion Value iii) Flakiness and Elongation Indices iv) Soundness test (Sodium or Magnesium Sulphate test) v) Water absorption of aggregates	i) Number of samples per lot and tests as per IS:73 or IRC:SP:53, IS:15462 ii) One test per 350 cu.m of aggregate for each source and whenever there is change in the quality of aggregate iii) One test per 350 cu.m of aggregate for each source and whenever there is change in the quality of aggregate iv) One test for each source and whenever there is change in the quality of aggregate v) One test for each source and

Sr. No.	Type of Construction	Test	Frequency {min.}
		vi) Sand equivalent test vii) Plasticity Index viii) Polished stone value ix) Percentage of fractured face x) Mix grading xi) Stability and voids analysis of mix including theoretical maximum specific of loose mix xii) Moisture Susceptibility of mix (AASHTO T283) xiii) Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction xiv) Binder content	One test for each source and whenever there is change in the quality of aggregate One test for each source and whenever there is change in the quality of aggregate One test for each source and whenever there is change in the quality of aggregate .. One test per 350 cu.m of aggregate when crushed gravel is used One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to minimum of two tests per day per plant One test for each mix type whenever there is change in the quality or source of coarse or fine aggregate At regular intervals One set for each 400 tonnes of mix
6)	Sand Asphalt Base course	i) Quality of binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Sand equivalent test iv) Plasticity Index v) Mix grading & binder content vi) Stability of Mix vii) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 5 Same as mentioned under Serial Nos. 2 and 3 Same as mentioned under Serial No. 5 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 5 Same as mentioned under Serial No. 5

Sr. No.	Type of Construction	Test	Frequency {min.}
7)	Slurry seal and Micro surfacing	i) Quality of Aggregate Sand Equivalent Value Water Absorption Soundness Test {Sodium/ Magnesium Sulphate Test) ii) Quality of Emulsion iii) Aggregate Moisture iv) Aggregate Gradation v) Binder Content vi) Calibration of Machine	One per source/ site One per lot of 20 t as per IS:8887 Two per day Two per day at site Two per lane per Km Once per
8)	Stone Matrix Asphalt	i) Quality of binder ii) Aggregate Impact Value/ Los Angeles Abrasion Value iii) Flakiness and Elongation Indices iv) Soundness Test (Sodium and Magnesium Sulphate Test) v) Water absorption of aggregate vi) Sand equivalent test vii) Plasticity Index viii) Polished stone value ix) Percent of fractured faces x) Mix grading xi) Air voids and VMA analysis of mix including theoretical maximum specific gravity of loose mix	Number of samples per lot and tests as per 15:73 or IRC:SP:53, IS:15462 One test per 100 cu.m of aggregate One test per 100 cu.m of aggregate One test for each method for each source and whenever there is change in the quality of aggregate One test for each source and whenever there is change in the quality of aggregate One test for each source One test for each source One test for each source One test per 50 cu.m of aggregate when crushed gravel is used One set for individual constituent and mixed aggregate from dryer for each 4.00 tonnes of mix subject to minimum of two tests per day per plant Three tests per day
		(xiv) Binder content (xv) Rate of spread of mix material (xvi) Density of compacted layer	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant After every 5 ^l truck load h

Sr. No.	Type of Construction	Test	Frequency {min.}
9)	Mastic asphalt	i) Quality of binder ii) Aggregate Impact Value and Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value v) Water Sensitivity of mix vi) Grading of aggregates vii) Water absorption of aggregates viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) ix) Percentage of fractured faces x) Binder content and aggregate	i) Same as mentioned under Serial No. 5 ii) Same as mentioned under Serial No. 5 iii) Same as mentioned under Serial No. 5 iv) Same as mentioned under Serial No. 2 v) Same as mentioned under Serial No. 5 vi) Two tests per day per plant on the individual constituent and mixed aggregates from the dryer vii) Same as mentioned under Serial No. 5 viii) Same as mentioned under Serial No. 5 ix) Same as mentioned under Serial No. 5
10)	Recycled Material Grading of aggregate		Two tests per day
11)	Cold Mixes		All tests as per S. No.5
12)	Quality of Modified Binder		Number of samples per lot and tests as per IS:15462
13)	Geotextiles		The requirements of Section 700 shall apply

Note: Daily, weekly, monthly reports on test results shall be prepared indicating the location of sampling and testing, deviation from the specified values for materials and works and remedial action taken in respect of removal of defective work shall certified be prepared by the Contractor. The test record shall be certified by the Engineer that these tests were done in his presence and testing carried as per prescribed methodology.

903.5. Quality Control Tests for Concrete Road Construction

903.5.1. Dry lean concrete sub-base :

903.5.1.1. Sampling and testing of cubes: Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 sq.m. or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 sq.mm. The compaction shall be uniformly applied for 60 ± 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be scarified before the next layer is added to give key for. the next layer. The final layer shall be finished flush

with the top of the cube mould.

The dry lean concrete cubes shall be cured in accordance with IS:516.

903.5.1.2. In-situ density: The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 601.5.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges.

903.5.1.3. Thickness: The average thickness of the sub base layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 10 mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.5.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

903.5.1.4. Frequency of quality control tests: The frequency of quality control tests for levels, alignment and materials shall be as in Table 900-6.

903.5.2. Pavement concrete

903.5.2.1. Sampling and testing of beam and cube specimens: At least two beam and two cube specimens, one each for 7 day and 28 day strength testing shall be cast for ever 150 cu.m (or part thereof) of, concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered to the paving plant. Each pair shall be from a different delivery of concrete and tested at a place to be designated by the Engineer in accordance with the testing procedure as outlined in Clause 602.3.3. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the strength requirements. The specimens shall be transported in an approved manner to prevent sudden impact causing fractures or damage to the specimen. The flexural strength test results shall prevail over compressive strength tests for compliance.

A quality control chart indicating the strength values of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut from the hardened concrete at such locations. The cores shall be cut at the rate of 2 cores for every 150 cu. m. of concrete. The results of crushing strength tests on these cores shall not be less than 0.8 times the corresponding crushing strength of cubes, where the height to diameter ratio of the core is two. Where height to diameter ratio is varied, then the necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$f = 0.11 n + 0.78$$

where f = correction factor and

n = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm.

If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., at least over an area extending between two transverse joints where the defects could be isolated or over larger areas, if necessary, as assessed by additional cores and their test results. The equivalent flexural strength at 28 days shall be estimated in accordance with Clause 602.3.3.2.

In order to ensure that the specified minimum strength at 28 days is attained in 99 per cent of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 2.33 times the standard deviation calculated first from the flexural strengths of test beams made from the trial mix and subsequently from the accumulating result of flexural strengths of job control test beams.

The standard deviation shall be re-calculated from the test results obtained after any change in the source or quality of materials and the mix shall be adjusted as necessary to comply with the requirements.

An individual 28 day test strength below the specified strength shall not be evidence for condemnation of the concrete concerned if the average 28 day strength of this beam plus the preceding 5 and succeeding 4 beams exceeds the specified strength by 2.33 times the standard deviation and provided that there is no other evidence that the concrete mix concerned is substandard.

Beams shall be made each day in pairs at intervals, each pair being from a different batch of concrete. At the start of the work, and until such time as the Engineer may order a reduction in the number of beams required, at least six pairs of beams and cubes shall be made each day, one of each pair for testing at 28 days for determination of the minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix. When the first thirty number of 28-day results are available, and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the 28 day flexural strengths to detect any deterioration in the quality of the concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence of non-compliance of the concrete from which they were taken.

Concrete shall not comply with the Specification when more than one test beam in a batch has a 28 day strength less than the specified strength and the average 28 day flexural strength of the batch of beams is less than the specified strength plus 2.33 times the standard deviation of the batch.

Should the concrete fail to pass the Specification for strength as described above, the Contractor may, all at his own expense, elect to cut cores from the suspect concrete as the Engineer shall direct. From the relation between cube strength and flexural strength, the core strength shall be converted to flexural strength.

The equivalent flexural strength at 28 days shall be the estimated insitu strength multiplied by 100 and divided by the age-strength relation obtained from Table 900-5.

Any concrete that fails to meet the strength specification shall be removed and replaced at Contractor's expense.

**TABLE 900-5. AGE - STRENGTH RELATION OF CONCRETE
(RELATED TO 100 PER CENT AT 28 DAYS)**

Days	0	2	4	6	8
0	—	41.0	60.0	71.0	77.5
10	81.5	85.0	87.5	90.0	92.0
20	94.0	96.0	97.5	98.5	100.0
30	101.0	102.0	103.5	104.5	105.5
40	106.5	107.0	108.0	109.5	110.0
50	110.5	111.0	112.0	112.5	113.0
60	114.0	114.5	115.0	115.5	116.0
70	116.5	117.0	117.5	118.0	118.5
80	119.0	119.5	119.5	120.0	120.5
90	121.0	121.5	122.0	122.0	122.5
100	123.5	123.5	123.5	124.0	124.5
110	125.0	125.0	125.5	125.5	126.0
120	126.0	126.0	127.0	127.0	127.5
130	127.5	128.0	128.5	128.5	129.0
140	129.0	129.5	129.5	130.0	130.0
150	130.5	130.5	131.0	131.0	131.5
160	131.5	131.5	132.0	132.0	132.5
170	132.5	132.5	133.0	133.0	133.5
180	133.5	134.0	134.0	134.5	134.5
190	135.0	135.0	135.0	135.5	135.5
200	135.5	135.5	136.0	136.0	136.5
210	136.5	136.5	137.0	137.0	137.0
220	137.0	137.5	137.5	137.5	138.0
230	138.0	138.5	138.5	138.5	138.5
240	139.0	139.0	139.0	139.5	139.5
250	139.5	140.0	140.0	140.0	140.0
260	140.5	140.5	140.5	140.5	141.0
270	141.0	141.0	141.5	141.5	141.5
280	142.0	142.0	142.0	142.0	142.0
290	142.5	142.5	142.5	142.5	142.5
300	143.0	143.0	143.0	143.0	143.5
310	143.5	143.5	144.0	144.0	144.0
320	144.0	144.5	144.5	144.5	144.5

Days	0	2	4	6	8
330	144.5	145.0	145.0	145.0	145.0
340	145.0	145.5	145.5	145.5	145.5
350	146.0	146.0	146.0	146.0	146.0
360	146.0	146.0	146.5	146.5	146.5

903.5.2.2. In-situ density : The density of the compacted concrete shall be such that the total air voids are not more than 3 per cent. The air voids shall be derived from the difference between the theoretical maximum dry density of the concrete calculated from the specific gravities of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150 mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the vibratory effort imparted i.e the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. In case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculating the density, allowance shall be made for any steel in cores.

Cores removed from the main carriageway shall be reinstated with compacted concrete with mix proportions of 1 part of portland cement: 2 parts of fine aggregate : 2 parts of 10 mm nominal size single sized coarse aggregate by weight. Before filling the fine mix, the sides shall be hacked and cleaned with water. Thereafter cement-sand slurry shall be applied to the sides just prior to filling the concrete mix.

903.5.2 J. Thickness: Thickness shall be controlled by taking levels as indicated in Clause 902.3. Thickness of the slab at any point checked as mentioned above shall be within a tolerance of -5 mm to + 25 mm of the specified thickness as per Drawing. Thickness deficiency more than 5 mm may be accepted and paid for at a reduced rate given in Clause 602.15.2. In no case, however, thickness deficiency shall be more than 25 mm.

903.5.2.4. Summary or control tests : Table 900-6 gives a summary of frequency of testing of pavement quality concrete.

TABLE 900-6 . FREQUENCY OF QUALITY CONTROL TESTS FOR PAVING QUALITY CONCRETE

1)	Levels, alignment and texture	
i)	Level tolerance	Clause 902.3
ii)	Width of pavement and position of paving edges	Clause 902.2
iii)	Pavement thickness	Clause 902.3 and 903.5.2.4
iv)	Alignment of joints, widths, depth of dowel grooves	To be checked @ one joint per 400 m length or a day's work
v)	Surface regularity both transversely and longitudinally	Once a day or one day's work without disturbing the curing
vi)	Alignment of dowel bars and their accuracy/tie bars	To be checked in trial length as per
vii)	Texture depth	Clause 602.12
2)	Quality of materials and concrete shall be as under :	

	1) Cement Physical and chemical Tests		18:269 18:455 18:1489 18:8112 18:12260	Once for each source of supply and occasionally when called for in case of long/ improper storage. Besides, the Contractor also will submit daily test data on cement released by the manufacturer.
	2) Coarse and Fine Aggregates	i) Gradation	18:2386	One test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; (may be relaxed later at the discretion of the Engineer)
		ii) Deleterious	18:2386 (Pt. 2)	-do-
		iii) Water absorption	18:2386 (Pt. 3)	Regularly as required subject to a minimum of one test a day for coarse aggregate and two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix or
	3) Coarse Aggregate	i) Los Angeles Abrasion value or Aggregate Impact test	18:2386 (Pt. 4)	Once for each source of supply and subsequently on monthly basis.
		ii) Soundness	18:2386 (Pt. 5)	Before approving the aggregates and every month subsequently.
		iii) Alkali aggregate reactivity	18:2386 (Pt. 7) 18:456	-do.:
	4) Water	Chemical Tests	IS:2386	Once for approval of source of supply subsequently only in case of doubt.
	5) Concrete	i) Strength of concrete	IS:516	2 cubes and 2 beams per 150 cu.m or part thereof (one for 7 day and other for 28 day strength) or minimum 6' cubes and 6 beams per day's work whichever is more.
		ii) Core strength on hardened concrete	IS:516	As per the requirement of the Engineer, only in case of doubt.
		iii) Workability of fresh concrete- Slump Test	IS:1199	One test per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumper.
		iv) Thickness determination		From the level data of concrete pavement surface and sub-base at grid points of 5/6.25 m x 3.5 m
		v) Thickness measurement for trial length		3 cores per trial length
		vi) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving		String line or steel forms shall be checked for level at an interval of 5.0 m or 6.25 m. The level tolerance allowed shall be ± 2 mm. These shall be got approved 1-2 hours before the commencement of the concreting activity.

903.5.3. Rolled Concrete Base

903.5.3.1. Sampling and testing of beams and cubes: Clause 903.5.2.1 shall apply

903.5.3.2. Thickness : Thickness shall be controlled by taking levels as indicated in Clause 903.5.1.3.

903.5.3.3. In-situ density : The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 601.5.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or 40 determine the extent of defective area in the event of non compliance. Density holes at random may be made to check the density at edges.

903.5.3.4. Summary of control tests : Table 900-6 gives the summary of tests for levels, alignment and materials.

903.5.4. Summary of rate of sampling and testing:

- (i) Strength : 3 beams and 3 cubes for each 100 sq. m. or part thereof laid each day.
- (ii) Density : 3 density holes for each 2000 sq.m. or part thereof laid each day.
- (iii) Cores : Only when Engineer instructs. They shall not be cut on regular basis.

A relation between flexural strength and compressive strength may be developed by regression analysis using the available data. This may be updated from time to time.

I000

Material for Structures

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 covered under these specifications.

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 MATERIAL

The Contractor shall notify the Engineer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

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 10.5 MPa for average 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 + 5 per cent.

1004. STONES

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

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

The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

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 in the works shall be any of the following types with the prior approval of the Engineer :

- a) Ordinary Portland Cement, 33 Grade, conforming to JS:269.
- b) Rapid Hardening Portland Cement, conforming to IS:8041.
- c) Ordinary Portland Cement, 43 Grade, conforming to IS:8112.
- d) Ordinary Portland Cement, 53 Grade, conforming to IS:12269.
- e) Sulphate Resistant Portland Cement, conforming to IS:12330.

Cement 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 540 kg/cu.m. of concrete.

Cement conforming to IS:8112 and 15:12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28-day range can be achieved by finer grinding and higher constituent ratio of C_3S/C_2S , where C_3S is Tricalcium Silicate and C_2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

Cement conforming to 15:12330 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 15:456 are sulphate concentration in excess of 0.2 per cent in soil substrata or 300 ppm (0.03 per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to 15:12330 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 540 kg/ cu.m. of concrete.

Cement conforming to 15:8041 shall be used only for precast concrete products after specific approval of the Engineer.

Total chloride cement in cement shall in no case exceed 0.05 per cent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 per cent and 3.0 per cent when tri-calcium aluminate per cent by mass is upto 5 or greater than 5 respectively.

1007. COARSE AGGREGATES

For plain and reinforced cement concrete (PCC and - RCC) or prestressed concrete (PSC) works, coarse aggregate 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 consist 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 aggregate 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.

The maximum value for flakiness index for coarse aggregate, shall not exceed 35 per cent. The coarse aggregate shall satisfy the following requirements of grading:

TABLE 1000-1 Grading Requirements of Coarse Aggregate

IS Sieve Size	Per cent by Weight Passing the Sieve		
	40mm	20mm ¹	12.5mm
63 mm	--	--	--
40 mm	95-100	100	--
20mm	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. SAND/FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS:2116.

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. 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. Motorised sand washing machines should be used to remove impurities from sand. Fine aggregate 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.

Sand/fine aggregate for structural concrete shall conform to the following grading requirements :

TABLE 1000-2 : Grading Requirements for Fine Aggregates

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 ram	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

1009. STEEL

1009.1. 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. 0.3 per cent to 0.5 per cent copper may be added to increase the corrosion resistance properties.

1009.2. Steel for Prestressing

The prestressing steel shall conform to either of the following :

- Plain hard drawn steel wire conforming to IS:1785 (Part I) and IS:1785 (PartII).
- Cold drawn indented wire conforming to IS:6003
- High tensile steel bar conforming to IS:2090
- Uncoated stress relieved strands conforming to IS:6006.

1009.3. Reinforcement / Untensioned Steel

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 Specification	IS Characteristic Strength f_y MPa	Elastic Modulus GPa
Fe240	IS:432 Part I Mild Steel	240	200
Fe415	IS:1786 High Strength Deformed Steel Bars (HSD)	415	200
Fe500 of Fe 5000	IS:1786 High Strength Deformed Steel Bars (HSD)	500	200
Fe500 of Fe 5500	IS:1786 High Strength Deformed Steel Bars (HSD)	550	200
Fe600	IS:1786 High Strength Deformed Steel Bars (HSD)	600	200

Other grades of bars conforming to IS:432 and IS:1786 shall not be permitted.

All steel shall be procured from original producers, no re-rolled steel shall be incorporated in the work.

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

Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS:13620. Additional requirements for the use of such reinforcement bars have been given below :

- Patch up materials shall be procured in sealed containers with certificates from the agency who has supplied the fusion bonded epoxy bars.
- PVC coated G.I. binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.
- Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.
- The cut ends and damaged portions shall be touched up with repair patch up material.
- The bars shall be cut by saw-cutting rather than flame cutting.
- While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.
- 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.
- While concreting, the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars.

When specified in the contract, protective coating prescribed by CECRI shall be provided in conformance to specifications given in *Appendix 1000/I*. The CECRI coating process shall be allowed to be implemented at the site of works provided a representative of the Institute is present throughout the duration of the coating process who shall certify that the materials and workmanship are in accordance with prescribed specifications developed by the Institute.

1009.4. 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.

1009.5. 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 will be taken as per IS: 1875 with minimum reduction ratio of 1.8:1. Alternatively, if forging is made from ingot, a minimum reduction ratio between the ingot and forging will be 4:1. Forging shall be normalised.

1009.6. Structural Steel

Unless otherwise permitted herein, 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 & high strength qualities)
IS:1148	:	Hot rolled rivet bars (upto 40mm dia) for structural purposes
IS:1149	:	High (ensile rivet bar 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 authority. Refer to Section 1900 for further details.

1009.7. 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 the accepting authority, but in no case be inferior to mild steel. Generally, stainless steel is available as per AISI grades. AISI 304 which is equivalent to grade 04Cr18Ni110 of IS:6911 satisfies the requirements of 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 injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. 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 :

- To neutralise 200 ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal N_2OH .
- To neutralise 200 ml sample of water, using methyl orange as an indicator, it

- should not require more than 10 ml of 0.1 normal HCL
- (c) The permissible limits for solids shall be as follows when tested in accordance with IS:3025 :

	Tested as Per	Permissible Limit max
Orgqnic	IS:3025(Pt.18)	200 mgllit
Inorganic	IS:3025(Pt.18)	3000 mg/lit
Sulphates (SO ₃)	IS:3025(Pt.28)	400 mg/lit
Chlorides (CI)	IS:3025(Pt.32)	2000 mg/lit for concrete work not containing embedded steel and 500 mg/lit for prestressed/reinforced concrete work
Suspended matter	IS:3025(Pt.17)	2000 mgllit

- * In case of structures of lengths 30m and below, the permissible limit of chlorides may be increased upto 1000 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 staled herein.

- (d) The pH value shall not be less than 6.

1011. **TIMBER**

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

1012. **CONCRETE ADMIXTURES**

1012.1. **General**

Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened slate.

Concrete 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 :

- Normal dosage and detrimental effects, if any, of under dosage and over dosage.
- The chemical names of the main ingredients in the admixtures.
- The chloride content, if any, expressed as a percentage by the weight of the admixture.
- Values of dry material content, ash content and relative density of the admixture which can be used for Uniformity Tests.
- Whether or not the admixture leads to the entertainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
- Where two or more admixtures are proposed 10 be used in any one mix, confirmation as to their compatibility.
- There would be no increase in risk of corrosion of the reinforcement or other embedments as a result of using the admixture.

1012.2. **Physical and Chemical Requirements**

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

- "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".
- Except where resistance to freezing and thawing and to disruptive action of de-icing salts is necessary, the air content of freshly mixed concrete in accordance with the pressure method given in IS: 1199 shall not be more than 2 per cent higher than that of the corresponding control mix and in any case not more than 3 per cent of the lest mix.
- The chloride content of the admixture shall not exceed 0.2 per cent 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 shall also be observed.
- (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 in the same are indicated below :

Dry Material Content : to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.

Ash content : to be within 1 per cent of the value stated by the manufacturer.

Relative Density (for liquid admixtures) : to be within 2 per cent of the value stated by the manufacturer.

- (e) All tests relating to the concrete admixtures shall be conducted periodically at an independent laboratory and compared with the data given by the manufacturer.

1013. REINFORCED CONCRETE PIPES

Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS:458.

1014. STORAGE OF MATERIALS

1014.1. General

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

1014.2. Brick

Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded, to minimise breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be slacked separately.

1014.3. Aggregates

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained. If necessary, the ground shall be covered with 50 mm plank.

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). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

In the case of fine aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Engineer.

1014.4. 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 not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.

Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.

The Contractor shall prepare and maintain proper records on 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 make a monthly return to the Engineer on the date corresponding to

the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

1014.5. Reinforcement /Untensioned Steel

The reinforcement bars, when delivered on the job, shall be stored 5, above the surface of the ground upon platforms, skids, or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

1014.6. Prestressing Materials

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

(a) Tendon : Wire, strand and bar from which tendons are to be fabricated shall be stored about 300mm 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, tendon material shall be subjected to' any welding operation or on site heat treatment or metallic coating such as galvanising. Storage facilities and the procedures for transporting material into or out of store, shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5mm dia, coils of about 2m dia without breaks or joints shall be obtained from manufacturer and stored. 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 is recommended where prolonged storage is required. Such protective material shall be guaranteed by the producer to be non-aggressive and non-degrading.

Prestressing steel shall be stored in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable grease. The prestressing steel should be absolutely clean and without any signs of rust.

All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

1014.7. Water

Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be 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 prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at

site in the laboratory approved by the Engineer before use. Any cement with lower quality than those 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.

1015.1. 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 or his representative for which the Contractor shall make all the necessary arrangements and bear the entire cost.

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

1015.2. Sampling of Materials

Samples provided to the Engineer or his representative for their retention are to be in labelled boxes suitable for storage.

Samples required for approval and testing must be supplied well in advance by at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to works arising from the late submission of samples will not be acceptable as a reason for delay in the 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 not conform to the prescribed tests and quality shall be rejected by the Engineer or his representative 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 modifications.

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.

1500

FORMWORK

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, False-work 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 1500/1, 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.

Ballies 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 T-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 HOPE 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 false work, 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 (machinery 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.
- v) 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.

1600

STEEL REINFORCEMENT

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.
 - iii) 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.
 - iv) 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.
 - v) 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

1606.1 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.

1606.2 Welding

1606.2.1 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.

1606.2.2 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.

1606.2.3 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-acetylene 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.

1606.2.4 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.

1606.2.5 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.

1606.3 Mechanical at Couplers and Anchorages

1606.3.1 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.

1606.3.2 Anchorages

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.

I700

STRUCTURAL CONCRETE

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 these Specifications.

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
	MSO	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.

1703.2 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.

1703.3 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 ³	Minimum Grade of Concrete
Moderate	0.45	340	M25
Severe	0.45	360	M30
Very Severe	0.40	380	M40

Note:

- i) All three provisions given in the above table for a particular exposure condition, shall be satisfied.
- ii) 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 fly-ash and ground granulated blast furnace slag in the blended cement shall be as specified in IS:1489 (Part 1) and IS:455 respectively.
- iii) 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/m³ for use of 12.50 mm nominal size aggregates and decreased by 30 kg/m³ for use of 40 mm nominal size aggregates.

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

Class	Concentration of Sulphates as S03			Type of Cement (Note ii)	Minimum Cement Content, kg/m³	Maximum Water / Cement Ratio	Minimum Grade of Concrete
	In Soils		In Ground Water, g/l				
	Total S03, %	S03 in 2:1 Water: Soil Extract, g/l					
1)	Traces	< 1.0	< 0.3	-OPC, PPCor PSC	280	0.5	M25

Class	Concentration of Sulphates as S03			Type of Cement (Note ii)	Minimum Cement Content, kg/m³	Maximum Water / Cement Ratio	Minimum Grade of Concrete
	In Soils		In Ground Water, g/l				
	Total S03, %	S03 in 2:1 Water: Soil Extract, g/l					
2)	2.0 to 0.5	1.0to1.9	0.3 to 1.2	-OPC, PPCor · PSC -SRPC	330	0.5	M25
3)	0.5 to 1.0	1.9to3.1	1.2 to 2.5	-SRPC, -PPC or PSC	330 350	0.5 0.45	M25 M30
4)	1.0to2.0	3.1 to 5.0	2.5 to 5.0	--SRPC	370	0.45	M35
5)	>2.0	>5.0	>5.0	-SRPC with protective coatings	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.

1703.4 Concrete used in any component or structure shall be specified by designation along with prescribed method of design of mix i.e. 'Design Mix' or 'Nominal Mix'. 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.

1703.5 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.

1704.2 Requirements for Design Mixes

1704.2.1 Target Mean Strength

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

- i) 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.
- ii) 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)
M15	10	25
M20	10	30
M25	11	36
M30	12	42
M35	12	47
M40	12	52.
M45	13.	58
M50	13	63
M55	14	69
M60	14	74
M65	15	80
M70	15	85
M75	15	90
M80	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 15:10262, JS: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

a) 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.

b) 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.

c) 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	
M20	250		25	22

1704.4

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:

- a) 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 SO₃, 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 IS: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.

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 superplasticiser 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

Components	Maximum Nominal Size of Coarse Aggregate (mm)
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 size adopted for the concrete mix.

1707

EQUIPMENT

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under :

- a) Production of Concrete :
 - i) 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).
 - ii) 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.

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	: ± 3 percent of the quantity of aggregate in each batch
Measurement of Admixture	: ± 3 percent of the quantity of admixture in each batch

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 BS 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's receiving 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 11\0re 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.
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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 superplasticizers 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-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 aggregates 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 his 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:

- a) Premature drying out particularly by solar radiation and wind
- b) High internal thermal gradients
- c) Leaching out by rain and flowing water
- d) Rapid cooling during the first few days after placing
- e) Low temperature or frost
- f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.
- g) 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 C171 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 fly-ash 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 superplasticizers 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.

i) **Rapid Chloride Ion Permissibility Test**

Rapid Chloride ion permeability test 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.

ii) **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.

Flyash 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 flyash and shall conform to grade-I of IS:381'2.

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 IS:12089.

Silica fume conforming to IS:15388 shall be used.

The cement content of concrete inclusive of any mineral admixtures shall not be less than 380 kg/m³

The cement content excluding any mineral admixtures (Portland cement content alone) shall not exceed 450 kg/m³. 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 Pozzolan or hydraulic dilutes shall be ensured by trials as outlined under Clause 705.

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

Grade Designation	Specified Characteristic Compressive Strength at 28 days (MPa)	Target Mean Strength (MPa)
M40	40	52
M45	45	58
M50	50	63
M55	55	69
M60	60	74
M65	65	80
M70	70	85
M75	75	90
M80	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 Jots for the purpose of sampling before commencement of work. The basis of delimitation of lots shall be as follows:

1717.4 Sampling and Testing

- i) No individual lot shall be more than 30 cu.m in volume
- ii) Different grades of mixes of concrete shall be divided into separate lots.
- iii) Concrete of a lot shall be used in the same identifiable component of the bridge.

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 Jot 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 JS: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 ± 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, m³	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 ³ or part thereof

At least one sample shall be taken from each shift of work.

1717.7 Acceptance criteria

1717.7.1 Compressive Strength

1) Cubes

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

- a) The mean strength determined from any group of four consecutive non-overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
- b) 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.

2) 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 (SO₃ 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:

- i) A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared.
- ii) 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.
- iii) The concrete specimen shall be subjected to a water pressure of 0.5 N/mm² 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.
- iv) 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.
- v) 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.
- vi) 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 substandard 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:

$$\text{Percentage reduction in rate} = \frac{\text{Design Strength} - \text{Observed Strength}}{\text{Design Strength}} \times 100$$

1800

PRESTRESSING

1801 DESCRIPTION

The work shall consist of imparting prestress to structural concrete members by stressing of wires/strands/tendons/cables with jacks of required capacity and holding them between appropriately designed anchorages fixed internally or externally to the members.

1802 GENERAL

The work shall be carried out in accordance with the drawings and these Specifications or as approved by the Engineer.

Structural concrete and un-tensioned steel for the production of prestressed concrete members shall conform to the requirements of Section 1700 and Section 1600 respectively, of these Specifications.' unless specifically modified by requirements set forth in this Section.

1803 MATERIALS

1803.1 All materials shall conform to Section 1000 of these Specifications.

1803.2 Sheathing

1803.2.1 General

The sheathing ducts shall be of the spiral corrugated type either in mild steel or HOPE or in PP for internal tendons. They shall be in as long lengths as practicable from considerations of handling and transportation without getting damaged.

External tendons shall be housed in either High Density Poly-Ethylene (HOPE) sheaths or metallic steel sheaths (plain or with protective coatings), which have smooth internal surfaces.

1803.2.2 M.S. Sheathing Ducts

The material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS:513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

The material shall be clean and free from rust and normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used.

The sheathing shall conform to the requirements specified in Table 1800-1 and Appendix 1800/1. All the joints of sheathing shall be water tight and conform to provisions contained in Clause 1804.6.

Table 1800-1 : Details of Ducts

No. of Strands/ Dia in mm	Diameter of Duct in mm		Thickness of MS Sheathing in mm	Thickness of HOPE Duct in mm
	Metallic	HOPE		
6/13	50	50	0.3	2.0
12/13	75	75	0.4	2.5
19/13	85	85	0.4	2.5
27/13	100	100	0.5	3.0
12/15	85	85	0.4	2.5
19/15	100	100	0.5	3.0
27/15	125	130	0.5	4.0

1803.2.3 Corrugated HOPE Sheathing Ducts

The material for the ducts shall be high density polyethylene or polypropylene with more than 2 percent carbon black to provide resistance to ultraviolet degradation. The ducts shall be corrugated on both sides. All tests on raw materials and tests to be conducted on the finished product shall be in accordance with fib Technical Report Bulletin 7 "Corrugated plastic ducts for internal bonded post tensioning".

Each batch of the HOPE ducts supplied to the site shall be accompanied by the supplier's certificate for properties of the raw materials which shall comply with the Technical report Bulletin 7. In addition the shore hardness for D-3 sec value shall be 60 ± 5 . For the approval of the finished product, the tests mentioned in the Appendix A1 to A9 of fib Technical Report Bulletin 7, shall be conducted at the reputed institutions or at the manufacturer's laboratories. Results shall comply with the provisions of the fib Technical report Bulletin 7, except for the wear resistance, minimum bending radius and bond length test which are modified as follows:

- a) Wear resistance test: The wear resistance of the duct i.e. the minimum residual wall thickness after loss shall not be less than 1.5 mm for ducts up to 85 mm in diameter and not less than 2 mm for ducts greater than 85 mm in diameter.
- b) Minimum bending resistance: The test apparatus shall be identical to the wear test apparatus with the same clamping force. However sample shall not be moved but shall be as held in position for a period of 7 days. The residual wall thickness shall be as mentioned in (a) above.
- c) Bond length test: The ducts shall transmit full tendon strength from the tendon to the surrounding concrete over a length of not greater than 40 times duct diameter.

Each supply of the ducts shall be accompanied by test report of the finished product also. The test certificates issued by the institutes will be valid for a period of two years.

1803.2.4 Diameter and Thickness of Sheathing Ducts

The internal diameter and thickness of sheathing shall be as shown in the drawing or as indicated in Table 1800-1, whichever is greater:

Where prestressing tendons are required to be threaded after concreting, the internal diameter of sheathing shall be about 5 mm larger than required above for spans more than 30 m. In severe environment, cables shall be threaded after concreting. In such cases a temporary tendon shall be inserted in the sheathing or the sheathing shall be stiffened by other suitable method during concreting.

1803.3 Anchorages

1803.3.1 Prestressing accessories like jacks, anchorages, wedges, block plates, etc. shall be procured from authorized manufacturers only. Anchorages shall conform to "Recommendations for acceptance and application of prestressing systems" published by FIB. The prestressing accessories shall be subjected to an acceptance test prior to their actual use on the work. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

1802.3.2 Swages of prestressing strand and button-heads of prestressing wire, where provided shall develop a strength of at least 95 percent of the specified breaking load of the strand or wire as the case may be. Where swaging/button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to taking up the work.

1802.3.3 Untensioned steel reinforcements, around anchorages shall conform to the details of prestressing system and as shown on the drawing.

1803.4 Couplers

Couplers or other similar fixtures used in conjunction with the prestressing strands or bars, shall have an ultimate tensile strength of not less than the strengths of the individual strands or bars being joined and shall also meet the requirements of individual anchorages.

1804 TESTING OF PRESTRESSING STEEL AND ANCHORAGES

All materials specified for testing shall be furnished free of cost by the Contractor and shall be delivered in time for tests to be made, well in advance of anticipated time of use.

All wires, strands or bars to be shipped to the site, shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall also be similarly identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5 m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or type to be used, shall be furnished along with short lengths of strands as required.

1805 WORKMANSHIP

1805.1 Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersing in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

1805.2 Straightening

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter, such that tendons shall retain their physical properties and shall be straight as they unwind from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing wire/strand shall be removed only just prior to forming of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires/strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

1805.3 Positioning

1805.3.1 Post Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The location of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High capacity tendons shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distance between any two cable ducts shall in no case be less than 50 mm or diameter of duct, whichever is greater, when grouping of cable is not involved. Where precast segments are used, the clear distance between cables shall be at least 150 mm.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars, so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to the

approval of the Engineer. The temporary tendon shall be pulled out by a special threading machine or other contrivance, before threading the permanent tendon.

Where possible, tendons shall be placed prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendons which are damaged or contaminated shall be cleaned or replaced.

1805.3.2 Pre-tensioning

Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

1805.3.3 Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer, prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.

1805.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The flame cutting of wire or strand shall be carried out at least 75 mm beyond the point where the tendon will be gripped by the anchorage or jacks.

In post tensioned members the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

1805.5 Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these Specifications or as directed by the Engineer.

In the case of external prestressing, steel shall be encased in suitable polyethylene pipes before grouting.

1805.6 Sheathing Duct Joints

1805.6.1 General

The sheathing and all joints shall be water tight and shall withstand a pressure of 1.1 times the grouting pressure and maximum grouting head due to grout. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

Special attention shall be paid to the junction at the anchorage end, where the sheathing must be tightly fitted on the protruding trumpet end of anchorage and thereafter sealed preferably with tape, to make it water-proof.

1805.6.2 Coupling of MS Sheathing Ducts

For major projects, the sheathing duct should preferably be manufactured at the project site utilizing appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers.

Where sheathing duct joints are unavoidable, they shall be made cement slurry tight by the use of corrugated threaded sleeve couplers, which can be tightly screwed on to the outer side of the sheathing ducts.

The length of the coupler should not be less than 150 mm but should be increased upto 200 mm wherever practicable. The joints between the end of coupler and duct shall be sealed with tape to prevent penetration of slurry during concreting. The couplers of adjacent ducts shall be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers can be conveniently manufactured using the sheath making machine with the next higher size of die set.

For typical details of coupling refer Appendix 1800/1.

1805.6.3 Coupling of HOPE Sheathing Ducts

The HOPE sheathing can be joined by any one of the following three methods.

- a) Use of threaded sleeve couplers in the same manner as given for metallic sheathing.
- b) Welding of two ends of HOPE sheathing using appropriate machine such as Roaster Machine or Mirror Machine.
- c) Use of heat shrink couplers made of HOPE sleeves. The sleeves are integrated with the parent sheathing by hot process by using heating torch.

For typical details of coupling, refer Appendix 1800/1.

1805.7 Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. For cables longer than 50 m grout vents or drains may be provided at or near the lowest points: Additional vents shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20 m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without leakage of water, air pressure or grout.

1805.8 Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially

through the anchorage assembly. The anchorages shall be recessed from the concrete surface by a minimum of 100 mm. After the prestressing operations are completed and prestressing wires/strands are cut the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 micron per coat and entire recess shall be filled with concrete or non-shrink/ pre-packaged mortar of epoxy concrete.

1806

SUPERVISION

Prestressing operation and grouting shall be entrusted only to specially trained and qualified personnel. All prestressing accessories shall be procured from authorized manufacturers with in-house testing facilities. The Contractor shall be required to engage specialized agencies who should also be entrusted with the total service contract for fabrication of cables, protection of cables during concreting, prestressing and grouting. Necessary certificates shall be accorded by such specialized agencies that the work has been carried out in accordance with prescribed specifications. In exceptional cases, the prestressing and grouting operations could be entrusted to the bridge Contractor himself, if the Employer is convinced that he is well experienced and has qualified personnel and sufficient track record to substantiate his performance in the particular system of prestressing being adopted.

1807

TENSIONING EQUIPMENT

All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements :

- i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.
- ii) Where two or more wires/strands constitute a tendon, a single multi-pull stressing jack shall be used, which is capable of tensioning simultaneously all the wires/strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.
- iii) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete.
- iv) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the liner measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

All dynamometers and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two percent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 percent of its breaking load, the gauge is reading between 50 percent and 80 percent of its full

capacity. Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check, whenever requested for by the Engineer.

Jack and pump shall be calibrated from an approved laboratory prior to use and then at intervals not exceeding three months.

1808 POST TENSIONING

Tensioning force shall be applied in gradual and steady steps, in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure, continue tensioning till the specified gauge pressure is attained, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.
- b) If the calculate elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq. cm until the calculated elongation is reached, provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.
- c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this discrepancy:
 - i) Check the correct functioning of the jack, pump and leads.
 - ii) De-tension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re-tension the cable, if free.
 - iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

- d) When stressing from one end only, the slip at the end remote from the jack, shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/111.

The number of stages of prestressing and grouting shall be kept to a minimum, preferably two in the case of simply supported girders.

1809 GROUTING OF PRESTRESSED TENDONS

Grouting of prestressed tendons shall be carried out in accordance with provisions given in Appendix 1800/111. A record of grouting operations shall be maintained in the format given in Appendix 1800/IV.

1810 PRE-TENSIONING

1810.1 General

The planning and construction aspects of the tensioning bed, tensioning bench, abutments at location of anchorage, steam curing system, formwork of the concrete elements and arrangements for de-moulding, lifting, stacking and transportation of the pre-tensioned concrete elements are all specialised items of work and shall be entrusted to engineers specifically experienced in this type of work.

1810.2 Concrete Mix Requirements

Minimum cement content, maximum water cement ratio and other durability requirement shall be same as indicated in Table 1100:2 and Table 1700-3 of these Specifications except that minimum grade of concrete shall be M40.

1810.3 Form Work

All sides, bottoms and header forms shall be of steel or any other suitable material. 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. All joints of form work shall be leak proof. The bottom shutter shall have arrangement to permit longitudinal movement of girder concrete, which occurs while imparting prestress. Identifying marks shall be placed on the girders to indicate the correct orientation to ensure correct de-bonding locations, which may not be symmetrical, longitudinally.

1810.4 Laying of Deflected Tendons

For long span pre-tensioned girders, deflected tendons shall be used instead of the conventional straight tendons. This requires the use of hold-up/hold-down devices at each deflected location, in order to hold the tendons in the desired profile and location. A hold-down device normally consists of rollers attached to a vertical rod, which passes through the bottom form and is anchored to the form substructure or foundation to resist the prestress force. The force which must be resisted by the hold-up/hold-down device, and therefore its size, depends on the number of deflected strands and the trajectory angles of the strands. The strand can be either tensioned after it is held in its deflected profile by means of hold-up/hold-down devices or it

can be tensioned first and then brought into its deflected profile. The number of deflected strands and their angle directly influence the size and cost of the hold-up/hold-down devices.

1810.5 Production and Testing of Concrete

A fully automated, computer-controlled batching plant shall be used. The batching plant shall be provided with moisture measuring and compensating devices and automatic pump for dispensing admixtures.

Sampling and testing of concrete shall be as per Section 1700 of these Specifications. Additional cubes shall be prepared to determine the concrete strength at the time of removal of forms and transfer of prestress. Adequate number of samples shall be taken for this purpose, which shall be cured in identical conditions to those of the concrete of respective girders.

1810.6 Compaction, Removal of Form Work and Curing

Compaction of concrete may be achieved through needle vibrators or form vibrators along with needle vibrators. For casting of precast beams, any of the two commonly known techniques of precasting viz. (i) Long Line method or (ii) Short Line method may be used.

The girders shall not be moved from the casting location until stipulated strength requirements have been attained. The concrete shall have attained a minimum compressive strength of 20 MPa at the time of removal of forms. Curing of concrete may be achieved through water or steam followed by water curing. Approved curing compound may also be used.

Longitudinal movement of the girders that takes place while releasing the prestress shall be suitably catered for. In case of long line method of precasting adequate longitudinal gap shall be provided between girder ends during precasting, to accommodate projecting reinforcement and required length of the projecting strands.

1810.7 Stressing Bed for Pre-tensioning

The abutments and bed for pre-tensioning of tendons shall be designed to withstand the total tensioning force.

A notice shall be displayed adjacent to the stressing bed showing the maximum tensioning force permitted.

Where concrete elements are cast and prestressed individually, the stressing bench or moulds shall be rigid enough to sustain the reaction of the prestressing force without distortion.

In the long line method of prestressing, sufficient locator plates should be distributed throughout the length of the bed to ensure that the wires are maintained in their proper position during concreting. The moulds shall be free to slide in the direction of their length and thus permit the transfer of the prestressing force to all the concrete elements along the whole line.

Sufficient space shall be left in between the ends of concrete elements to permit access for cutting the strands/wires after transfer. Hold-downs or deflectors shall be

used for holding or deflecting the tendons in required position firmly. Deflectors which are in contact with the tendon shall have a diameter not less than the tendon or 15 mm, whichever is more.

The tensioning force required to be applied as stated on the drawings shall be the force remaining in the strands/wires after all strands/wires have been anchored to the abutments of the stressing bed and after the anchorage slip has already taken place. The tensioning force shall be determined by direct reading of the pressure gauges or dynamo-meters and by the measured elongation after slip.

The Contractor shall submit method of tensioning the tendons including the arrangement and layout of prestressing beds and all tendon deflection points, to the Engineer for approval before manufacture commences". The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold-downs and the slip during anchoring.

De-bonding of strands, wherever required, shall be carried out using HOPE de-bonding tubes. PVC tubes shall not be permitted for this purpose. After pre-tensioning the strands and before concreting, a recheck shall be made to ensure that the de-bonding tubes are placed at the intended locations. Both ends of de-bonding tubes shall be effectively sealed against ingress of any cement slurry using epoxy putty or any other suitable material.

The Contractor shall also submit calculation showing that the hold-downs have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

1810.8 Pre-tensioning and De-tensioning Operations

1810.8.1 Pre-tensioning of Strands

Pretensioning of strands may be carried out either using single-pull jack or multi-pull jack. In case of the former, it shall be ensured at each stage, that the strands are stressed symmetrically, so that the supporting system of the strands does not rotate or distort. This may be achieved through suitably designed moving trolley engaging the strands or any other suitable arrangement. Prestressing force shall be transferred to metallic spacer, trolley, etc. so that the force does not remain on the hydraulic system for long.

It is necessary to apply a small prestressing force, through hydraulic jacks to remove slackness of the strands. After removal of the slackness, the strands must be thoroughly examined to ensure correct alignment, including that of the de-bonding tubes. Reference marks for measuring elongation shall then be established and the full strand load is applied thereafter. Loads indicated by the gauging system shall control the tensioning, with elongation checked on every strand.

It shall be ensured that the entire length of each strand between the grips is free of any defects. This is of particular importance while precasting girders using long line method entailing, longer pieces of strands between the grips.

Transfer of prestress shall not proceed until the Engineer has approved the proposed method. Strands and deflection devices shall be released in such a pre-determined order that unacceptable tensile stresses are not induced in the concrete.

Prior to transfer of the force to the units, all strands shall be tested for tightness and any loose strands shall be reported to the Engineer, who will decide whether the affected units should be rejected.

The Engineer may require that strands be marked at each end of any unit to allow measurement of the pull-in of the strands.

The sequence of transfer of prestressing force shall be done strictly as indicated in the drawings and ensuring that eccentricities of the prestressing force in the vertical and horizontal directions of the concrete element are minimum during the entire sequence.

The maximum slip of any tendon during transfer shall not exceed 3 mm for bottom strands and 5.5 mm for a top strands at any end of the concrete element. In case the slip exceeds above value, design of the member shall be got checked for the actual slip before acceptance.

1810.8.2 De-tensioning of Strands

De-tensioning, in order to impart the prestress shall be effected gradually, so that there is no significant loss of bond due to slippage of strands and consequent increase in the transmission length. For de-tensioning, the trolley is pulled outward by a small distance, in order to release the metallic spacers, before releasing the prestressing force. Even when the pre-tensioning is carried out through single-pull jack, the release of the force in all the strands, while imparting the prestress to the concrete, shall be simultaneous. It shall be ensured that, during this process, prestressing forces at any stage does not exceed 90 percent of 0.1 percent proof stress.

1810.9 Cutting of Strands

Cutting of strands shall be carried out carefully so as not to affect the un-tensioned reinforcement which is in their close proximity. Diamond bit saw shall be used to cut the strands. Strands and un-tensioned reinforcement shall be so arranged that the un-tensioned reinforcement and those strands which are required to be extended into the adjoining cast in-situ concrete, do not get affected during cutting operation.

Under factory conditions, flame cutting may be resorted to. Yellow flame should be used first to heat the strand without introducing undue stresses and then blue flame for the actual cutting. Heat cutting of strand shall be carried out symmetrically about the vertical axis of the members. One strand at a time on each side of the vertical axis for all girders in a long line shall be cut in the same manner. The above process shall be repeated till all the strands are cut. This will ensure gradual and uniform transfer of prestress to girders.

1811 PROTECTION OF ENDS

The exposed ends of the strands and the concrete surfaces of the ends of the units shall be wire brushed clean of all rust, loose mortar, grease and dirt.

The exposed ends of the strands and concrete surface within 50 mm of tendons shall be then abraded to provide a clean sound surface. An epoxy tar paint suitably formulated to give a dry film thickness of 80 micron per coat; shall then be immediately applied over the ends of the tendons unless otherwise directed.

A second coat of paint shall be applied prior to the drying out of the first coat.

1812 SAFETY PRECAUTIONS DURING TENSIONING

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity. Jacks shall be secured in such a manner that they will remain in position, even if their grip on the strand is lost.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and measurement of the elongation shall be carried out in such a manner and that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon which might become loose, from recoiling unchecked.

During actual tensioning operation, warning signs shall be displayed at both ends of the tendon.

After prestressing, concrete shall not be drilled cut, chipped, or disturbed in anyway, without express approval of the Engineer.

No welding shall be permitted on or near strands nor shall any heat be applied to tendons. Any strand which has been affected by welding or weld spatter or heat shall be rejected.

1813 SURFACE PREPARATION

All surfaces, coming in contact with deck slab/ diaphragm shall be adequately prepared by green cutting, using surface retarders, by mechanical means to remove the laitance and just expose the aggregates. Usually, precast girders join the cast in-situ concrete of end diaphragms at the points of high shear stress. Therefore, it is extremely important to adequately prepare the end faces of the girders for effective bonding of the new concrete. This shall be done using suitable mechanical means (such as 100% hacking) to ensure that the coarse aggregates are just exposed. Surface retarders, may also be used for this purpose.

1814 TRANSPORTATION STORAGE AND HANDLING OF PRECAST GIRDERS

Precast girders shall be transported in an upright position. Points of support and the direction of the reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

Method of transportation should be planned in such a way that the vehicle employed to transport the long girders can successfully negotiate the available road geometry. Adequate care shall be taken to ensure that the girder being transported does not topple due to unstable arrangement. For this purpose, height of the vehicle shall be kept as low as possible. This will also help in accommodating greater height of the system during transportation below existing bridges or through any other constraints. Girders should be transported only after 28 day concrete strength is achieved.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the

ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of precast units to prevent them from being cracked or damaged. Units cracked or damaged by improper storing or handling, shall be replaced by the Contractor at his cost.

Handling of precast girders from precasting location to the bridge site requires careful operation. Lifting location shall be strictly as indicated on the construction drawings.

Lifting devices generally consist of loops of prestressing strand or mild steel bars or any other suitable arrangement. If it is anticipated that embedded material for lifting devices will be cast into the face of the member that will be exposed to view or to corrosive materials in the completed structure, the depth of removal of the embedded material and the method of filling the resulting cavities, shall be as shown on the construction drawings. The depth of removal shall not be less than the clear cover required to the reinforcing steel. The cavity so formed shall be suitably grouted for protecting the embedded metal. Also, the projecting reinforcement shall be suitably protected against corrosion.

1815 TOLERANCES

1815.1 Permissible Tolerances for Structural Unit

The dimensional tolerances for precast girders shall be as under:

Length	-	± 10 mm
Flange width and thickness	-	± 5 mm
Depth	-	± 5 mm
Web thickness	-	± 5 mm
Minimum surface unevenness	-	1.5 mm on 3 m template

1815.2 Tolerances for Prestressing Strands

Permissible tolerances for positional deviation of prestressing strands shall be as under:

Variation from the specified horizontal profile	-	5mm
Variation from the specified vertical Profile	-	5mm
Variation from the specified position in member	-	3mm

1816 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.

1817 MEASUREMENTS FOR PAYMENT

Prestressed concrete shall be measured in cubic metres. The volume occupied by mild steel reinforcement/HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

High tensile (prestressing) steel shall be paid for separately. Its length, as actually incorporated in the finished work, shall be measured and weight calculated therefrom in tonnes on theoretical basis, for payment.

Anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grouting, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same, protection by painting with epoxy and furnishing samples for testing, shall all be deemed to be incidental to and included in the item of high tensile steel and shall not be measured separately.

1818 RATE

The contract unit rate for cast in-situ prestressed concrete shall cover the cost of all materials, labour, tools and plant required for mixing, placing in position, vibrating and compacting, finishing as per directions of the Engineer, curing and other incidental expenses for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to specifications. The contract unit rate shall also include the cost of making, fixing and removing of all centering and formwork required for the work unless otherwise specified in the contract.

For precast prestressed concrete members, the unit rate, in addition to above, shall also include the cost of all materials, labour, tools and plant required, manufacturing in casting bed, transporting and placing the members in their final position as shown on the drawings and as directed by the Engineer.

The contract unit rate for high tensile steel shall cover the cost of material, labour, tools and plant required for procuring, placing, tensioning, anchoring and grouting the high tensile steel in the prestressed Concrete as shown on the drawings and as per specifications or as directed by the Engineer.

The cost of anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same, protection by painting with epoxy and furnishing samples for testing, shall all be included in the unit rate. Rate shall also include payments, if any, to be made to the supplier of the prestressing system, who has to monitor, ensure and certify the correctness of all operations.

1900

STRUCTURAL STEEL

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

1903.1 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 VS.

(S_0 = cross-sectional area).

1903.2 Materials for castings and forgings, fasteners, welding consumables and welding shall be as under:

1903.2.1 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

1903.2.2 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	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

1903.2.3 Welding Consumables

Welding consumables shall comply with the following Indian Standards as

appropriate :

IS:814 (Part 1)	Covered Electrodes for Metal Arc Welding of Structural steel for welding other than sheets
IS:814 (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

1903.2.4 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

1903.3 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.

1903.4 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

1904.1 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.

1904.2 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.

1904.3 Straightening and Bending

1904.3.1 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.

1904 3.2 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.

1904.3.3 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.

1904.4 Preparation of Edges and Ends

1904.4.1 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.

1904.4.2 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.

1904.4.3 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.

1904.4.4 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 smoothened 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.
- c) 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.
- d) Edges of single shaped plates over 2 mm thick not capable of being machined by ordinary method, which may be machine flame cut and the end surface ground.
- e) Edges of universal plates or flats of the same nominal width used in tiers, if so authorized by the Engineer.

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.

1904.5 Preparation of Holes

1904.5.1 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-rilled 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.

1904.5.2 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.

1904.5.3 Size of Holes

The diameters of rivet holes in millimetres are given in Table 1900-1.

Table 1900-1 :Diameters of Holes for Rivets

Nominal dia of. Rivets (mm)	Dia of Holes (mm)
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

1904.5.4 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 gradeH8.

The holes not drilled through all thicknesses in one operation shall be drilled to smaller size and reamed after assembly.

1904.5.5 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 plie 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

1904.5.6 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.

1904.6 Rivets and Riveting

1904.6.1 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.

1904.6.2 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-1. The underside of the head shall be free from burrs.

1904.6.3 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.

1904.6.4 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

1904.6.5 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.

1904.6.6 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.

1904.6.7 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.

1904.6.8 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.

1904.7 Bolts, Nuts and Washers

1904.7.1 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.

1904.7.2 Close Tolerance Bolts

Close tolerance bolts shall be faced under the head and turned on the shank.

1904.7.3 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.

1904.7.4 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.

1904.7.5 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% times the diameter of bolts and with a thickness not less than one quarter of diameter, shall be provided.

1904.7.6 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.

1904.7.7 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.

1904.7.8 Tightening Bolts

Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of code 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 18:4000.

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 stiffer 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.

1904.7.9 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 1Y2 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.

1904.8 Pins and Pin Holes

1904.8.1 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.

1904.8.2 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 p.in 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.

1904.9 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.

1904.10 Welding

1904.10.1 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.

1904.10.2 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 1), IS:7310 (Part I) and IS:7318 (Part I) to the satisfaction of the Engineer.

1904.10.3 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 inter pass temperature shall be in accordance with provisions of IS:9595.

1904.10.4 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.
- b) 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.

1904.10.5 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.

1904.10.6 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

1904.10.7 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

plates shall be removed by grinding or by any other method approved by the Engineer.

1904.10.8 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.

1904.11 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)	Length		
	a)	Member with both ends finished for contact bearing	$\pm 1 \text{ mm}$
	b)	Individual components of members with end plate connection	$+0\text{mm}$ I -2mm
	c)	Other members of length i) Upto and including 12 M ii) Over 12M	$\pm 2\text{mm}$ $\pm 3.5\text{mm}$
2)	Width		
	a)	Width of built-up girders	$\pm 3\text{mm}$
	b)	Deviation in the width of members required to be inserted in other members	$+0\text{mm}$ -3mm
3)	Depth		
	Deviation in the depths of solid web and open web girders		$+3\text{mm}$ -2mm
4)	Straightness		

	a)	Deviation from straightness of columns	L/3000 subject to maximum of 15 mm where L is length of member +5mm -0mm L/1000 subject to a maximum of 10 mm
	i) in elevation		
	ii) In plan		
5)		Deviation of centre line of web from centre line of flanges in built-up members at contact surface	3mm -
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	U/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 1.5mm.

1904.12 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:

- The temperature of the furnace shall not be more than 300°C at the time welded assembly is placed in it.
- 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.
- 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

1905.1 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.

1905.2 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 false-work 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 12% 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 or 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.

1905.3 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.

1905.4 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.

1905.5 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.

1905.6 Field Inspection

1905.6.1 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.

- 1905.6.2 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.

1905.6.3 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.

1905.6A Testing of Connections

1905.6.4.1 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.

1905.6.4.2 Riveted Connections

Rivets and riveted connection shall be inspected as per Clause 1904.6 and tested for compliance of code 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.

1905.6.4.3 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 18:7318 (Part 1). For approved welding procedures, the approval tests shall be as per requirements of 18:7310 (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 (3tion 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 18:9595 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.

1905.7 Procedure tests for Welds

The destructive and non-destructive test of weld shall be carried out according to IS:7307 (Part 1).

1905.7.1 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 18:1182 and 18:4853.

- 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 18:4260 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 18:3658.

- 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.

1905.7.2 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.

1905.7.3 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.

1905.7.4 Inspection of Members

1905.7.4.1 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.

1905.7.4.2 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

1906.1 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.

1906.1.1 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.

- 1906.1.2 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.

1906.1.3 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

- 1906.1.4 Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS:1477 (Part 1).

1906.2 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.

1906.3

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 coats = 200 micron

b) 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:113 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 18:2339 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.

1906.4 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.

1906.5 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.

1906.6 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 finishing coats 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.

1906.7 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 μm	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 μm (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 :130-150 μm	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. Total dry film thickness : 200 μm	Severe coastal and non-coastal interior situations
vi)	Blast clean the surface; 350-450 μm thickness coal tar epoxy.	Severe

	Type of Coating	Exposure Condition
vii)	Pickle; hot dip galvanised (Zinc). Total thickness: 85 µm (life up to 15-20 years)	Moderate
viii)	Grit blast, hot dip galvanised. (Zinc). 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 tonnes 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: 7.84×10^{-3} kg/cu.cm. Cast Iron : 7.21×10^{-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
33	27.2

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.

2000

BEARINGS

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

2003.1 Materials

2003.1.1 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.

2003.1.2 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 normalized 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.

2003.1.3 High Tensile Steel

High tensile steel shall comply with 18:961.

2003.1.4 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 18:1030.

Quality level of castings shall be Level3 as per 18:9565.

2003.1.5 Stainless Steel

Stainless steel shall be in accordance with Clause 1009.7 of these Specifications.

2003.1.6 Welds

Welding of steel conforming to IS: 2062 shall be as per 18:1024 using electrodes as

per IS: 814.

2003.1.7 Grease

The grease for bearings shall conform to the requirements of IS: 503 (Grade 4).

2003.2 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.
- c) 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.
- d) 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.
- e) 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.

2003.3 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.

2003.4 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 18:19.

Tolerances on diameter of all concave surfaces shall conform to DB of 18:19.

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.

2003.5 Installation

2003.5.1 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.
- d) For bridges in gradient, the bearing plates shall be placed in a horizontal plane.

2003.5.2 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.

2003.5.3 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.

2003.6**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):

18:1030 for casting

15:2062 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 18:9565. 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/OPT 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.

2003.7 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

2004.1 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.

2004.2 Pin Bearing

2004.2.1 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.

2004.2.2 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.

2004.2.3 Materials

- i) The material of pin bearing including rocker plates shall be high tensile steel conforming to 15:961.
- 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.

2004.2.4 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.

2004.3 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.

2004.4 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.

2005.1 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 percent. 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 18:3400-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.

2005.1.2 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 IS Specification Reference
(1)	(2)	(3)			(4)
1. Physical properties					
1.1 Hardness	IRHD	50±5	60 ±5	70 ± 5	18:3400 (Part II)
1.2 Minimum tensile strength					
- Moulded test piece	MPa	17	17	17	18:3400 (Part I)
- Test piece from bearing		14	14	14	
1.3 Minimum elongation at break					
- Moulded test piece	%	450	400	300	18:3400 (Part II)
- Test piece from bearing	%	400	350	250	18:3400 (Part II)
2. Maximum compression set(%) (24 h, 100 ± 1 °C)	%	< 35			IS:3400 (Part X)

3. Accelerated aging (72 h, 100 ± 1 °C) (Maximum change from un- aged value)			IS:3400 (Part IV)
3.1 Maximum change in hardness	IRHO	±5	
3.2 Maximum change in tensile strength	%	±15	
3.3 Maximum change in elongation	%	±30	

2005.1.3 Shear modulus (G) is the apparent "conventional shear modulus" of the elastomer bearing determined by testing. At nominal temperature of 23 °C ± 2°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±5	0.7	±0.15
60±5	0.9	± 0.18
70±5	1.15	± 0.20

2005.1.4 The adhesion strength of elastomer to steel plates determined according to 18:3400 (Part XIV) method A, shall not be less than 7 Kn/m.

2005.1.5 For elastomeric bearings (CR) used in adverse climatic conditions, the ozone resistance of elastomer shall be proved satisfactory when assessed by test according to 15:3400 (Part XX). The testing shall be carried out for a duration of 96 hours at a temperature of 40±1°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.

2005.1.6 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.

2005.1.7 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.

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.

2005.2 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 vulcanized 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 vulcanization using suitable bonding agent for bonding of elastomer to steel such that the bond peel strength is at least 7 N/mm widths when tested in accordance with 18:3400 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 are large.

2005.3

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)	Overall linear plan dimensions	-3 mm, +6 mm
2)	Total mean bearing thickness (The mean thickness is the arithmetic average of the thickness measured at five points on the major surface as indicated for various shaped bearings: Rectangular : corners and centre Circular : corners of inscribed square and centre)	-2.5%, +5%
3)	Parallelism	
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)	Thickness of individual layer of elastomer	
a)	Inner layer of elastomer	±12% (max of 2 mm)
b)	Outer layer of elastomer	+20% (max of 1 mm)
c)	Side cover	-0 mm, +3 mm
5)	Dimension of laminates	
a)	Plan dimensions of laminates	-3mm, +0
b)	Thickness of laminate	±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 and the surface shall not exceed the tolerances specified below	
a)	Load bearing surface of the bearing	0.3% of diameter or diagonal or 2% of mean bearing thickness whichever ever is higher
b)	Steel laminate	1% of diameter or diagonal (max of 1.5 mm)

2005.4 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.

2005.4.1 Acceptance Lot

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 numbers 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 of the purpose of acceptance testing.

2005.4.2 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 borne by the user, while the cost of all other materials, equipment and testing shall be borne by manufacturer.

2005.4.3 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:

2005.4.3.1 Acceptance Testing Level I

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 earing 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 vulcanizing 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	+ 0.2.
Ash Content	± 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.

2005.4.3.2 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.

2005.4.4 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

2005.4.5 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.

2005.4.6 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 result 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.

2005.4.7 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.

2005.6 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 comers 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.

2005.7 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 ± 3 mm).
- iii) Concrete surfaces shall be free from local irregularities (maximum tolerance ± 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.

2005.8 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.

2006 POT BEARINGS

2006.1 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.

2006.2 Materials

2006.2.1 Structural steel, mild steel, high tensile steel and steel for forging shall conform to the requirements of Section .1009 of these Specifications.

2006.2.2 Cast steel shall comply with Grade 280-520W or 340-570W of IS:1030. -

2006.2.3 Stainless steel shall conform to AISI316 L or $O_2Cr_{17}Ni_{12}MO_2$ of IS:6911.

2006.2.4 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).

2006.2.5 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-	

2006.2.6 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.

2006.2.7 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.

2006.2.8 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

2006.3 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 inter locking 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 2% quality as per IS:9595.
- 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.

2006.3.1 Manufacturing Tolerances

2006.3.1.1 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 15:4897
7)	Stainless steel sliding surface (a) Flatness (b) Surface finish	0.0004L, where L= length in direction of movement Ras0.251Jm as per IS:3073

2006.3.1.2 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 ± 0.5 mm, ± 0.5 mm and ± 1.0 mm respectively.

2006.3.1.3 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	± 1.0	-0 to +0.5	-0 to +0.5
>600, S1200	± 1.5	-0 to +0.6	-0 to +0.6
>1200, S1500	± 2.0	-0 to +0.7	-0 to +0.8

2006.3.1.4 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.

2006.4 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
- ii) 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 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.

2006.4.1 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).

2006.4.2 Process Inspection/Tests

- i) Test on welding shall consist of DP test and visual inspection as per IS:82

- ii) The hardness of all major steel components shall be tested to determine the Brinell 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 JS: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.

2006.4.3 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 (μ) 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

Average Pressure on Confined PTFE (MPa)	Maximum Coefficient of Friction
5	0.08
10	0.06
20	0.04
≥ 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.

2006.4.4 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

2006.5 Installation

2006.5.1 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.

2006.5.2 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.

2006.5.3 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 mean 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.

2006.5.4 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.

2006.5.5 Installation Tolerances

Bearings shall be located so that their centre lines are within ± 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 ± 0.0001 times the sum of the adjacent spans of a continuous girder, but not exceeding ± 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.

2006.6 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 elastomeric bearings shall be measured in cubic centimetres 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.

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 this Specification.

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:

- 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) 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

- i) 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.
- ii) 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.
- iii) 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.
- iv) 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.
- v) 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.
- vi) The concrete surface shall be finished smooth with a 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) Apit 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.
 - b) Water table is depressed by well point system or other methods.
 - c) Steel/concrete caissons or sheet piling are used 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.
- xi) 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.
- xii) Protective works, where provided shall be completed before the onset of floods so as to avoid the risk of the foundation getting undermined.

2105 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

- a) Variation in dimensions : +50 mm, -10 mm
- b) Misplacement from specified position in plan : 15mm
- c) Surface unevenness measured with 3m straight edge : 5mm
- d) Variation of levels at the top : ± 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.

2200
SUBSTRUCTURE

2201 DESCRIPTION

The work shall cover furnishing and providing masonry or reinforced concrete substructure in accordance with the drawings and as per these Specifications or as directed by the Engineer.

2202 MATERIALS

Materials shall conform to Section 1000 of these Specifications.

2203 GENERAL

2203.1 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.

2203.2 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.

2203.3 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

2204.1 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.

2204.2 In case of tall piers and abutments, use of slip form shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be subjected to additional specifications as necessary. All specifications and arrangements for use of slip form and placing of concrete therein shall be subjected to the approval of the Engineer.

- 2204.3 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.
- 2204.4 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.
- 2204.5 The surface finish shall be smooth, except on the earth face of abutments which shall be rough finished.
- 2204.6 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

- 2205.1 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.
- 2205.2 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.
- 2205.3 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

- 2206.1 In case of cantilever return wall, no construction joint shall be permitted. The dirt wall and cantilever return walls shall be cast in one operation.
- 2206.2 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.
- 2206.3 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.

2206.4 For masonry/concrete return walls and wing walls, weep holes shall be provided as prescribed for abutments or as shown on the drawings.

2206.5 The finish of the surface on the earth side shall be rough while that of the front face shall be smooth.

2206.6 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

2207.1 The materials shall be tested in accordance with these specifications and shall meet the prescribed requirements.

2207.2 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, -5 mm
b)	Misplacement from specified position in plan	10mm
c)	Variation of levels at the top	±10 mm
d)	Variations of reduced levels of bearing areas	±5mm
e)	Variations from plumb over full height	±10 mm
f)	Surface unevenness measured with 3 m straight	
	All surfaces except bearing areas edge	5mm
	Bearing areas	3mm

2209 MEASUREMENTS FOR PAYMENT

2209.1 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.

2209.2 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.

2209.3 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.

2209.4 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. as show on the drawings.

2300

CONCRETE SUPERSTRUCTURE

2301 DESCRIPTION

The work shall cover furnishing and providing of concrete superstructure in accordance with the drawings and as per these Specifications or as directed by the Engineer.

2302 MATERIALS

Materials shall conform to Section 1000 of these Specifications.

2303 GENERAL

2303.1 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

2303.2 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.

2303.3 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.

2303.4 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

2304.1 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 contra flexure, 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.

2304.2 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

2305.1 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.

2305.2 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.

2305.3 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.

2305.3.1 Grades of Concrete

Minimum grades of concrete, minimum cement content, maximum water-cement ratio and other durability requirements shall be as indicated in Tables 1tb0-2 and 1700-3 of these Specifications.

2305.3.2 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 sorted 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.

2305.3.3 Tolerances in Precasting

Finished segment tolerances should not exceed the following:
Finished segment tolerances should not exceed the following:

Length of match-cast segment (not cumulative)	±5mm
Overall span length between bearings	± 10mm
Web thickness, depths of top and bottom flanges, width of top and bottom flanges, overall depth of segment, thickness of diaphragm	±5mm
Grade of edge and and soffit	± 1 mm/m
Tendon hole location	±3mm
Position of shear keys	±5mm

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.

2305.3.5.1 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.

2305.3.5.2 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 20MPa at 12 hrs, 40 MPa at 24 hrs and 75 MPa at 168 hrs (at lower temperature limit)

2305.3.6 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.

2305.3.7 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.

2305.3.8 Prestressing Ducts

In the case of dry jointed segments, the prestressing ducts shall necessarily be of HOPE. In the case of epoxy jointed segments, either metallic or HOPE 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, HOPE, 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

2307.1 Precast Concrete 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 |
| b) | Variations in web thickness | -5 mm to +10 mm |
| c) | Variations in overall depth or width | ± 5 mm |
| d) | Variation in length overall and length between bearings | shall not exceed ± 10 mm or $\pm 0.1\%$ of the span length, which ever is less |
| e) | Permissible surface unevenness in deck slab when measured with a 3 m straight edge or template | 5 mm |

2307.2 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 | ± 5 mm |
| d) | Variation in length overall and length between bearings | shall not exceed ± 10 mm or $\pm 0.1\%$ 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.

2600

EXPANSION JOINTS

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

2602.1 The type of expansion joint proposed to be used shall conform to the design and got approved by the Engineer.

2602.2 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.

2602.3 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.

2602.4 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

2603.1 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.

2603.2 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.

2603.3 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
- vii) look good aesthetically.

2603.4 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

2604.1 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:

2604.2 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 18:1838, 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.

2604.3 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

2605.1 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.

2605.2 Material

- i) Mild steel to be used for manufacture of steel reinforcing plates, inserts and anchorage shall comply with Grade 8 of IS:2062.
- ii) Cast steel to be used for manufacture of steel reinforcing plates shall comply with 18:1030
- 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 ± 5 .

2605.3 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 2% 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 : $\pm 5\text{mm}$

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

2606.1 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 mm²
- 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 mm² 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 ± 40 mm parallel to the joint.

Minimum gap for inserting the Chloroprene seals in the expansion joint shall be 25 mm.

2606.2 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 8 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 8 of IS: 2062 or equivalent standard.

Table 2600-1 : Properties of Chloroprene Seal

Property	Standard	Specific Value
Hardness	DIN53505 ASTM D 2240 *	63 + 5ShoreA 55+ 5 Shore A
Tensile Strength	DIN 53504 ASTM D 412*	Min 11 MPa Min 13.8 MPa
Elongation at fracture	DIN 53504 ASTM D 412*	Min 350% Min250%
Tear propagation strength longitudinal transverse	DIN 53507 ASTM D 624* (Dia C)	Min 10N/mm Min 10N/mm
Shock elasticity	DIN 53512	Min25%
Abrasion	DIN 53516	Max220 mm ³
Residual compression strain (22h/70°C/30% strain)	DIN 53517 ASTM D 395* (Method B)	Max28%
Ageing in hot air (14 days/70°C) Change in hardness Change in tensile strength change in elongation at fracture	DIN 53508	Max + 7 Shore A Max – 20% Max – 20%
Ageing in ozone (24h/50pphm/25°C/20% strain)	DIN 53509	No cracks
Swelling behavior in oil (168h/25°C) ASTM oil No. 1 Volume Change Change in hardness ASTM oil No. 3 Volume Change Change in hardness	DIN 53521	Max+5% Max – 10 Shore A Max+ 25% Max – 20 Shore A
Cold hardening point	ASTM D 1043	Min -35°C

Note: *Only one specification viz., ASTM or DIN shall be followed depending on the source of supply.

2606.3 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.

2606.4 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

2607.1 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 (H). 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 25mm.
- 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.

2607.2 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.

2607.3 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).

2607.4 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

2608.1 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.

2608.2 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 01190 at a rate of 3.2 mm/hour at and tested to limits 88:2499) : 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	
	20mm	25mm
	Percentage by Weight Passing the Sieve	
26.5 mm	100	-
19.9 mm	85-100	100
13.0 mm	0-35	85-100
9.5mm	0-7	0-35
6.3mm	-	0-7
2.3mm	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:

PSV > 60

MV > OS

AIV < 18

ACV= 10-25

The surface characteristics should promote proper adhesion.

- iii) **Closure Plate :** The closure plate shall be weld able structural steel conforming to 15:2062. 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/ backer rod 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 kg/m³ to 30 kg/m³

2609 COMPRESSION SEAL JOINT

2609.1 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/ni 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.

2609.2 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 ² (max)
Ash Content	IS:3400 Part XXII	5%
Polymer identification test (infrared spectro photometry)	ASTM D 3677	Comparison of spectra with reference to sample of polychloroprene

- 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

2610.1 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 1st 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 2nd 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 2nd (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.

- x) 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.

- xi) 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.

2610.2 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 Lipper 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.

2610.3 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.

2610.4 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.
- iv) 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.

2610.5 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/steedge 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.

2610.6 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:

i) 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.

ii) 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 2nd 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 very 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.

iii) 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.

iv) 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 earring course.

While completing this part of the wearing course, adequate care shall be taken to ensure a water proof joining with the already existing wearing course.

v) 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.

vi) 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

2612.1 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 5Hz 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 recognized 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 18:3400 (Part 3) or DIN 53516.

2612.2 Pre-installation Criteria

The pre installation criteria shall include the routine tests and acceptance tests as described below:

2612.2.1 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), 5235 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 G) swelling behavior 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.

2612.3 Acceptance Tests

2612.3.1 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 7.5.
- 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.

2612.3.2 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
Pending	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	Applicable*
Vehicular braking/traction test	Not Applicable	Not Applicable	Applicable	Applicable	Applicable*

* For modular strip seal expansion joint pending test, debris expelling test, pull-out test and vehicular braking/tractor 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 expansion joint shall be measured in running metres.

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 metre 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.

2700

WEARING COAT AND APPURTENANCES

2701 DESCRIPTION

The work shall include wearing coat and bridge appurtenances such as railing, crash barrier, approach slab, drainage spout and weep holes. The work shall be executed in conformity with details shown on the drawings and these specifications or as approved by the Engineer.

2702 WEARING COAT

2702.1 Bituminous Wearing Coat

Bituminous wearing coat shall comprise of following types:

Type 1: Bituminous Concrete 50 mm thick laid in single layer

Type 2 : Bituminous Concrete 40 mm thick overlaid with 25 mm thick-mastic asphalt

Type 3: Stone Matrix Asphalt 50 mm thick laid in single layer

Type 4: Mastic Asphalt 50 mm thick laid in single layer

Before laying wearing coat the deck surface shall be thoroughly cleaned and tack coat shall be applied. The construction operations and bituminous mixes and tack coat shall conform to Section 500 of these Specifications.

2702.2 Cement Concrete Wearing Coat

Cement concrete wearing coat shall be laid separately over the bridge deck. The thickness of wearing coat shall be 75 mm. The concrete shall be of minimum M30 grade. Steel reinforcement of 8 mm diameter at 150 mm spacing in both directions shall be provided at the mid depth of the wearing coat. In a length of 1 m near the expansion joint additional reinforcement of 8 mm diameter bars shall be provided in both directions to make the spacing as 75 mm.

Cement concrete and steel reinforcement shall conform to Section 1700 and Section 1600 respectively of these Specifications.

Curing of wearing coat shall start as early as possible.

All carriageway and footpath surfaces shall have non-skid characteristics.

2702.3 The cross slope in the deck shall be kept as 2.5 percent.

2702.4 For the structures with flat deck surface, camber/super elevation in the wearing coat shall be achieved as below:

- i) In bituminous wearing coat provide profile making course before laying wearing coat. The profile making course shall be of the same material as of wearing coat. The thickness of wearing coat at any point shall not be less than that given in Clause 2702.1 of these Specifications.
- ii) In case of cement concrete wearing coat provide profile corrective course along with

wearing coat in single layer.

- 2702.5** Overlay on the existing wearing coat on bridge decks shall not be permitted. In case the wearing coat is damaged, it shall be repaired or replaced. The dismantling of wearing coat shall be as per Section 2800 of these Specifications.

2703 RAILING AND CRASH BARRIER

2703.1 General

- a) Bridge railing/crash barrier includes the portion of the structure erected on and above the kerb.
- b) Railing/crash barrier shall not be constructed until the centering false work for the span has been released and the span is self-supporting.
- c) For concrete with steel reinforcement, specifications for the items of controlled concrete and reinforcement mentioned under relevant Sections of these Specifications shall be applicable.
- d) The railing/crash barrier shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled with non-shrink mortar.
- e) The type of railing/crash barrier to be constructed shall be as shown on the drawings and shall conform to IRC:5 and IRC:6.
- f) Care shall be exercised in assembling expansion joints in the railing/ crash barrier to ensure that they function properly.
- g) The railing/crash barrier shall be of such design as to be amenable to quick repairs.
- h) The material of metal railing/crash barrier shall be handled and stored with care, so that it remains clean and free from damage. Railing/crash barrier materials shall be stored above the ground on platforms, skids, or other supports and kept free from grease, dirt and other contaminants.

Any material which is lost, stolen or damaged after delivery shall be replaced or repaired by the Contractor. Methods of repairs shall be such that they do not damage the material or protective coating.

2703.2 Metal Railing/Crash Barrier

Materials, fabrication, transportation, erection and painting for bridge railing/crash barrier shall conform to the requirements of Section 1900 of these Specifications.

All steel railing elements, pipe terminal Sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint.

If galvanised, all elements of the railing/crash barrier shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done as per method approved by the Engineer.

Damaged galvanised surfaces, edges of holes and ends of steel railing/crash barrier cut after galvanising shall be cleaned and re-galvanised.

The railing/crash barrier shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout its length. Holes for field connections shall be drilled with the railing/crash barrier in place in the structure at proper grade and alignment.

Unless otherwise specified -on the drawings, metal railing/crash barrier shall be given one shop coat of paint and three coats of paint after erection, if sections are not galvanised.

Railing/crash barrier shall follow the alignment of the deck. Where required as per the drawings, the rail elements shall be before erection.

2703.3 Cast In-Situ Concrete Railing/Crash Barrier

The portion of the railing/crash barrier or parapet which is to be cast in-situ shall be constructed in accordance with the requirements for Structural Concrete Section and reinforcement conforming to Sections 1600 and 1700 of these Specifications.

Forms shall be fabricated conforming to the shape of railing/crash barrier shown on the drawings. It shall be ensured that no form joint appears on plane surfaces. For bridges/ viaducts of length more than 500 m horizontal slip forms shall be used for casting of crash barriers.

All mouldings panel work and bevel strips shall be constructed according to the details shown on the drawings. All comers in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects. Castings of posts shall be done in single pour.

2703.4 Precast-Concrete Railing/Crash Barrier

Precast members for railing/crash barrier shall be of reinforced cement concrete and shall conform to Sections 1600 and 1700 of these Specifications. The maximum size of the aggregate shall be limited to 12 mm and minimum concrete grade shall be M30 for railings and M40 for crash barriers. The precast members shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days, during which they shall be protected from sun and-wind. Any precast member that becomes chipped, marred or cracked before or during the process of placing shall be rejected.

2704 APPROACH SLAB

Reinforced concrete approach slab with 12 mm dia. bars at 150 mm c/c in each direction both at top and bottom in M30 grade of concrete covering the entire width of the roadway, shall be provided as per details given on the drawings or as approved by the Engineer. Minimum length of approach slab shall be 3.5 m and minimum thickness 300 mm.

The cement concrete and reinforcement shall conform to Sections 1700 and 1600 respectively of these Specifications.

The approach slab shall rest on a base of 150 mm thick M15 grade concrete or as shown on the drawings or as directed by the Engineer.

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.

2705.1 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.

2705.2 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.

2705.3 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 18:1834 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.

2706 WEEP HOLES

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 1.00 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:

- i) Bituminous and cement concrete wearing coat shall be measured in cubic metres. Steel reinforcement in wearing coat shall be measured in tonnes.
- ii) Railing and metal beam crash barriers shall be measured in running metres.
- iii) For concrete crash barriers concrete shall be measured in cubic metres and steel shall be measured in tonnes.
- iv) Approach slab and its base shall be measured separately in cubic metres.
- v) Drainage spouts shall be measured in numbers.
- vi) 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.

2900

PIPE CULVERTS

2901 SCOPE

This work shall consist of furnishing and installing reinforced cement concrete pipes, of the type, diameter and length as per design and details and at locations shown on the drawings or as ordered by the Engineer and in accordance with the requirements of these Specifications.

2902 MATERIALS

All materials used in the construction of pipe culverts shall conform to the requirements of Section 1000.

Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the Engineer either at the place of manufacture or at the site before their incorporation in the works.

2903 EXCAVATION FOR PIPE

The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to levels as shown on the drawings. In case of high embankments where the height of fill is more than three times the external diameter of the pipe, the embankment shall first be built to an elevation above the top of the pipe equal to the external diameter of the pipe, and to width on each side of the pipe of not less than five times the diameter of pipe, after which a trench shall be excavated and the pipe shall be laid.

Where trenching is involved, its width on either side of the pipe shall be a minimum of 150 mm or one-fourth of the diameter of the pipe whichever is more and shall not be more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

The pipe shall be placed where the ground for the foundation is reasonably firm. Installation of pipes under existing bridges or culverts shall be avoided as far as possible. When during excavation the material encountered is soft, spongy or other unstable soil, and unless other special construction methods are called for on the drawings or in special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with approved granular material which shall be properly shaped and thoroughly compacted upto the specified level.

Where bed-rock or boulder strata are encountered, excavation shall be taken down to atleast 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/ boulders in this area be removed and the space filled with approved earth, free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Trenches shall be kept free from water until the pipes are installed and the joints have hardened.

2904 BEDDING FOR PIPE

The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be of one of the following two types as specified on the drawings:

- i) **First Class Bedding** :Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for atleast ten percent of its overall height or as otherwise shown on the drawings. The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted/rammed. The compacted thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75 mm.
- ii) **Concrete Cradle Bedding**: When indicated on the drawings or directed by the Engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M 15 conforming to Section 1700. The shape and dimensions of the cradle shall be as indicated of the drawings. The pipes shall be laid on the concrete bedding before the concrete has set.

2905 LAYING OF PIPE

No pipe shall be laid in position until the foundation has been approved by the Engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

The arrangement for lifting, loading and unloading concrete pipes from factory/yard and at site shall be such that the pipes do not suffer any undue structural strain, any damage due to fall or impact. The arrangement may be got approved by the Engineer.

Similarly, the arrangement for lowering the pipe in the bed shall be got approved by the Engineer. It may be with tripod-pulley arrangement or simply by manual labour in manner that the pipe is placed in the proper position without damage.

The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

2906 JOINTING

The pipes shall be jointed either by collar joint or by flush joint. In the former case, the collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be so placed that its center coincides with the joint and an even annular space is left between the collar and the pipe.

Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing

space 13 mm wide. The jointing space shall be filled with cement mortar, 1 cement to 2 sand, mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

For jointing pipe lines under light hydraulic pressure, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

2907 BACKFILLING

Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, excessive amounts of sods or other vegetable matter, and lumps and shall be approved by the Engineer. Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used.

Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of high embankment, after filling the trench upto the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.

2908 HEAD WALLS AND OTHER ANCILLARY WORKS

Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer. Masonry for the walls shall conform to Sections 1300, 1400 or 1700 as applicable. Aprons shall conform to Section 2500.

2909 OPENING to TRAFFIC

No traffic shall be permitted to cross the pipes unless height of filling above the top of the pipes is atleast 600 mm.

2910 MEASUREMENTS FOR PAYMENT

RCC pipe culvert shall be measured as complete work in linear metres along its length between the inlet and outlet ends. Culverts with multiple rows of pipes shall be measured as one unit, irrespective of the number of rows.

2911 RATE

The Contract unit rate. for the pipe culvert shall include the cost of pipes including

loading, unloading hauling, handling, storing, laying in position and jointing and all ancillary works such as excavation, bedding for pipes, backfilling, concrete, masonry and aprons and incidental costs to complete the work as per these Specifications.

SPECIALIZED SPECIFICATION FOR ITEN NO. 16 TO 19 & 30

Bridge Works - Super Structure (Steel)

4.1.1 All steel work, whether in fabrication or in erection, shall be done in accordance with the relevant Codes of Practice, Indian Railway Standard Specification serial No. B1- 2001 with latest correction slips and Standard Specifications, subject to any further provisions contained in this chapter. These specifications are equally applicable to steel structures in buildings and sheds except where specified otherwise. In the event of any of these provisions being at variance with the standard IRS specifications, the latter shall prevail unless otherwise specified by the Engineer or in Drawings.

4.1.2 Weight for Payment

- (a) Weight for payment for steel work shall be based only on the theoretical weight of main components and gusset plates, without any additional weight on account of rivets, bolts, welds etc. unless specifically specified otherwise in the description of an item of Bill(s) of Quantity.
- (b) In calculating the weight of the finished work, the overall lengths of the members used in the fabrication (i.e. as measured square) shall be taken into account and no deduction shall be made for rivet or bolt holes, skew cuts, notches etc. Gussets shall be measured as per the dimensions of the smallest enveloping rectangles.
- (c) In case of composite work (welding and HSFG bolts), only HSFG bolts shall be paid in addition.
- (d) Holding down bolts, nuts and washers as well as anchor channels or plates, shall be measured separately.
- (e) Materials, used temporarily for assembly and erection but not forming part of the permanent work, shall not be payable.

4.2 MATERIALS

4.2.1 General requirements

General requirements relating to the supply of material shall conform to IS:1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Mild steel shall be to IS:2062 and HTS to IS:961 unless otherwise specified. In case of imported material, Steel work Specifications of the country of origin or equivalent IS Specifications shall be as indicated in the Contract or by 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. They shall also be free from loose mill scale, rust, pitting or other defects affecting its strength and durability.

The acceptance of any material on inspection at the mill i.e. rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective. Unless specified otherwise, high tensile steel rivet conforming to IS:1149 shall be used for members of high tensile steel conforming to IS:961 and shall not be used for mild steel members. Unless specified otherwise, 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 portion of the bridge structure, except where it is subject to direct compression and as shown in the drawings.

4.2.2 Standards Applicable

4.2.2.1 All materials shall conform to requirements of respective IS Codes and IRS Specifications listed below. Special requirements are given below:

Steel for bolts and nuts shall conform to IS:2062 and IS:1148 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 and IS:1149 but with a minimum tensile strength of 58 kg/sq.mm. High strength friction grip bolts as per RDSO report No. BS-111 shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these specifications) specified by the Engineer or included in the special provisions of the Contract.

4.2.2.2 For cast steel, the yield stress shall be determined and shall not be less than 50 per cent of the minimum tensile strength.

4.2.2.3 Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

4.2.2.4 Parallel barrel drifts shall have a tensile strength not less than 55 kg/ sq.mm. With elongation of not less than 20 per cent measured on a gauge length of 4 So (So = cross sectional area in sq.mm).

4.2.2.5 Materials for castings and forgings, fasteners and welding consumables shall be as per relevant IS code.

4.2.3 Use of Corrosion Resistant steel

In aggressive environment, corrosion resistant steel can be used. These are low-alloy steels containing a total of 1% to 2% alloys, in particular, copper, chromium, nickel and phosphorous.

4.2.4 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. Relevant Chapter of Specification on painting deals with Painting including of steel work and may also be referred to.

4.3 FABRICATION OF STEEL WORK

4.3.1 Codes of Specifications: The work shall be done in accordance with the following codes and specifications and any other requirements that may be prescribed in special cases.

(a) Bridge Work

1. IRS Steel Bridge Code
2. IRS Specification Serial No. B1-2001 for Steel Girder Bridges
3. IRS Specification No. M 3-Class I, II, III and IV Steel forgings, blooms for forgings and billets for re-rolling
4. IRS Specification No. M-28: IRS specification for classification, testing and acceptance criteria of manual Metal arc welding electrodes and gas welding rods.
5. IRS Specification No M-39: IRS specification for classification, testing and acceptance criteria of fire and flux for submerged arc welding of structural steel for use on Indian Railways.
6. IRS Specification No M-41 Corrosion resistance steel
7. IRS Specification No M-42 High strength low alloy structural steel with enhanced corrosion resistance.
8. IRS Specification No M-49 High strength excavating structural steel rivet bars with enhanced

- corrosion resistance.
- 9. Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest
- 10. Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest
- 11. High performance Anti-Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018 or latest
- 12. Poly urethane based Aluminium finish paint to RDSO specification no. M&C/PCN/110/2020 or latest
- 13. Epoxy Based Coal Tar Paint (Two Pack) to RDSO specification No. M&C/PCN/105/2020 or latest
- 14. Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures).
- 15. Specification for Hot Dip Galvanizing on Structural steel and other allied products conforming to IS: 4759 and IS: 2629.
- 16. IS: 104 -Specification for Ready Mixed Paint, Brushing, Zinc Chrome Priming.
- 17. IS: 2074 -Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome Priming.
- 18. IS: 2339 –Specification for Aluminum Paint for General Purposes in Dual Container.
- 19. IS: 5666 - Specification for Etch (Pretreatment) Primer.
- 20. IS: 77- Specification for Linseed Oil, Boiled for Paints.
- 21. Grade SS 304 for stainless steel tubes, sheets, strips etc.
- 22. Grade 316L for stainless steel structural members
- 23. IS:1367 &IS:4000 for HSFG Bolts

The fabrication and erection of the steel work shall be in accordance with IRS Specification Serial No. B1-2001 supplemented by relevant provisions of this Specifications.

- (b) Iron and steel tanks and staging: IRS Specification No. B-3-61 Part 4
- 4.3.2 Quality of Steel: The steel used for fabrication work shall conform to the appropriate quality as per latest amended standards specified below, unless the use of any other quality of steel is specially approved.
 - i) IS 2062: (Standard quality): For non-welded structures subjected to dynamic loading and for welded non-dynamically loaded structures, if the thickness of material welded does not exceed 20mm.
 - ii) IS:2062 (Fusion welding quality) - For all welded structures for which IS:2062 (Standard Quality) is not suitable.
 - iii) IS:2062 (Ordinary quality)
- (a) Grade ST 44-0: For non-welded structures not subjected to dynamic loading other than wind (e.g. sheds, buildings, foot over bridges) except structures designed according to plastic theory.
- (b) Grade ST-32-0: For general purposes where the load carried is not the main consideration (e.g. grills, railings)
- 4.3.3 Straightening of members: All members used shall be straight except those meant to be curved and any straightening necessary shall be carried out before the material is worked upon. The straightening shall be done by pressure and no heating resorted to except with the prior approval of the Engineer and with such safeguards as considered by him to be necessary.
- 4.3.4 Cutting of Steel

Cutting of steel for fabrication may be done by shearing, sawing or by gas. For less important works the Engineer may permit the use of chisels and Jim crows also. Gas cutting for important works shall preferably be done by mechanically controlled torches. Cut edges shall be machined where so specified. If machining is not specified, hand flame cut, chisel cut and

Jim crowed edges shall be ground smooth where so directed by the Engineer. Para 17 of IRS Specification Serial No. B1-2001 may also be referred to in this connection.

4.3.5 Making of Holes

- a) In all important works and in splices, the holes for rivets or bolts shall either be drilled to the correct sizes or sub-punched initially to a diameter 6mm less than the finished diameter and reamed subsequently to the correct sizes as indicated in Para 18 of IRS Specification Serial No. B1-2001. Sub-punching is, however, not permissible in the main truss members of open-web bridge girders.
- b) Forming of holes by gas-cutting is strictly forbidden.
- c) Holes for rivets and black- bolts shall be 1.5mm (1/16 inch) larger in diameter than the rivet bar or the bolt, and care shall be taken not to exceed this limit. In the case of turned bolts the holes shall be drilled to such tolerances as laid down in Para 18.5 of IRS Specification Serial No. B1-2001 Specification for Steel girder Bridges and Locomotive turn-tables.
- d) Marking and drilling of holes in members, especially for the end connections, shall preferably be done with the use of templates. Holes in rolled sections shall follow the standard gauge lines unless otherwise indicated in the drawings.

4.3.6 Riveting

- a) Unless otherwise specified, the size of the rivet shall be designated by the diameter of the rivet bar and not that of the hole or the finished rivet. Rivets and Rivetting shall be in accordance with Para 23 of IRS Specification Serial No. B1-2001 supplemented by following specifications.
- b) The rivet shank shall be of length just sufficient to fill the hole thoroughly and to form a full head of the standard proportions as shown below. Generally, the sizes in the Table at Annexure 4.1 shall be found sufficient.
- c) Rivets shall completely fill the holes and shall be machine driven, unless otherwise permitted by the Engineer under special circumstances. Riveting shall be done by means of pressure or percussion riveters of approved design. Hand riveting shall not be resorted to except with the prior approval of the Engineer. The rivets shall be at the proper heat and in no case shall the tip be hotter than the head. Rivets less than 10mm (or 3/8 in.) in diameter may be driven cold.
- d) Before riveting is commenced, the work shall be kept tightly bolted together. Special care shall be taken to retighten the bolts frequently as the riveting proceeds.
- e) Driven rivets, when struck sharply on the head with a 110 g (1/4 lb) rivet testing hammer, shall be free from movement and vibration. All loose and burnt rivets and those with cracked badly formed, eccentric or deficient heads shall be cut out and replaced. While cutting out rivets care shall be taken not to damage the surrounding metal and not to disturb adjoining rivets. Recouping and caulking shall in no circumstance be resorted to.

4.3.7 Welding

- a) In the case of welded fabrication, the following directions shall be observed in addition to the provisions of the IRS welded Bridge Code.
- i) Shop welding shall be adopted wherever possible in fabricating components and sub members for welding shall be done by submerged Arc Welding.
- ii) Suitable jigs and fixtures shall be used, both in the field and in the shop, to avoid distortion during welding, and in the case of plated construction, to control distortions within the same limits as applicable to corresponding rolled sections.

- iii) Components which are mass fabricated in the shops should be proved in master templates.
- b) Unless specified otherwise, the lowest classes of electrodes to be used for different types of welding work shall be as given in Table 4.1 (a) under, based on IRS Specification No.M.28-2020 for the classification.

Table 4.1 (a) Classification of Electrodes as per their application

IRS Class	Purpose of use	IS Specification	IS/AWS Code*
A1	Fabrication of component meant for static application made of steels to IS: 2062- 2016 Gr. E250 Quality A, IS:1875-2014 Class I & IA or equivalent. Suitable for joining steel sheets to IS: 513-2013, IS: 1079-2017 & Gr. Fe 330 to IS: 5986-2017 or equivalent and for repair welding of cast steels to IS: 1030-2012 Gr. 200-400W. This electrode can also be used for welding where strength requirement is not specified.	IS: 814-2004 (R2016)	ER4112 (Medium coated)
A2	Fabrication of component meant for semi-dynamic application such as bridges etc., made of steel to IS: 2062-2016 Gr. E250 Quality BR&B0, IS: 1875-2014 Class I & IA or similar. The weld deposit shall be of radiographic quality	IS: 814-2004 (R2016)	ER4211X (Medium coated)
A3	Fabrication of component meant for highly dynamic application made of steels to IS: 2062-2016Gr.E250 quality C or for other applications where low temperature impact property is required. The weld deposit shall be of radiographic quality.	IS: 814-2004 (R2016)	EB5326H2X (Heavy coated)
A4	Application same as A3 above with high deposition efficiency	IS: 814-2004 (R2016)	EB5326H2JX (Heavy coated)
A5	For pipe welding or other applications where high penetration of arc is needed.	IS: 814-2004 (R2016)	EC4316X (Medium coated)
B1	Fabrication of component made of steels to IS: 2062-2016Gr.E300 & E350 all quality, IS: 2002-2009 Gr. 1 & 2, IS: 1875-2014 Class 2, 2A and 3 or similar. Also suitable for repair welding of cast steels to IS: 1030-2012 Gr. 230-450W. The weld deposit shall be of radiographic quality. Also for joining of stainless steels type 3Cr12, IRS M-44 or its equivalent with mild steel/ low alloyed steel/ Corten steel.	IS: 814-2004 (R2016)	EB5426H3X (Heavy Coated)
B2	Application same as B1 above with high deposition efficiency	IS: 814-2004 (R2016)	EB5426H3JX (Heavy coated)
B3	Fabrications of components made of steels to ASTM 516 Gr.70 or equivalent where low temperature (at -46°C) impact properties are required. The weld deposit shall be of radiographic quality.	IS:1395-2013	E55BC126 (Heavy coated)

IRS Class	Purpose of use	IS Specification	IS/AWS Code*
B4	Application same as B3 above with high deposition efficiency	IS:1395-2013	E55BC126J (Heavy coated)
C1	Fabrication of component made of steels to IS: 2062-16 Gr.E410, E450, IS:2002- 2009 Gr. 3, IS: 1875-2014 Class 3A or similar. The weld deposit shall be of radiographic quality.	IS:1395-2013	E63BD126 (Heavy coated)
C2	Application same as C1 above with high deposition efficiency	IS:1395-2013	E63BD126J (Heavy coated)
D	For joining weathering steels conforming to IRS M-41 or M-42 with same steel or steels to IS: 2062-2016, IS: 2002-2009 & IS: 1875-2014 as mentioned above. This can also be used for combination joint of IRS M-44 & IRS M-41 and IRS M-41 & M-42. The weld deposit shall be of radiographic quality.	AWS A5.5/5.5M:2014	E8018W2 (Heavy coated)
E1	For fabrication & repairing of Buckles, Gear cases, Protector Tubes, Door Patches, Side panels, End wall patches etc. of Rolling stock & locomotives. The electrode shall be low heat input type** with 350mm length.	IS: 814-2004 (R2016)	ER4211X (Medium coated)
E2	For repair welding of bogies, both cast and fabricated. The electrode shall be low heat input type** with 350mm length.	IS:1395-2013	E55BG1Ni26 (Heavy coated)

Note: In any strength weld, the first run shall not ordinarily be deposited with an electrode of gauge larger than 8 S.W.G. For subsequent runs the electrode shall not be increased by more than two sizes between consecutive runs.

4.3.8 Shop Painting

- a) Fabricated steel work shall not be painted over except to the extent specified in Sub-Para (b) below until it has been inspected and passed by the Engineer or his representative and any defect, pointed out by him has been rectified. Till then, all rivet heads and weld metal shall be protected by coating with clean boiled linseed oil conforming to IS: 77.
- b) All surfaces which shall be in permanent contact and any others which will not be accessible for painting later on, shall be cleaned thoroughly and given One coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 or other approved composition in the prescribed number of coats immediately prior to assembly, and for this no extra payment shall be admissible
- c) In case of riveted structures, the splice locations and inaccessible locations are to be painted with one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 followed by one finishing coat of Aluminum Paint confirming to IS: 2339 before dispatch and the 2nd finishing coat of Aluminum Paint confirming to IS: 2339 to be applied before or after erection.

- d) In case of HSFG bolted connections, after metallization, girders are to be painted with one coat of Etch primer IS: 5666 followed by one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of 1st finishing coat of Aluminum Paint except at Joining faces of splice locations where only metalizing to be done but no painting to be done. After final assembly and erection at site, the 2nd finishing coat of Aluminum Paint to be applied including splice location.
- e) After the steel work has been inspected and passed, painting shall be done as stipulated in Para 39 of IRS Specification Serial No. B1-2001 for the prescribed number of coats, uniformly over the work. Payment for this painting shall be made separately unless it is specifically included in the rate for the fabrication.
- f) Further reference is drawn to general provisions detailed in relevant chapter on painting.

4.4 WORKMANSHIP IN STEEL WORK

4.4.1 General

Fabrication - Such work shall be performed only within the plants and by fabricators who have at the tendering stage established, to the satisfaction of the Engineer / Railway, that they have the experience, knowledge, trained man power, quality controls, equipment and other facilities required to produce the steel work to desired quality. Prequalification of the plant and fabricator shall be established either by the submission of detailed written proof or through in plant inspection by the Engineer.

The contractor shall advise the Engineer in writing, atleast 20 calendar days in advance of the actual start of fabrication.

4.4.2 Rolling Margin

The rolling margin in plates, sections and bars shall be in accordance with the relevant Indian Standard and all materials outside these limits shall be liable to rejection.

4.4.3 Interchangeability of Parts

The Contractor shall arrange for corresponding parts of each unit manufactured from the same drawing to be interchangeable as far as economic manufacturing conditions permit and shall advise the Engineer of the precise arrangements made in this respect. There should be level, finished concrete floor of sufficient dimensions in the fabrication yard, on which the fabricator shall precisely set out the outline of the structure (to full scale) as per drawings for the purpose of preparing templates. Only steel tapes shall be used for all measurements and they shall be held tight and level on the floor while measuring or marking.

4.4.4 Templates

The templates for the work shall be steel bushed in cases where the Engineer may consider necessary. Where actual materials from the work have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit for use as part of the finished structure.

4.4.5 Steel Tapes

Steel tapes used for marking out the work shall be calibrated at a temperature of 20°C.

4.4.6 Universal Plates and Flats

Where universal plates or flats are used as part of a built-up section and with their edges exposed, such edges shall be true or planed true.

4.4.7 Drilling

- a) Rivet and Bolt Holes: No holes shall be punched full size without the permission of

Engineer. See also Para 4.3.5.

- b) Reamed Holes: All holes for turned bolts shall be reamed in the manufacturer's works.
- c) Holes in welded Members: All bolt and rivet holes in members built up by welding shall be drilled after welding has been completed.
- d) Removal of Burrs: Holes which are drilled through two or more separable parts shall have all burrs removed after separating the parts.
- e) Holes for Countersunk H.S.F.G. Bolts: Holes for countersunk H.S.F.G. bolts shall conform to the proportions for flat countersunk heads with 80° included angle and head diameter approximately twice the diameter of the bolt. The counter sunk shall be truly concentric with the shank holes. Bolt heads shall be dressed flush where necessary for proper construction.

Close Butted Joints

- i) Where close butted joints are required, they shall be indicated on the Drawings and the butting ends of the parts shall be machined to ensure close contact when the joint is made.
- ii) Close contact shall be deemed to have been achieved when at least 90% of the area is in close contact and the remaining 10% or so also has clearance not exceeding 0.2mm.

4.4.8 Shearing of Plates: Shearing and grinding of steel plates shall not be carried out without the permission of the Engineer.

4.4.9 Notches: The roots of all notches shall be smoothened.

4.4.10 Procedure Trials for Welding and Cutting

Where required by the Engineer, welding and flame cutting trials shall be carried out and completed before fabrication on representative samples of materials to be used in the work, as follows:

- a) The samples of materials shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.
- b) Trials on material 19mm thick may be taken to include all material under 19mm thick and on material 38mm thick to include material between 19mm and 38mm thick. Over 38mm thickness material shall be tested for every thickness increment of 6mm. The trials of flame cutting shall be carried out on material representative of all thicknesses to be used in the work.
- c) The welding and flame cutting trials shall demonstrate workmanship / quality to the satisfaction of the Engineer. The procedures to be adopted shall include:
 - i) Welding procedure in accordance with IRS welded Bridge Code supplemented by IS:813 (1986).
 - ii) The heat control techniques required to ensure that the flame cut surfaces of any imported steel like steel to B.S. 4360 Grade WR 50, 50B, WR 50B, 50C and WR 50C are suitable for inclusion in welds.
- d) The trials shall include specimen weld details from the actual construction which shall be welded in a manner simulating the most unfavourable instances of fit up and preparation which it is expected will occur in the particular fabrication. After welding, the specimens shall be held as long as possible at room temperature, but in any case, not less than 72 hours, and shall then be sectioned and examined for cracking.
- e) Procedure Trials: Testing shall be done as prevalent IS Code or if approved to B.S. 709. The following groups of tests, shall be carried out in accordance with the type of welds.
 - i) Butt welds: - Transverse tensile test. Transverse and longitudinal bend test with the root of the weld in tension and compression respectively and Charpy V notch impact test.
 - ii) Fillet welds: Fillet weld fracture test
 - iii) Tack welds: Inspection for cracking

- iv) All welds: Macro examination specimen for each type of weld. Additional tests not included in (i) and (ii) above shall be specified by the Engineer as required. Shop welded joints shall be 100% examined radiographically and with other Non-destructive methods.

4.4.11 Welding Requirements

4.4.11.1 Qualification and Testing of Welders as per IS: 7310, IS:7307 and approved WPSS Only qualified welders will be engaged in the work and they also will be tested for their skill in welding to full satisfaction of the Engineer as directed below.

- i) No welding operator shall be employed on the work until he has, in the presence of the Engineer, passed the appropriate tests laid down in relevant codes.
- ii) Where plates of 12mm thick and over are to be butt welded the tests. Engineer may specify other tests to be conducted.
- iii) Routine re-testing of welding operators may be required every six months if considered necessary by Engineer.
- iv) The Engineer can also require any welding operator to be retested at any time during the Contract.

4.4.11.2 Supervision of Welding

- i) The Contractor shall appoint welding supervisors whose competence and qualifications shall be subject to approval of the Engineer and all welds shall be carried out under their direction.
- ii) Except where agreed by the Engineer, a record shall be kept to enable butt welds to be identified with the welders responsible for the work but material shall not be marked by hard stamping for this purpose.

4.4.11.3 Welding Plant

The welding plant shall be capable of maintaining at the weld, the voltage and current specified by the manufacturer of the electrodes used. The Contractor shall supply instruments for verifying voltage and current as and when required by the Engineer.

4.4.11.4 Welding

Metal Arc welding shall be carried out in accordance with IRS Welded Bridge Code (and if so required with B.S. 5135) and the following additional requirements.

- i) The general welding programme for shop and site welds, including particulars of the preparation of fusion faces, pre-heating where required and methods of making welds shall be submitted in writing to the Engineer for approval before the work is put in hand. No deviations shall be made from the welding programme or from the details shown on the Drawings, without the prior approval of the Engineer.
- ii) Approval of the welding procedure shall not relieve the Contractor of his responsibility for correct welding and for minimising of distortion in the finished structure.
- iii) The procedures for welding and flame cutting established by the procedure trials under Para 4.4.11 shall be strictly followed.
- iv) All main butt welds shall have complete penetration and shall comply with the requirements of IRS Welded Bridge Code. They shall be made between prepared fusion faces. Where possible they shall be welded from both sides. The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by the use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining, or by other approved means and the ends and surfaces of the welds shall be smoothly finished.
- v) In the fabrication of built-up assemblies all butt welds in the component parts shall be complete before the final assembly.

- vi) Pre-heating and temperature conditions, electrodes, and size of single runs shall be as follows:
 - a) Grades 43A and 43C steel – no welding of these and similar mild steels shall be undertaken where the ambient or plate temperature is 0o C or below.
 - b) Grades WR 50B and WR 50C Steel - for all welding of steel to Grades 50B and 50 C and similar carbon manganese steels the temperature shall be not less than 10oC when welding is commenced.
- vii) Controlled hydrogen electrodes shall be dried out and used in strict accordance with the manufacturer's instructions.
- viii) Loose flux used for automatic and semi-automatic welding shall be kept free from contamination and used in accordance with the manufacturer's instruction.
- ix) All tack welds shall be of the same quality and size as the first run of the main weld. The main weld shall fuse completely with the ends of the tack welds to form a regular profile. Where preheat is required for the main welds the tack welds shall be made under the same heat conditions. The length of the tack welds shall not be less than four times the thickness of the thicker part or 50mm whichever is the smaller.
- x) The position of welds required for temporary attachments shall be approved by the Engineer before the work starts.
- xi) Temporary attachments shall be removed without damage to the parent metal, which shall be finished smooth by grinding in the direction of the applied stress in the finished structure.
- xii) All cracked welds shall be cut out to the satisfaction of the Engineer before re-welding.
- xiii) Where automatic or semi-automatic welding processes are used, back gouging shall not be required when it is demonstrated to the Engineer that satisfactory welds are produced.
- xiv) Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction of the applied stress.
- xv) Run – off plates and run-on plates.
 - a) One pair of “run-on” plates and one pair of “run-off” plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds so that the direction of rolling of the added plates is parallel to that of the parent metal.
 - b) Except as directed by the Engineer the plates in approximately 1 in 5 pairs of run- off plates shall each be 150mm wide by 200mm long, the length being measured in the rolling direction of the metal and at right angles to the weld.
 - c) The welds shall run the full length of the joint and extend at full section for a minimum distance of 25mm into the run-off plates.
 - d) On completion of the welds the 150mm x 200mm run-off plates shall not be removed until they have been marked by the Engineer to identify them with the joints to which they are attached.
 - e) When removing the run-off and run-on plates by flame cutting the cuts shall not be nearer than 6mm to the sides of the parent metal and remaining metal shall be removed by grinding in the direction of the applied stress or by other method approved by the Engineer.
 - f) Specimens for test shall be selected from the run-off plates as required by the Engineer.

4.4.12 Welding Inspection
Radiographic or other non-destructive examinations shall be conducted on all main

welds carrying tension and on other welds to the satisfaction of Engineer. If required, samples of the welds in permanent or temporary works shall be cut out for examination by the Engineer.

- 4.4.13 **Stress Relieving**
If required by the Engineer or specified elsewhere herein or specified on the Drawings, welds shall be stress relieved and special units may require to be normalized.
- 4.4.14 **Flame Cutting**
Where the flame cut surface is not subsequently incorporated in a weld, machine flame cutting may be used subject to the following requirements.
- i) Grades 43A and 43C steel. All irregularities in the cut face, edges and corners shall be removed by grinding in the direction of the main stress to be carried by the material.
 - ii) Grades WR 50, 50B, WR 50B, 50C and WR 50C steel: The heat input and cooling condition shall be in accordance with the procedures specified in Clause 13 of B.S. 5135, unless otherwise specified.
- 4.4.15 **Welding of stud shear connectors**
The stud shear connectors shall be welded in accordance with the manufacturer's instructions including preheating. The stud and the surface to which studs are 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. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder are adequately protected. 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.
- 4.4.16 **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 4.2.

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 0.5m.

TABLE 4.2: FABRICATION TOLERANCES

A. INDIVIDUAL COMPONENTS		
1.	Length	
	a) Member with both ends finished for contact bearing	$\pm 1\text{mm}$
	b) Individual components of members with end plate connection	$+ 0\text{ mm}$ $- 2\text{ mm}$
	c) Other members	
	i) Upto and including 12M	$\pm 2\text{mm}$
	ii) Over 12M	$\pm 3.5\text{mm}$
2.	Width	
	a) Width of built-up girders	$\pm 3\text{mm}$
	b) Deviation in the width of members required to be inserted in other members	$+ 0\text{mm}$ $- 3\text{mm}$

3.	Depth	
	Deviation in the depths of solid web and open web girders	+ 3mm -2 mm
4.	Straightness	
	a) Deviation from straightness of columns	L/3000 subject to a maximum of 15mm
		where L is length of member
	i) In elevation	+ 5mm - 0 mm
	ii) In plan	L/1000 subject to a maximum of 10mm
5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	3mm
6.	Deviation from flatness of plate of webs of built- up members in a length equal to the depth of the member	0.005 d to a maximum of 2mm 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 maximum of 2mm where b is width of the member
	b) at other places	0.015b 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 column. These dimensions 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 or girder	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 1.5mm

4.5 ERECTION OF STEEL WORK

4.5.1 Reference Specifications

The erection of steel work for different types of structures shall be done in accordance with the respective Indian Railway standard specifications as listed below.

- Bridge work: IRS Specification Serial No. B1-2001 for Erection and Riveting of Bridge Girders.
 - General Structural Work: IRS Specification No.B2 for Steel Structures (other than Girder Bridges) - Part 3.
 - Iron and Steel tanks and staging – IRS Specification No.B3- Part 4.
- The important provisions of IRS Specification Serial No. B1-2001 (Part 3) which is commonly required to be followed in the field for all steel girders are extracted and given below for ready reference, duly amplified where necessary.

4.5.2 Material Handling

- a) The materials, on receipt, shall be carefully unloaded, examined for defects, checked, sorted and stacked securely on a level bed, out of danger from flood or tide and out of contact with water or ground moisture. They shall be supported on timber or concrete plinths so that they do not touch the ground.
- b) The materials shall be verified with the marking shown on the marking plan, if any, or with the detailed drawings issued for the work.
- c) Any material found damaged or defective shall be stacked separately. The materials should, as far as possible, be inspected before unloading from trucks to ascertain if any damage has occurred in transit. The portions found damaged or defective shall be marked with paint of distinctive colour. Such materials shall be dealt with under orders of the Engineer and without delay. Slightly distorted parts may be straightened by gradual pressure without heating, whereas badly damaged portions may require to be replaced. In exceptional cases, where rectification of badly distorted or broken parts is allowed by the Engineer, it shall be done in such manner and with such safeguards as directed by him. Connection plates, if slightly bent or twisted shall be straightened cold. If bent so sharply as to require heating, the whole plate thus treated shall be annealed before use on work. Engineer at his discretion may have such rectified component tested for its load carrying capacity before use on work.

4.5.3 Preliminary Requirements

- i) Before starting the work, the method of erection and the details of the erection equipment proposed to be used shall be got approved by the Engineer, but such approval shall not be considered as relieving the Contractor of his responsibility for safety or for carrying out the work in full accord with the drawings and specifications. All temporary works shall be properly designed and substantially constructed for the loads they would be called upon to sustain, including wind and lateral forces, etc. according to the local conditions.
- ii) A careful inspection of plant and tackle shall be made to ensure that they are in good order and well upto the capacity required. When chains or ropes are used for lashing, care must be taken to protect them as well as the members lashed, to avoid damage to either.
- iii) Frame and steel skeleton structures shall be carried up true and plumb. Temporary bracings shall be provided, if required, to take care of stresses from erection equipment or other loads carried during erection and also to ensure lateral stability of structures during the process of erection.
- iv) All surfaces which shall be in permanent contact after assembly shall be thoroughly cleaned to remove all paint and mill scale and shall receive, immediately before being assembled one coat of Ready Mixed paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 or in accordance with relevant Para in Painting Iron Work, with the prescribed number of coats. Care shall be taken to see that any burr or other surface defects are removed before the parts are assembled. Field rivets, welds and bolted connections shall be protected by a coat of clean boiled linseed oil till the work is inspected and passed by the Engineer's representative. After passing, these shall be cleaned and painted with one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS:2074, irrespective of whether the final painting of the finished structure is to be done by the Contractor or not.

4.5.4 Assembling Steel

4.5.4.1 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.

4.5.4.2 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 tension 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.

- 4.5.4.3 All joint surfaces 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, to the plane normal to bolt axis, otherwise suitable tapered washer shall be used.
- 4.5.4.4 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 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up 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.
- 4.5.4.5 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.
- 4.5.4.6 The field riveting, and bolted and pin connection shall conform to the requirements of Para 4.5.5 as appropriate.
- 4.5.4.7 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 and his approval of the method of correction obtained. The correction shall be made in the presence of the Engineer.
- 4.5.5 Riveting
 - (a) Riveted connections shall be securely bolted up before the rivets are driven.
 - (b) Parallel barrel drifts, with their greatest diameter not exceeding that of the rivet hole, may be used for drawing members into position; but no drifting to match up unfair holes shall be allowed. Any apparent error in fabrication work which prevents assembling and fitting up of the parts by the proper use of these drifts shall be investigated immediately. No reamering shall be undertaken without the written authority of the Engineer, and if it be approved, any special rivets that may be required shall be used to fill such holes, and for this no extra payment shall be admissible to the Contractor. All correspondence relating to the recourse to reamering and the use of special rivets shall invariably be recorded by the Engineer for information.
 - (c) In cases where the joint has to withstand stresses arising from special methods of erection before being riveted up, parallel barrel drifts and turned bolts shall be used to withstand the whole of such stresses, the number of drifts being subject to a maximum of 40 per cent of the total.
 - (d) In the event of any emergency arising, such as staging being in danger of being carried away by floods before the riveting can be completed, the joints shall be made secure by filling 40 per cent of the holes with drifts and an equal number with service bolts fully tightened up.
 - (e) Riveting shall not be started until such time as the Engineer or his representative has personally satisfied himself that the alignment and levels of the members are correct, the verticals plumb, all joints and cover plates well in order, service bolts tight and the field rivet

- holes properly matching.
- (f) Joints shall normally be made by filling not less than 50 per cent of the holes with service bolts and parallel drifts in the ratio of 4 to 1. The service bolts shall be fully tightened up.
- 4.5.6 Bolted Connection: Permanent bolted connections shall be used only where shown on the drawings or where specially approved by the Engineer. In all such cases, washers not less than 6mm thick shall be used under the heads and nuts, and the nuts drawn tight and “checked” by burring over the threads with a chisel. In case of High Strength Friction Grip (HSFG) bolts, Sub-Para 7.12 of Steel Bridge Code shall be followed.
- 4.6 PAINTING STEEL WORK
- 4.6.1 General: Unless otherwise specified all painting and protection coating work shall be done in accordance with Para 39 of IRS Specification Serial No. B1-2001 and IS:1477 (Part 1) supplemented by the specifications given below. In locations where girders are subjected to satisfy such as close vicinity of sea and or over creeks, metalizing with sprayed aluminium as given in Appendix VII to IRS Specification Serial No. B1-2001 shall be done followed by painting with (i) one coat of Etch Primer to IS:5666 (ii) one coat of zinc chrome primer to IS:104 the zinc chrome to be used in the manufacturer conforming to Type- 2 of IS:51 and (iii) two coats of Aluminium paint to IS:2339 by brushing or spraying as specified. One coat is to be applied in shop before dispatch and second after erection after touching up the earlier coats if damaged in transit or during erection.
- 4.6.2 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.
- Dry or wet grit / sand blasting
 - Pickling which should be restricted to single plates, bars and sections
 - Flame cleaning
- Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, primary coat shall be applied 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.
- 4.6.3 Coatings
- Prime coat to be used shall conform to the specification of primers specified hereinafter or in Drawings / Contract and should be approved by the Engineer. Metal coatings shall be regarded as priming coatings. 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. In case the Primer coat is not applied in the stipulated time, boiled linseed oil to IS: 77 to be applied to avoid rusting of members. All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The primer undercoat and finishing coat shall preferably be from the same manufacturer to ensure compatibility. 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:
- Epoxy Based Painting
 - Surface preparation: Remove oil / grease by use of petroleum hydrocarbon solution (IS:745) and Grit blasting to near white metal surface and the prepared surface shall match to minimum Sa 2.5 of ISO Specification No. 8501-1:2007 or latest.
 - Paint system: 2 coats of Epoxy Zinc Phosphate Primer to RDSO Specification No.

M&C/PCN/102/2020 or latest (70-micron DFT/per coat) followed by one coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100 - 175-micron DFT/per coat. Finished coats approved by --- Air less Spray of coats of Epoxy Zinc Phosphate Primer to RDSO Specifications No. No. M&C/PCN/102/2020 or latest (Total 5 coats = 350-micron, Min).

- b) Conventional Painting System for areas where corrosion is not severe
 Priming Coat: One coat of ready mixed zinc chrome priming conforming to IS:104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074 or two coats of zinc chromate red oxide primer conforming to IRS P-31.
 Finishing Coats: Two coats of 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: One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of red oxide zinc chrome 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.

4.6.4 Painting in the Shop

- i) All fabricated steel shall be painted in the shops 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.
- ii) Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.
- iii) Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. Paint shall be completely dried before loading and transporting to site.
- iv) Surface not in contact but inaccessible after shop assembly shall receive the fully specified protective treatment before assembly.
- v) 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 expected to impair the quality of site welds.
- vi) Exposed machined surfaces shall be adequately protected.
- vii) In case of HSFG Bolted structures, the contact surfaces shall not be painted over metalized surface as friction to be developed between the contact surfaces.

4.6.5 Painting at Site

- i) Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.
- ii) 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.
- iii) Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.
- iv) 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.
- v) Specified protective treatment shall be completed after erection.

4.6.6 Methods of application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and approved by the Engineer or as indicated in painting chapter to the extent they are applicable to major steel structures. 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 hard to gain access for painting and areas shaded for spray application shall be coated first by brushing.

The primer, intermediate and finishing coats 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 at the Contractor's expense.

- 4.6.7 Guideline of Specifications for Protective Coating System in Different Environments
- Since the seriousness of the problem 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.
 - However, as a guide to specifying authorities, broad recommendations in this respect are given in Table 4.3 for various types of coatings in various environmental conditions, extracted from MORTH Specifications for Roads and Bridges. Approximate life to first maintenance is also indicated and can be used as a guide.

TABLE 4.3 RECOMMENDATIONS FOR TYPES OF PROTECTIVE COATINGS

System	Environment
i) Wire brush to remove all loose rust and mill scale: (a) Primer coat: One coat of Ready mixed paint, brushing, Zinc chromate priming to IS: 104 (Dry film thickness of approx. 25 microns) (b) Primer coat: One coat of Ready mixed paint, brushing, red oxide zinc chrome primer to IS: 2074 (Dry film thickness approx. 25 microns) (c) Top coat: Two coats of Aluminium finish paint to IS: 2339 (Dry film thickness approx. 40 microns) Total DFT=100 Micron, Min	Suitable for mild conditions where appearance is of some importance and where regular maintenance is intended. This system may deteriorate to a marked extent if it is exposed to moderate aggressive atmospheric conditions for lengthy period.
(ii) Wire brush to remove all loose rust and mill scale; Painting System: (a) One coat of High-performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100–175 micron DFT/per coat) (c) Top coat: One coat of Polyurethane (PU) Based Aluminium finish paint to RDSO Specification No. M&C/PCN/110/2020 (Three Pack) (Dry film thickness approx. 35 microns) (Total DFT=300 Micron, Min)	Similar to (i) but where appearance is not very important provides longer life in mild condition. Will provide upto 5 years life to first maintenance in polluted inland environment
(iii) Blast-clean the surface to minimum Sa 2.5 grade as per ISO: 8501-1: (a) Apply one coat of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70 micron DFT/per coat). (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100-175 micron DFT/per coat). (Total 5 coats = 350 micron, Min).	Compared to (i) this would provide a longer life in mild conditions and could be used in less mild situation e.g. inland polluted, where maintenance could easily be carried out at regular intervals
System	Environment
(c) Top coat: Two coat of Polyurethane (PU)Based Aluminium finish paint to RDSO Specification No.	

System	Environment
M&C/PCN/110/2020(Three Pack) (Dry film thickness approx. 70 microns) (Total DFT=300 Micron, Min)	
iv) Blast clean the surface to minimum Sa 2.5 grade as per ISO: 8501-1; (a) Apply one coat of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70 micron DFT/per coat) (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification No. M&C/PCN/103/2020 or latest (100-175 micron DFT/per coat.) (c) Top Coat: Two coats of Poly urethane based Aluminium (PU) finish paint to RDSO specification no. M&C/PCN/110/2020 or latest (dry film thickness approx.70 microns, Min) (Total 4 coats = 250 micron, Min).	Suitable for general structural steel work exposed to ordinary polluted inland environments where appearance is not of primary importance.
v) Blast clean the surface to minimum Sa 2.5 grade as per ISO: 8501-1; (a) 1 coat of sprayed Zn/Aluminium 150 microns. (b) High performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (c) Top coat: One coat of Polyurethane (PU) Based Aluminium finish paint to RDSO Specification No. M&C/PCN/110/2020 (Three Pack) (Dry film thickness approx. 35 microns) (Total DFT = 300 Micron, Min)	Suitable for structures in reasonably aggressive conditions e.g. near the coast. Will provide, long term protection than (iv) in non-coastal situations. Also suitable for aggressive interior situations such as industrial areas.
vi) Blast clean the surface to minimum Sa 2.5 grade as per ISO: 8501-1; Coal tar Epoxy Based Coal Tar Paint (Two Pack) to RDSO specification No. M&C/PCN/105/2020 or latest, Total Dry Film Thickness (350-450) µm, Min.	Suitable for sea water splash zones or for conditions of occurrence of frequent salt sprays

System	Environment
<p>vii) Pickle:</p> <p>(a) Hot Dip Galvanised (Zinc) conforming to IS: 4759 and IS: 2629. Total thickness: 85 Micron.</p> <p>(b) One coat of High performance Anti-Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron.</p> <p>(c) One Intermediate coat Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures), DFT=30 Micron</p> <p>(d) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co- polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures)-Class-1 ,DFT=30 Micron</p> <p>Total dry film thickness: 250 µm, Min</p>	<p>Suitable for steel work in reasonably mild conditions. Life of 15-20 years before first maintenance could be expected in many situation</p>
<p>viii)Grit blast to minimum Sa 2.5 grade as per ISO: 8501-1,</p> <p>(a) Hot Dip Galvanised (Zinc) conforming to IS: 4759 and IS:2629.</p> <p>Total thickness = 140 Micron (b)One coat of High performance Anti-Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron.</p> <p>(c) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co- polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures)-Class-1, DFT=25 Micron</p> <p>Total dry film thickness: 300 µm, Min</p>	<p>Provides a longer life than (vii) because of thicker zinc coating</p>

System	Environment
<p>ix) Grit blast to minimum Sa 2.5 grade as per ISO: 8501-1:</p> <p>(a) 1 coat of Zn/Aluminium spray, 150 µm, Min</p> <p>(b) One coat of High-performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No.</p> <p>M&C/PCN/123/2018, DFT Min 125 Micron.</p> <p>(c) One Intermediate coat Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures), DFT=30 Micron</p> <p>(d) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co- polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures) - Class-1, DFT=25 Micron</p> <p>Total dry film thickness: 325 µm, Min</p>	<p>Expected to provide long term protection approx. 15-20 years in aggressive atmosphere</p>

4.7 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, erecting, painting of structural steel work shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

4.8 MEASUREMENTS FOR PAYMENT

- a) The measurements of steel work shall be as Para 4.1.2.
- b) The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis:
 - i) Rolled or cast steel: 7.85 x 103 kg/cum.
 - ii) Cast Iron :7.21 x 103 kg/cum
- c) Weight of structural sections shall be nominal weight. No additions shall be made for the weight of protective coating or weld fillets.
- d) No separate payment shall be made for supply of bolts and nuts and drifts required in temporary connections for erection purposes and any wastages thereof.
- e) In the event of a dispute arising as to the weight of a portion of steel work, a weighment shall be made in the presence of Inspecting Officer.

Annexure 4.1
(Refer Para 4.3.6)
Lengths (L) Required for Different Diameters of Rivets
(All dimensions in mm).

Grip Length	(i) Cuphead Rivets						(ii) Countersunk Head Rivets					
	10	12	16	18	20	22	10	12	16	18	20	22
12	<u>31</u>	<u>33</u>	<u>38</u>	<u>41</u>	..	..	23	..	..	..	..	..
	32	32	40	40								
14	<u>33</u>	36	<u>41</u>	43	46	..	<u>25</u>	..	..	..	..	..
	32		40				26					
16	36	<u>38</u>	43	46	<u>48</u>	<u>51</u>	<u>28</u>	..	..	..	..	..
		40			49	52	29					
18	<u>38</u>	<u>41</u>	<u>45</u>	<u>48</u>	<u>51</u>	<u>53</u>	<u>30</u>	<u>31</u>	32	..	..	..
	40	40	46	49	52	52	29	32				
20	<u>41</u>	43	<u>48</u>	<u>50</u>	<u>53</u>	<u>56</u>	<u>33</u>	<u>33</u>	<u>35</u>	..	..	..
	40		49	49	52	55	32	32	36			
22	<u>44</u>	46	<u>50</u>	<u>53</u>	55	58	36	36	<u>37</u>	..	..	..
	43		49	52					36			
24	46	<u>48</u>	<u>53</u>	55	58	<u>60</u>	<u>38</u>	<u>38</u>	40	40	..	..
		49	52			61	40	40				
26	49	<u>51</u>	55	<u>57</u>	<u>60</u>	<u>63</u>	<u>41</u>	<u>41</u>	<u>42</u>	<u>42</u>	43	..
		52		58	61	64	40	40	43	43		
28	<u>51</u>	<u>53</u>	<u>57</u>	<u>60</u>	<u>62</u>	<u>65</u>	43	43	<u>44</u>	<u>45</u>	<u>45</u>	..
	52	52	58	61	61	64			43	46	46	
30	<u>54</u>	<u>56</u>	<u>60</u>	<u>62</u>	<u>65</u>	67	46	46	<u>47</u>	<u>47</u>	<u>48</u>	49
	55	55	61	61	64				46	46	49	
34	..	61	64	67	<u>69</u>	<u>72</u>	<u>51</u>	<u>51</u>	<u>51</u>	52	52	<u>54</u>
					70	73	52	52	52			55
38	..	<u>66</u>	<u>69</u>	<u>71</u>	<u>74</u>	76	..	<u>56</u>	<u>56</u>	<u>56</u>	<u>57</u>	58
		67	70	70	73			55	55	55	58	
42	..	<u>71</u>	<u>74</u>	76	<u>78</u>	<u>81</u>	..	61	61	61	61	<u>63</u>

Grip Length	(i) Cuphead Rivets						(ii) Countersunk Head Rivets					
		70	73		80	80						64
46	..	76	<u>79</u>	<u>81</u>	83	<u>85</u>	..	<u>66</u>	<u>66</u>	<u>66</u>	<u>66</u>	67
			80	80		86		67	67	67	67	
50	..	<u>81</u>	83	<u>85</u>	<u>88</u>	<u>90</u>	..	<u>71</u>	70	70	<u>71</u>	<u>72</u>
		80		86	89	89		70			70	73
55	..	<u>87</u>	89	<u>91</u>	<u>93</u>	<u>96</u>	..	<u>77</u>	76	76	76	<u>78</u>
		86		92	92	95		76				80
60	95	<u>97</u>	99	<u>101</u>	..	83	<u>82</u>	<u>82</u>	<u>82</u>	83
				99		102			83	83	83	
65	<u>101</u>	<u>103</u>	<u>105</u>	<u>107</u>	..	..	<u>88</u>	<u>88</u>	<u>88</u>	89
			102	102	108	108			89	89	89	
70	<u>107</u>	<u>109</u>	<u>111</u>	<u>113</u>	..	..	<u>94</u>	<u>94</u>	<u>94</u>	95
			108	108	114	114			95	95	95	
75	<u>113</u>	<u>115</u>	<u>116</u>	118	..	..	<u>100</u>	<u>100</u>	99	<u>100</u>
			114	114	118				99	99		99
80	<u>120</u>	<u>122</u>	<u>124</u>	..	..	<u>106</u>	<u>105</u>	<u>105</u>	<u>106</u>
				118	125	125			108	108	108	108
85	<u>128</u>	<u>130</u>	..	..	<u>112</u>	<u>111</u>	<u>111</u>	<u>112</u>
					125	132			114	114	114	114
90	135	..	..	..	<u>117</u>	<u>117</u>	<u>117</u>
										118	118	118
95	<u>141</u>	..	..	..	..	<u>122</u>	<u>123</u>
						140					125	125
100	<u>129</u>
												132

Notes:

- 1) The lengths given above are those required theoretically, except that where two lengths are indicated, the figure in the denominator represents the length to which rivets are generally produced by standard manufacturers.
- 2) Interpolate between the theoretical lengths for intermediate grip lengths.

RAILWAY RELIEVING GIRDER SPECIFICATION

LAUNCHING OF RAILWAY'S RELIEVING GIRDER

1. Transportations of relieving girder within 2Km. for launching with mechanical means, labours, etc. as per direction of Engineer in charge. Nothing extra shall be paid on this account.
2. This item basically involves dismantling of existing track on all type of sleepers excavating of existing bank at the location where relieving girder is to be inserted in traffic block of suitable duration and inserting relieving girder 26.80m long, already fixed with linked track. The payment for excavation will be done in relevant USSOR items.
3. Linking of track with wooden/channel sleepers on the girder, stacked by the side of the bridge. The linking will be paid separately against the relevant NS item. In case, the track is already linked with minor deficiencies the adjustment to the track parameters and providing missing fittings/sleepers etc. shall be done against this items only and no payment for linking shall be made. For linking payment shall be made only if track is provided afresh.
4. Once the relieving girder with track linked on it is ready short duration traffic blocks of (about one hour each) shall be arranged by Railway for making the trench for inserting the girder and contractor has to excavate the earth and insert the C.C. Cribs, wooden gutkas below the Rail and provide sufficient wooden packing and ensure leveling arrangement for passage of traffic at 20 kmph after every blocks.
5. Two to Three hours traffic block shall be arranged by Railway to provide ends cribs for resting the R/girders and contractor has to arrange sufficient labour & excavators for excavation, for insertion and leveling the C.C. Cribs complete as per the drawing, with complete leveling / alignment for passage of traffic @ 20 kmph, after block. For insertion of R/Girder in 2-3 hrs. traffic block contractor shall arrange road crane of suitable capacity for tackling the R/Girder with sufficient labour and stand by arrangement of road crane and ensure insertion work shall be completed in three hours block.
6. After insertion of R/Girder, the contractor has to connect the track on both approaches and pack the track in order to make the track fit to pass the train at 20 kmph on the relieving girder and both the approaches.
7. After insertion of R/Girder, the contractor has to arrange a gang of about sufficient skilled labour round the clock for maintaining the R/Girder & its track in proper line/levelling and alignment and the gang will work as per instructions of site- in-charge. In case of settlements of the sleeper/cc crib the additional pickings and other repairs shall be done against this item only. Contractor has to arrange sufficient tools like track jacks, pully blocks, wooden packing, crow bars etc. and plants for maintaining the R/girder and track on approaches.
8. The rate quoted by the contractor shall include all labour, machinery, tools and plants, cranes, etc. to complete the work. The complete work is to be carried out in traffic blocks of suitable duration as decided by the Engineer-in-charge. Contractor shall ensure that sufficient labour, T&P, machinery, crane of

required capacity is arranged on the scheduled day of block and if the Engineer-in-Charge is not satisfied with the arrangement made by the contractor he will be at liberty not to take the traffic block. The contractor will have no right to claim whatsoever.

9. The rate includes all kinds of operations required for handling of track before and after inserting the relieving girder in order to maintain continuity of track so as to pass the trains at a restricted speed of 20 KMPH. For this purpose the track on approaches may have to be lifted and packed. The contractor shall make his own arrangement and the rate includes cost of lifting and packing if required on approaches.
10. The railway shall make efforts to provide block as required, however, no extra payment shall be allowed on account of non-grant of block on any day/date or of any duration. The contractor shall account for such eventuality in the rate for this item.
11. For crane working, the special conditions given elsewhere in the document shall be applicable.

12. The launching to be done by side slewing or use of road cranes or any other method , scheme for which shall be submitted for approval by the railway/competent authority.
13. While launching of girders, sufficient stand by equipment, including cranes shall be kept and sufficient labour shall be brought to ensure no bursting of block is there.
14. Girder shall not be damaged during handling.
15. In case the girder is to be removed / delaunched from track and re-launched in the track in same block, payment shall be made under this item only and no payment for de-launching separately shall be made. The decision of engineer in charge regarding whether the delaunching and launching is to be done in same or separate blocks shall be final and binding on the contractor.

DE-LAUNCHING OF RAILWAY'S RELIEVING GIRDER

This item basically involves de-linking of track from relieving girder to the existing track in traffic block of suitable duration and Removing of relieving girder including C C / wooden cribs supports etc. by use of road crane of required capacity or manually by side slewing. The relieving girders shall be stacked at suitable location near the bridge within 2Km. as per the instructions of the Engineer. Following points to be observed/noted for operation of this item

1. The girder should be kept sufficiently away from the track so as to preclude any possibility of it infringing the running track. The supports on which girder is kept shall be sufficiently strong as to not yield as to lead to slippage of girder towards track. If required girder shall be anchored on off side of track using ropes, dead man etc.
2. The girder shall be de-launched carefully and shall not be damaged the box or embankment /track.
3. The space of girder shall be done in ballast or quarry dust or other non-cohesive granular soil suitably so that there is no settlement during train passage. The

earth work, ballast/quarry dust shall be paid for under separate relevant USSOR item.

4. The work shall be planned by keeping sufficient earth/quarry dust/ballast in gunny bags/cement bags and sufficient labour/T & P that work can be completed within the allowed block.
5. The track shall be linked over the fill and packed which shall be done against this item only.
6. Gunny bags/cement bags required shall be provided against this item only and released bags if any shall be contractor's property.
7. The rate quoted by the contractor shall include all labour, machinery, tools and plants, cranes, etc. to complete the work including transportation of relieving girder within 1Km. as per direction of Engineer in charge. The complete work is to be carried out in traffic block of suitable duration as decided by the Engineer-in-charge. Contractor shall ensure that sufficient labour, T&P, machinery, crane of required capacity is arranged on the scheduled day of block and if the Engineer-in-Charge is not satisfied with the arrangement made by the contractor he will be at liberty not to take the traffic block. The contractor will have no right to claim whatsoever.
8. The railway shall make efforts to provide block as required, however, no extra payment shall be allowed on account of non grant of block on any day/date or of any duration. The contractor shall account for such eventuality in the rate for this item.

LOADING, UNLOADING, CARTING AND STACKING GIRDER

This item has been kept for transporting the relieving girders kept at convenient station to the bridge site or from bridge site to nearest station having siding by use of road , dip lorry etc. Convenient station to the bridge site by use of road, dip lorry etc.

1. The Bridge site is not well connected by the road up to very close vicinity, therefore new girders may be required to be carted by road from the station by means of transport i.e. by Road vehicles and rail track dip lorries.
2. The tenderer shall examine and survey the existing road approaches, their condition and the period during which they are pliable.
3. If the contractor wants to cart the girder, by means of the track dip lorries, then the Railway will arrange the block of 1.30 Hrs to 2.30 Hrs duration depending on the pattern of the rail traffic on that particular day. Due to small duration of traffic block, a girder may be required to be handled (i.e. loaded, unloaded etc), two to three times for completing its journey to the specified destination. The dip lorries will have to be arranged by the contractor.
4. The new girders may be carted looking to the site condition viz .space available for stacking in the launching area. Hence the girders may have to be carted for the required no. of times, in phases, according to and depending upon progress of launching of the girders. The carted girders shall be stacked properly, as per the

direction of site in-charge. It must be ensured that girders are not damaged during handling.

5. All the arrangements, required for loading, unloading, carting etc. shall be done by the contractor's tools & plants, labours & material etc. complete at the contractor's cost only.
6. The rate includes cost of all arrangements including loading, unloading on road vehicle /dip lorries and stacking the same.
7. Lead shall be measured by road/track by shortest route as per approach road/ track diagram.