

**Name of Work :- Strengthening of Tarsada-Kadod-Bardoli-
Sarbhon-Navsari road Ch. 33/10 to 75/00
(W.S. Ch. 53/00 to 59/00 & 64/60 to 68/00)
Dist.Surat. (CRIF-2025-26)**

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

1.0 PREAMBLE: -

1.1 The Technical Specifications contained herein shall be read in conjunction with the other Bidding Documents as specified in this Volume.

1.2 SITE INFORMATION: -

1.2.1 The information given here under provided elsewhere is given in good faith by the Employer but the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Employer is erroneous or insufficient.

2.0 GENERAL REQUIREMENTS: -

The technical specifications in accordance with which the entire work described herein after shall be constructed and completed by the Contractor shall comprise of the "SPECIFICATION"

2.1 Though "SPECIFICATION" for each item is attached with tender they are based on following.

1. "SPECIFICATION FOR ROAD AND BRIDGE WORKS' (Fifth REVISION printed in year 2013) issued by the Ministry of Road Transport & Highways (MORT & H), Government of India and Published by the Indian Roads Congress, hereinafter to as MORT&H Specifications.
2. The General Technical Specifications for Road works.
3. The General Technical Specifications for Bridge works.

Note: - (2) To (3) are Conventional Specifications Booklets usually attached for (R&B) Works.

2.2 If, a particular clause (which is incorporated in "SPECIFICATION") of specification booklets (1) to (3) above is Amended / Modified/ Added upon then the Amendment/ Modification/Addition shall supersede the relevant clause incorporated in " SPECIFICATION"

2.3 In, so far as Amended / Modified / Added Clause may come in conflict or be inconsistent with any of the provisions of the MORT & H Specifications under reference, the Amended/Modified/ Added Clause and the additional specifications shall always prevail.

2.4 In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specification, of IRC and BIS in that order. Where even these are silent, the construction and completion of the works shall conform to sound engineering practice as approved by the ' Engineer' and, in case of any dispute arising out of the interpretation of the above, the decision of the 'Engineer' shall be final and binding on the Contractor.

The Technical Specifications contained herein shall be read in conjunction with the other Bidding stipulations.

1.0 TECHNICAL SPECIFICATIONS:

- 1.1 The Technical Specifications in accordance with which the entire work described hereinafter shall be constructed and completed by the Contractor shall comprise of the following:
- 1.2 The General Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (FIFTH REVISION, April 2013)", as corrected in the original issued by the Ministry of Road Transport & Highway, Government of India and published by the Indian Roads Congress, New Delhi.
- 1.3 In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specifications of IRC and BIS in that order. Where even these are silent, the construction and completion of the works shall conform to sound engineering practice as approved by the Engineer and in case of any dispute arising out of the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor.
- 1.4 During construction of foundation, substructure and superstructure of bridge, tilt or shift occur due to high flood; contractor / agency has to rectify the same as per IRC requirement at his own cost.

2.0 GENERAL SPECIFICATIONS

- 2.1 The details of reinforcement of RCC work shall be as per design and instructions of Authority and his order will be considered final.
- 2.2 The Contractor shall have to maintain account of steel, cement and other materials that may be brought by him on site. The account shall be regularly maintained and kept open for inspection by Authority.
- 2.3 The Contractor shall remain responsible for workmen's compensation if any,

when such case occurs, the Contractor shall arrange for red lamps at night and fencing and pagi and shall be responsible for any damage of life and lime or property if any happen, during the execution of work. In case of dispute for unseen or overlooked items, the decision of Authority shall be final. The Contractor shall have to give site clean of all rubbish on completion of work and hand over the bridge with final finishing of the work as directed. All the rejected materials shall be removed from site within 24 hours by contractor at his risk and cost.

- 2.4 For mixing mortar either for masonry or for plaster or for any other purpose contractor shall have to prepare trough of bigger size and mix the mortar in required proportion. In no case he shall be allowed to mix the mortar either on floor or any finished surfaces.
- 2.5 The Contractor shall have to make his own arrangement for water required for the work and shall pay the water charges as per rules.
- 2.6 If in the interest of the Employer or site conditions it is necessary to change either any site or the design of the proposed work the Contractor shall carry out the same at his quoted rates, without charging any extra and he will be paid at the rates quoted by him and no claim for extra charges made will be entertained.
- 2.7 "Cement and Steel will not be supplied by the Employer. The Contractors have to make their own arrangements for procurement of indigenous Portland cement or imported Portland cement HYSD, TMT bars, Structural Steel and M.S. Round Bars including coils and Ribbed for Steel and prestressing strands for the entire work. The contractors shall have to give necessary test certificates as per relevant I.S Code before using the same in the work".
- 2.8 The Contractor will be fully responsible for compliance of the various provisions under Contract Labor Act, 1970 and the Rules framed there under.
- 2.9 the Contractor at his own cost. In the event of such works being accepted by carrying out repairs etc. as specified by the Engineer in charge, the cost of repairs will be borne by the Contractor and will be paid for the works actually carried

out by him at reduced rates of the tendered rates, as may be considered reasonable by the Engineer in charge in the preparation of final or on account bills.

2.10 Concrete Mix Design:

It is brought to the notice of the Contractor that the concrete design mix for higher grade of controlled concrete is required for foundation, substructure and super structure of bridge and other work. This richer mix is necessary from technical considerations. The Contractor should therefore, study all the possibilities of achieving the desired results for the richer mix. He should collect the coarse and fine aggregates of the best quality. The cement used for this type of concrete should be got tested periodically and should not be more than 3 months old. The Contractor may study the possibility should of adding the necessary plasticizers and admixtures to achieve this strength with desired workability and finishes without affecting durability and damaging the reinforcement and high tensile steel. The cost for any plasticizer admixtures shall be borne by contractor.

2.11 Setting out Works

The Contractor shall be responsible for the true and proper setting out of the works and for the correctness of the position's levels, dimensions and alignment of all parts of the works and for the provisions of all necessary instruments and appliances and labor in connection therewith. If at any time during the progress of works any error shall appear or arise in the positions, levels, dimensions or alignment of any part of the works, the Contractor on being required to do so by the Engineer shall at his own expenses rectify such errors to the satisfaction of the Engineer-in-Charge. The checking of any setting out or of any lines and levels by the Engineer-in-Charge or his representative shall not in any way relieve the Contractor of his responsibility for correctness thereof and the Contractor shall carefully protect, preserve and maintain all bench marks, site rails, pegs etc. used in setting out the works. The costs of providing, preserving, protecting and maintaining the site rails, pegs, benchmark etc. shall be deemed to be included

in the rate quoted for various items in the schedule B and no separate payment will be made for the same.

The Contractor shall incorporate into the structure the fixtures for lighting, drainage, road markers, signals etc. as may be given to him by the Engineer-in Charge, without claiming any extra cost.

- 2.12** All permanent and temporary works shall conform to the latest specifications of Codes of Indian Road Congress, Specifications of Road & Bridge works by Ministry of Road Transport and Highways, IS Standards and code of other relevant codes and prevailing sound Engineering practices as mentioned in the contract documents or approved by the competent authority as applicable.

2.13 Formed & Unformed Surface Finishes

The surface finishes for formed and unformed surfaces are classified and defined as below. Surface irregularities permitted for the various classes of finishes are termed either 'abrupt' or 'gradual'. Fins or offsets caused by displaced or misplaced form sheeting, lining or form sections, by loose knots in form lumber or by otherwise defective form lumber are considered abrupt irregularities. All other cases are described as gradual irregularities. Gradual irregularities will be measured with a template consisting of a straight edge for plans surfaces or its equivalent for curved surfaces. The length of template for testing gradual irregularities on formed surfaces shall be 1.5 m in length, the permissible gradual irregularities being measured over this length of the template.

Finish F1, F2 and F3 shall describe formed surfaces.

Finish U1, U2 and U3 shall describe unformed surfaces.

Class F1 Finish

This class of finish shall apply to all formed surfaces for which class F2 or F3 is not specified. It shall generally be formed by sawn timber formwork/timber frame or steel frame mounted with plywood or steel sheet. It shall be so constructed that there shall be no loss of material from the concrete during placement and compaction. After hardening, the concrete shall be in the required positions and shall have the shape and dimensions called for in the drawings.

Any abrupt irregularities shall not exceed 10mm. All fins and drifts in excess of the above limits shall be made good by chipping and grinding if required by the Engineer-in-Charge. Small blemishes caused by entrapped air or water may be expected but the surface shall be free from voids, honeycombing or other large blemishes. Class F1 finish shall be generally specified for all surfaces buried in ground or not visible during service or for surfaces that are to receive further rendering treatment such as plastering etc. Unless otherwise specified in the item of Bill of Quantity the surface finish shall be understood to be Class F1.

Class F2 Finish

Class F2 finish shall be obtained by the use of properly designed forms, either close jointed wrought timber forms or with forms having plywood or steel sheet lining. The abrupt irregularities shall not exceed 5mm and gradual irregularities shall be less than 8mm. Small blemishes caused by entrapped air or water may be permitted but the surface shall be generally free from honeycombing, voids and large blemishes. Surface irregularities in excess of those stipulated shall be removed by chipping or rubbing with abrasive stone.

Class F3 Finish

Class F3 finish shall be formed by specially designed close jointed rigid forms having lining of high-quality form plywood. The surface irregularities shall be limited to nil for abrupt irregularities and 3 mm for gradual irregularities. Class F3 finish may be obtained from class F2 finish by carefully removing all abrupt irregularities including fins and projections by rubbing/grinding. If steel forms are used, they shall have steel sheet backing faced with plywood.

In addition, finish F3 shall include filling air holes with mortar and treatment of the entire surface with sack rubbed finish. It shall also include clean-up of loose and adhering debris. For a sack rubbed finish, the surface shall be prepared within two days after removal of the forms. The surface shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one-part cement to one- and one-half parts by volume of fine (I.S. No. 16 mesh) sand. Only sufficient mixing water to give the mortar a workable consistency shall be used. The mortar shall then be rubbed over the

surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with clean burlap such that all air holes etc. are filled and the entire surface presents a uniform appearance without air holes, irregularities etc.

Class U1 Finish

This is the screened finish used on surfaces over which other finishes such as wearing coats etc. are to be placed. It is also the first step in the formation of U2 and U3 finishes. The finishing operation consists of leveling and screeding the concrete to produce an even and uniform surface so that the gradual irregularities are not greater than 5 mm. Surplus concrete should be removed immediately after consolidation by striking it off with a sawing motion of a straight edge or template across a wooden or metal strip that has been set as guide. Unless the drawings specify a horizontal surface or show the slope required, the tops of narrow surfaces, such as stair treads, walls, curbs and parapets shall be sloped approximately 10 mm per 300 mm width. Surfaces to be covered with concrete topping, terrazzo and similar surfaces shall be smooth screeded and leveled to produce even surfaces, irregularities not exceeding 5mm.

Class U2 Finish

This is a floated finish used on all outdoor unformed surfaces not prominently exposed to view such as tops of piers etc. The floating may be done by hand or power-driven equipment. It should not however be started until some stiffening has taken place in the surface concrete and the moisture film or 'shine' has disappeared. The floating should work the concrete no more than is necessary to produce a surface that is free from screed marks. All joints and edges should be finished with edging tools. It shall include the repair of gradual irregularities exceeding 5 mm. All abrupt irregularities shall also be repaired unless a roughened texture is specified.

Class U3 Finish

This is a trovelled finish used on all surfaces exposed to view at close quarters such as tops of parapets and kerbs etc. Steel trovelling should not be started until after the moisture film and 'shine' have completely disappeared from the floated surface and the concrete has hardened enough to prevent an excess of fine material and water from being worked to the surface. Excessive trovelling, especially if started too soon, tends to produce crazing and lack of durability. Too long a delay will result in a surface too hard for proper finishing. Steel trovelling should be performed with a firm pressure that will flatten and smooth the sandy surface left by floating. Trovelling should produce a dense, uniform surface free of blemishes, ripples and travel marks. It shall include the repair of all abrupt irregularities and the repair of gradual irregularities exceeding 5 mm. It shall also include finishing the joints and the edges of concrete with edging tools.

Design and Workmanship, Removal, Protection and Reuse

The design and workmanship of these formwork has to be got approved from the Engineer. The method of removing formwork without damaging the 'form-finished' surface, use of de-bonding agents, the protection and repair of forms and forms-surfaces, and limit on re-use etc. are to be as per specification/drawings in absence of which the proposed details are to be got approved from the Engineer. All such methods will have to be suitably improved based on the result of mock-up or field use. The final procedure and details shall be improved till the specified/desired architectural finish is obtained.

Mock-up

After design and before incorporation in the main work, the effectiveness and success in achieving the desired finish has to be demonstrated/ confirmed by casting the mock-up. The approved 'mock-up' surface shall be retained till the end of the project and then the 'mock-up' should be dismantled/removed from the work site and disposed off as directed by the Engineer.

Quality Control for Road Works

GENERAL

901.1 All materials to be used, all methods to be adopted and all works to be 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 Quality Control for works and all the required tests as per Specifications and/or as directed by the Engineer. The provision and maintenance of the laboratory shall be as per Clause 120 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 shall 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 the 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 hereunder. Additional tests may also be 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 as required by the Engineer from time to time. This shall include provision of laboratory equipment,

transport, consumables, personnel including labour attendants, assistants in packing and dispatching 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 be 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. Works falling short of quality shall be rectified/ redone by the Contractor at his 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 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 payment shall be made for the same. If, however, there is a separate 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 soils/soil mixes, granular materials and mixes, bituminous materials and mixes, cement concrete materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied by the Contractor at his own cost.

901.10 For cement, bitumen, steel, emulsion, road marking paint, sign boards, geosynthetics and similar other materials where essential tests are to be carried out in the presence of Engineer 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.

Manufacturer's test certificate together with invoice or delivery challan shall be furnished for every lot of supply apart from tests to be conducted at site laboratory for prime properties of the material like cement, bitumen, etc. Where facilities for testing of materials are not available at site laboratory the same shall be tested at an outside laboratory in the presence of the Engineer. For specialized items such as sign boards, road marking paint, etc. the Engineer may order for third party test from an approved laboratory.

901.11 The method of sampling and testing of materials shall be in accordance with the requirements of the relevant Indian Standards and these Specifications. Where they are contradicting, the provisions 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. The cost of all tests shall be borne by the Contractor.

901.12 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 and other materials for construction shall be from sources approved by the Engineer. Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

901.13 Defective Materials

All materials which the Engineer has determined as not conforming to 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 instruction of the Engineer, the Engineer shall have authority to cause the removal of

rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

901.14 Imported Materials

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 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 in the lot of materials shall be furnished at the Contractor's cost.

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33/10 to 75/00 (W.S. Ch. 53/00 to 59/00 & 64/60 to 68/00) Dist.Surat.
(CRIF-2025-26)

ITEM WISE SPECIFICATION

Item No. 01 Clearing and grubbing road land including uprooting trunk vegetation, grass bushes, shrubs, saplings and tree 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

201.1. 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.

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 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.

201-3. Methods, Tools and Equipments

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case 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.

201.4. 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 lead and lift.

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.

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**. 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 upto 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.

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 in girth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lead and lifts.

Item No. 02 Supplying and fixing reinforced concrete heavy duty non pressure pipes with collars of required length for culverts carrying heavy traffic as per Indian Railway Standard Specifications including setting the pipes in C.M. 1:2 watering and laying (to level or slope) of class NP4 900mm diameter.

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

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 up to the specified level.

Where bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/boulders in this area be removed and the space filled with approved earth, free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Trenches shall be kept free from water until the pipes are installed and the joints have hardened.

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 at least 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 on 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 a manner that the pipe is placed in the proper position without damage.

The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

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 sands, 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 another 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 up to 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the 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 up to the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.

2909 OPENING TO TRAFFIC

No traffic shall be permitted to cross the pipes unless height of filling above the top of the pipes is at least 600 mm.

2910 MEASUREMENTS FOR PAYMENT

RCC pipe shall be measured as complete work in **linear meters** along its length between the inlet and outlet ends.

2911 RATE

The Contract unit rate for the RCC pipe 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, and incidental costs to complete the work as per these Specifications.

Item No. 03 Removing of existing bituminous layers up to required width and depth by using Cold milling machine including hauling and stock piling excavated material as and where directed etc. complete.

502.1.1 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.

502.1.2 Stockpiling

In the cold process, the reclaimed bituminous pavement material shall be stockpiled with height of stockpiles not exceeding 3 m. 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 drum mix plant.

502.2 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.

502.3 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.

502.4 Arrangements for Traffic

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

502.5 Measurement for Payment

The cold milling work shall be measured in square metres of finished work as stated in the Contract.

502.6 Rate

The contract unit rate for cold milling shall be payment in full for carrying out the required operations including full compensation.

Item No. 04 Providing and laying 50 mm thick compacted B. M. with B.T. aggregate as per MORT&H specification using Emulsion grade RS-1 for coat at 2.5 Kg./10Sq.mt. with mechanical sprayer and bitumen grade VG-40 for mixing at the rate 34.0Kg/M.T. i.e. 3.4 % of total mix including heating the aggregate and asphalt by Batch mix plant and spreading the same by sensor paver finisher and consolidation with vibratory roller including providing all materials, equipments, tools and plants, oil, kerosene, fire wood, labour charges etc. complete.

504 Bitumen macadam

504.1 Scope

This work shall consist of construction in a single course having 37.50 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 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	Max. 40%	IS:2386 Part IV
	Aggregate Impact Value	Max. 30%	IS:2386 Part IV
Durability	Soundness (Sodium or Magnesium)	5 cycles	IS:2386 Part IV
	Sodium Sulphate	Max. 12%	IS:2386 Part V
	Magnesium Sulphate	Max. 18%	IS:2386 Part V
Water	Water Absorption	Max. 2%	IS:2386 Part III
Property	Test	Requirement	Test method
Absorption			

Stripping	Coating and stripping of Bitumen aggregate Mixtures.	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile strength*	Minimum 80%	AASHTO 283

If the minimum retained tensile strength falls below 80 percent, use of anti-stripping agent is recommended to meet the minimum requirements.

504.2.4 Aggregate Grading and Binder Content

The combined grading of the coarse aggregates and fine aggregates, when tested in accordance with IS:2386 Part 1, wet sieving method, shall conform to limits given in Table 500-8. The type and quantity of bitumen and appropriate thickness is also given in Table 500-7.

504.2.5 Proportioning of Material

The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 500-7. The binder content shall be within a tolerance of ± 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.

504.2.6 Construction Operation

504.2.7 Weather and Seasonal Limitations The provisions of Clause 501.5.1 shall apply.

Table 500-7: Aggregate Grading and Bitumen Content

Grading	1	2
Nominal maximum aggregate size*	40 mm	19 mm
Layer thickness	80-100 mm	50-75 mm
IS Sieve size (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
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**	3.50

* 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.

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.

Tack Coat: A tack coat in accordance with Clause 503 shall be applied as required under the Contract or as directed by the Engineer.

Preparation and Transportation of the Mix: The provisions of Clauses 501.3 and 501.4 as under shall apply.

504.3 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 Celsius)

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.	90 Min.
VG-20	145-165	145-170	145-165	135 Min.	85 Min.
VG-10	140-160	140-165	140-160	130 Min.	80 Min.

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 that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading.

504.4 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 to facilitate discharge of the material.

Spreading: The provisions of Clause 501.5.3 as under shall apply.

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.

Rolling: Compaction shall be carried out in accordance with the provisions of Clauses 501.6 and 501.7. as under

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 superelevated and unidirectionally cambered portions, it shall progress from the 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.

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 lane 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 lane edge or the lane 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.

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.

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.

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.

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

Measurement for Payment: Bituminous macadam shall be measured as finished work by weight in metric tonnes, ~~where used as regulating course, or square meters at the specified thickness as indicated in the Contract or shown on the drawings,~~ or as otherwise directed by the Engineer.

Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include cost for all components listed in Clause 501.8.8.2.

Item No. 05 Mastic Asphalt *(Providing and laying 25 mm thick mastic asphalt wearing course with paving grade bitumen meeting the requirements given in table 500-39, prepared by using mastic cooker and laid to required level and slope after cleaning the surface applied tack coat before glass grid and after glass grid, including providing antiskid surface with bitumen precoated fine-grained hard stone chipping of 13.2 mm nominal size at the rate of 0.005cum per 10 sqm and at an approximate spacing of 10 cm centre to centre in both directions, pressed into surface when the temperature of surfaces not less than 100°C, protruding 1 mm to 4 mm over mastic surface, all complete as per clause 516.)*

516 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.

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	40±10

Heavily stressed areas i.e. Junctions and toll plazas	40–50	13	45±10
Nominal size of coarse aggregate IS Sieve (mm)		13 mm Cumulative % passing by weight	
19		100	
13.2		88–96	
2.36		0-5	

fine 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
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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 brushed clean and free of dust and other deleterious matter. Under no circumstances shall mastic asphalt be spread on a base containing a binder which might soften under high application temperatures. If such material exists, the same shall be cut out and repaired before the mastic asphalt is laid.

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 aggregated.

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.

Item No. 06 "Asphalt Interlayer Composite (AIC): Providing and laying CE Marked Glassfibre Asphalt Interlayer Composite (AIC 100) indigenously manufactured by Techfab India or equivalent, made from high performance glass fibre roving to form a reticular structural material with a unique combination of fused fibre glass and polypropylene non-woven needle punched geotextile to asphalt overlay flexible pavements and asphalt overlay distressed rigid pavements for Reinforcement, seizure reflective cracks, reduced surface rutting & water infiltration. (Specification: MoRTH section-700).with prior approval of concerned Superintending Engineer."

Description of Work:

Providing and laying **CE Marked Glassfibre Asphalt Interlayer Composite (AIC 100)**, indigenously manufactured by *Techfab India* or equivalent, consisting of high-performance glass fibre roving arranged in reticular structural form, fused with polypropylene non-woven needle punched geotextile. The AIC shall be used as an interlayer in asphalt overlays on flexible pavements and over distressed rigid pavements.

Purpose & Functional Requirements:

- Reinforcement of asphalt overlays.
- Arresting and delaying propagation of reflective cracks.
- Reduction of surface rutting.
- Minimization of water infiltration into underlying layers.

Material Specifications:

- The AIC shall be CE Marked, conforming to international quality standards.
- Manufactured from high-performance glass fibre with polypropylene non-woven backing.
- Must comply with **MoRTH Specifications – Section 700 (Geosynthetics & Pavement Reinforcement)**.
- Equivalent products must be pre-approved by the Engineer-in-Charge/Superintending Engineer.

Laying Procedure:

1. **Surface Preparation:** Pavement surface shall be cleaned, dried, and free from dust, oil, and loose particles.
2. **Tack Coat:** A uniform tack coat of bitumen emulsion/bitumen (as per MoRTH Clause 503) shall be applied.
3. **Placement:** The AIC shall be laid manually or mechanically with proper overlap (minimum 100 mm) ensuring wrinkle-free placement.
4. **Bonding:** The AIC shall be pressed/bonded immediately with a light roller before placing the asphalt overlay.
5. **Overlay:** Bituminous layer shall be placed and compacted as per MoRTH specifications without damaging the AIC.

Measurement:

Measurement shall be taken in **square metres (m²)** of surface area actually covered and approved by the Engineer.

Payment:

Payment shall be made at the contract rate per square metre, which shall be inclusive

of cost of all materials, labour, equipment, tack coat, transportation, placement, and incidentals to complete the work as specified.

Item No. 07 Providing and laying 50 mm thick Dense Bituminous Macadam compacted thickness using specified graded black trap crushed stone aggregates as per MORTH gradation using emulsion for tack coat (Rapid setting) @ 2.5 Kg./10 Sq.m. with mechanical sprayer and VG 40 bulk bitumen for mixing at the rate of 4.5% (45 Kg./M.T.) by Batch mix and hot laid process using sensor paver finisher to the required camber and grade, and rolling with vibratory roller to achieve desire density including cost of fire wood, oil, Kerosene, flushing of stone dust as required, labour charges and hire charges of machineries etc. complete.

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 layer of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm.

505.2 Materials

505.2.1 Bitumen

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: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

Filter 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 IS:2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and filler for the particular mixture shall fall within the limits given in Table 500-10 for grading 1 or 2 as specified in the Contract. To avoid gap grading, the combined aggregate gradation shall not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

Table 500-8: Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam

Property	Test	Specification	Method of Test
Cleanliness	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%	IS:2386 Part IV
		Max. 27%	IS:2386 Part IV

Property	Test	Specification	Method of Test
Durability	Soundness either Sodium Sulphate or Magnesium Sulphate	Max. 12%	IS:2386 Part V
		Max. 18%	IS:2386 Part V
Water Absorption	Water Absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and stripping of Bitumen aggregate Mixtures.	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile strength*	Minimum 80%	AASHTO 283

To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.

Table 500-9: Grading Requirements for Mineral Filler

IS sieve (mm)	Cumulative Percent Passing by Weight of Total Aggregate
0.6	100
0.3	95-100
0.075	85-100

Table 500-10: Composition of Dense Graded Bituminous Macadam

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer Thickness	75 - 100 mm	50-75 mm
IS Sieve¹ (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	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245

Marshall Quotient (Stability/Flow)	2-5	2.5-5	MS-2 and ASTM D2041
% air voids	3-5		
% Voids Filled with Bitumen (VFB)	65-75		
Coating of aggregate particle	95 % Minimum		IS : 6241
Tensile Strength ratio	80 % Minimum		AASHTO T 283
% Voids in Mineral Aggregate (VMA)	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 Size¹ (mm)	Minimum VMA, per cent Related to Design Air Voids, Per cent		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0
37.50	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 mix;
 - b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
- iii) A single definite percentage passing each sieve for the mixed aggregate;

- iv) The individual gradings of the individual aggregate fraction, and the proportion of each in the combined grading;
- v) The results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;
- vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch;
- vii) Test results of physical characteristics of aggregates to be used;
- viii) Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications.

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

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

505.3.4 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 500-13 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 19nun sieve or larger	±8%
Aggregate passing 13.2mm, 9.5mm	±7%
Aggregate passing 4.75mm	±6%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	±5%
Aggregate passing 0.3mm, 0. 15mm	±4%
Aggregate passing 0.075mm	±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. 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 (Gmm) 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 501 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.

505.4.4 Stress Absorbing Layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517.

505.4.5 Prime Coat

Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in 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

Mixing shall be done in Fully automatic batch mix plant. 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 900 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 meters, tonnes or by the square meter at a specified thickness~~ **by weight in tonnes** as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

505.9 Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out all the required operations as specified and shall include, to all components listed in Clause 501.8.8.2. The rate shall include the provision of bitumen, at 4 percent and 4.5 percent by weight of the total mixture for grading 1 and grading 2 respectively.

The variation in actual percentage of bitumen used shall be assessed and the payment adjusted plus or minus accordingly.

Item No. 08 *Providing and laying 30 mm thick Bituminous concrete with B.T. stone chips as per MORTH gradation and specifications using VG 40 bulk bitumen for mixing at the rate of 5.4 % (54.0 Kg./M.T.) by wt. of total mix inclg. heating the asphalt, aggregates by continuous batching Batch mix plant and spreading the same by paver finisher to the required camber and grade, including rolling with vibratory roller to achieve desired density and using, fire wood, oil, Kerosene, labour charges and hire charges of machineries etc. complete*

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 40 mm/50 mm thick.

507.2 Materials

507.2.1 Bitumen

The bitumen shall conform to Clause 504.2.1.

507.2.2 Coarse Aggregates

The coarse aggregates shall be generally as specified in Clause 504.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-16 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 500-16 : Physical Requirements for Coarse Aggregate for Bituminous Concrete

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain Size analysis	Max. 5% passing 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. 30% Max. 24%	IS:2386 Part IV IS:2386 Part IV
Durability	Soundness either Sodium Sulphate or Magnesium Sulphate	Max. 12% Max. 18%	IS:2386 Part V IS:2386 Part V
Water Absorption	Water Absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and stripping of Bitumen aggregate Mixtures.	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile strength*	Minimum 80%	AASHTO 283

If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.

507.2.3 Fine Aggregates

The fine aggregates shall be all as specified in Clause 505.2.3.

507.2.4 Filler

Filler shall be as specified in Clause 505.2.4.

507.2.5 Aggregate Grading and Binder Content

When tested in accordance with IS:2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in Table 500-17. The grading shall be as specified in the Contract.

Table 500-17: Composition of Bituminous Concrete Pavement Layers

Grading	1	2
Nominal aggregate size*	19mm	13.0mm
Layer Thickness	50 mm	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. 5.50

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 (Gmm) obtained on the day of compaction in accordance with ASTM D2041.

507.4 Construction Operations

507.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

507.4.2 Preparation of Base

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

~~507.4.3 Geosynthetics~~

~~Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703.~~

~~507.4.4 Stress Absorbing Layer~~

~~Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517.~~

~~507.4.5 Tack Coat~~

~~The provisions as specified in Clause 504.4.6 shall apply.~~

507.4.6 Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3, 501.4 and 504.4.7 shall apply.

507.4.7 Spreading

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

507.4.8 Rolling

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

507.5 Opening to Traffic

Provisions in Clause 504.5 shall apply.

507.6 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

507.7 Arrangements for Traffic

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

507.8 Measurement for Payment

Bituminous Concrete shall be measured as finished work **by weight in tones** as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

507.9 Rate

The contract unit rate shall be all as specified in Clause 504.9, except that the rate shall include the provision of bitumen at **5.50 % by weight** of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

Item No. 09 Providing and laying quarry spall of approved quality including spreading, watering consolidation with vibratory roller including loading and unloading etc. complete.

1. The quarry spall shall be of approved quality as approved by the Executive Engineer prior to collection.
2. The quarry spall shall comply the grading requirement as stated below.

Grading For Quarry Spall

Sieve Designation	Per cent passing by IS sieve
75.0 mm	100
53.0 mm	80-100
26.5 mm	55-90
9.50 mm	35-65
4.75 mm	25-55
2.36 mm	20-40
0.425 mm	10-25
0.075 mm	3-10

Sieve Designation	Per cent passing by IS sieve
CBR Value (Minimum)	20

The quarry spall shall be hard, tough, solid durable of black trap quarry of close texture free from decay and weathering. The stone shall be angular and roughly cubical in shape and round elongated or flaky materials shall be rejected. No unsound or long rubble or angular chips smaller than specified size shall be allowed.

1. All unsound weathered or disintegrated stone obtained from the under-surface layer of the quarry or other layers of boulders shall be rejected.
2. Wherever any doubt as to whether above requirement is satisfied in whole or part of the collecting it shall be got screened by the contractor if so, ordered by the Executive Engineer and for which no extra payment shall be claimed by the contractor.
3. Any collection which does not fully satisfy the above requirements is liable to be rejected all together.
4. Stacking shall be made by the contractor for quantity of required layer.
5. Stacks shall as per actual requirement and any materials in excess shall be have to be transported by the contractor at the places directed by the Engineer in charge at the risk and cost of the contractor.
6. If desired and directed by the Engineer-in-charge the contractor shall have to stack stone aggregates in standard measure boxes of steel of size 2.0 mt. x 1.50 mt. x 0.50 mt. on road side for which no extra payment will be made to the contractor.
7. The permission for spreading the quarry spall shall be given by the Engineer in charge if
 - (i) The full quantity of a particular kilometer is completely collected.
 - (ii) The levels are recorded in the field book.
8. Q.S. shall if required, be screened, if containing rubbish dust, grass etc. it shall than be filled in basket & conveyed where required and spread evenly on the prepared surface be given twisting motion to the basket at the time of spreading. The surface shall then (15 m) be leveled by means of templates and strings as well as with camber boards and spirit level
9. Between the straight length and curves and at the meeting points of the convex and concave portions of the reverse curves, the change in camber of the road, due to super elevations shall be made as well as with camber boards and spirit level.
10. At the time of spreading Q.S. a small quantity (about 4 to 5 percent) of metal as directed shall be retained at the first instance. It shall be spread later on after partial

consolidation as required to rectify the camber and to fill up the hollows if any. No extra amount shall be paid for this.

11. The surface shall be brought to the required camber which shall be checked at every 50 ft. (15 M.) by means of templates while the length of the in between shall be tested by strings and corrected as required.
12. Pegs shall be driven on either side of the road and joined with strings true and parallel with a distance between them equal to the width to be laid with quarry spall. Similarly.
13. The Q.S. shall be laid as close as possible so as to leave minimum possible interstices and voids.
14. Before rolling is allowed on quarry spall, the side berms shall be filled up to the top of the soling and at least 3'-0" (1 m.) on either side so as to prevent quarry spall layer getting disturbed at times during rolling.
15. Immediately following the spreading of the Quarry Spall, rolling shall be started with vibratory roller. The capacity of the vibrating roller shall depend upon the type of the aggregate and shall be indicated by Engineer-in-charge.
16. Except on super elevated portions where the rolling shall proceed from inner edge to 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 inwards parallel to center line of the road in successive passes uniformly lapping preceding tracks by at least one half the width.
17. Rolling shall continue until the aggregate is thoroughly keyed and the creeping of the aggregate ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes wave like motion in the sub-grade or sub-base course.
18. The rolled surface shall be checked transversely and longitudinal with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and rerolling until, the entire surface conforms to desired camber and grade. In no case shall the use of screening be permitted to make up depression.
19. The blinding material where it is required to be used 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 moving roller

20. After the final compaction the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings of binding materials as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the surface has set. The Engineer-in-charge shall have the discretion to stop hauling traffic from using the completed surface if in his opinion it would cause excessive damage to the surface.
21. Payment will be made on **Cum** basis of the finished work and Rate shall include cost of quarry spall, spreading, rolling & watering, rent of machinery cost fuel, wages of drivers and cleaners and royalty etc. Measurement shall be taken by cross sectional area method and level shall be taken at 30 mt. C/C interval.

Item No. 10 Road marking with hot applied thermoplastic paints with reflectorising glass beads on bitumin surface providing and laying a hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250gms per sqm area, thickness of 2.5mm is excluding of surface applied glass beds as per IRC:35-2015. The finished surface to be level, uniform and free from streaks and holes. zebra patta /bump patta lane/center line/ edge line/cut patta. The white color marking should provide liminance coefficinet on cemend road shalll be min 130 mcd/m2/lux and Asphalt road shall be min 100 mcd/m2/lux during the service life during the day time. The marking should meet the performance criteria for night time reflectivity, wet reflectivity and skid resistance as mentioned in the section-15 of IRC 35-2015. Warranty for the Retro reflectivity should be two years.

Warranty for the Retro reflectivity should be two years.General :-

Hot Applied Thermoplastic Road Marking.

- (i) The work under this section consists of marking traffic stripes using a thermoplastic compound meeting the requirements specified herein.
- (ii) The Thermoplastic compound shall be screened / extruded on to The pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon

cooling to ambient pavement temperature, it shall be produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.

(iii) The colour of the compound shall be white or yellow (IS : colour No. 356) as specified in drawings or as directed by the Engineer.

(iv) Where the compound is to be applied to cement concrete pavement sealing primer as recommended by the manufacture, 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 marking are applied.

THERMOPLASTIC MATERIALS

GENERAL :

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads.

REQUIREMENT :

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 – 3.

Table 800 – 3 PROPORTIONS OF CONSTITUENTS OF
MARKING MATERIAL (percentage by weight)

Component	White	Yellow
Binder	18.00 min.	18.00 min.
Glass Beads	30 – 40	30 – 40
Titanium Dioxide	10.00 min.	- - -
Calcium Carbonate and Inert Fillers	42.00 max	See Note
Yellow Pigments	- - -	- do -

Note : Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provide all other requirement of this Specification are met.

II Properties : The properties of thermoplastic material, when tested in accordance with ASTM D36/ BX-3262- (Pa. T1) shall be as below :

A) Luminance :

White : Daylight luminance at 45 degree 65 per cent min. as per AASHTO M 249.

B) Drying time : When applied at a temperature specification by the manufactures 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 cards on application to concrete blocks.

E) Softening point : $102.5 \div 9.5''$ as per ASTM D 36.

F) Flow resistance : Note more than 25 per cent as per AASHTO M 249.

G) Yellowness index (for white thermoplastic paint) not more than 0.12 as per AASHTOM 249.

III Storage life : The materials shall meet the requirement of there Specifications for period of one year. The thermoplastic material must also melt uniformly with no evidence of skins of un-melted 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 803.4.3 of MORT & H Specification.

V Marking : Each container of the thermoplastic material shall be clearly and indelibly marked with the following information.

1. The name, trademark 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 Employer a copy of certified test report from the manufacturer of the thermoplastic material showing results of all tests specified therein and shall certify that the materials meets all requirements of this Specification.

REFLECTORZING GLASS BEADS

GENERAL : This Specification covers two types of glass beads to be used for to production of reflectorised pavement markings. Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800 – 3 and type – 2 beads are those which are to be sprayed on the surface vide Clause 803.6.3.

The glass beads shall be transparent, colourless and free from milliness, dark particles and excessive air inclusions.

These shall conform to the requirements spelt out in clause 5.4.3.3.

SPECIFIC REQUIREMENTS.

A GRADATION : The glass beads shall meet the gradation requirements for the two types as given in Table 800 – 4.

TABLE 800-4 GRADATION REQUIREMENT FOR GLASSBEADS

Sieve Size	Per Cent Retained	
	Table – 1	Table – 2
1.18 mm	0 to 3	--
850 micron	5 to 20	0 to 5
600 micron	--	5 to 20
425 micron	65 to 95	--
300 micron	--	30 to 75

180 micron	0 to 10	10 to 30
Below 180 micron		0 to 15

B. ROUNDNESS :

The glass beads shall have a minimum of 70 per cent 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 condition suitable for paints striping. They shall pass the free flow-test.

TEST METHODS :

The specific requirement shall be tested with the following methods.

I Free-flow test : Spread 100grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter desiccators which is filled within 25 mm of the top of a desiccators plate with sulphur acid water solution (specific gravity 1.10) Cover the desiccators and let it stand for 4 hours at 20 to 29 degree C. Remove Sample from desiccators, 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 essentially 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 Employer a copy of certified test report from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified therein and shall certify that material meets all requirements of this Specification. However, if so required, these tests may be carried out as directed by the Engineer in charge.

APPLICATION PROPERTIES OF THERMOPLASTIC MATERIAL

The thermoplastic materials shall readily get screed / 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 share edges.

The materials upon heating to application temperatures shall not exude fumes which are toxic. Obnoxious of injurious to persons property.

PREPARATION :

i) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic materials 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 materials. Which has natural binders or is otherwise sensitive to prolonged heating the materials shall 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.

PROPERTIES OF FINISHED ROAD MARKING :

- 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 up to 60 °C.
- d) The marking shall not deteriorate by contact with sodium chloride calcium chloride or oil drippings from traffic.
- e) The stripe of 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 chipping or cracking.

f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS : 164.

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 5.3.

APPLICATION

Marking shall be done by machine. For locations where painting cannot be done 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.

The thermoplastic materials shall be applied hot either by screening or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.

The pavement temperature shall not be less than 10 C. during application. All surface 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 on overlay of new material directly over an old line of compatible material. Such new material shall so bend 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 quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square meter area.

The minimum thickness specified in exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS- 3262 (Part 3).

The 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.

MEASUREMENT FOR PAYMENT.

The painted marking shall be measured in sq. meters of actual area marked (excluding the gaps. If any).

In respect of markings line directional arrows and lettering. Etc., the measurement shall be in Square meter basis.

Rate

The contractor unit rate for road markings shall be payment in full compensation of furnishing all labour, materials, tools, equipment, including all incidental costs necessary for carrying out the work at the site conforming to these specification complete as per the approved drawing (s) or as directed by the Engineer and other incidental cost necessary to complete the work to these Specifications.

Item No. 11 Supply and Apply Rumble Strips Road marking with hot applied thermoplastic paints with reflectorising glass beads on bitumin surface providing and laying a hot applied thermoplastic compound 8 mm thick including reflectorising glass beads @ 250gms per sqm area, thickness of 8mm is excluding of surface applied glass beds as per IRC:35-2015. The finished surface to be level, uniform and free from streaks and holes.

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 1.3 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 mm to 14 mm, including the base line or as specified in contract. 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 mcd/1xm² and not less than 250 mcd11x 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.

803.8.11 Measurement for Payment

Audible and vibratory pavement markings shall be measured in linear square 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 all tools, machines and equipment, and all incidentals necessary to complete the work

Item No. 12 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 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 manufacturers recommendation and The color of the marker should be as per the IRC 35-2015 and as directed by Engineer in- charge.

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 $35 \pm 5^\circ$ 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 mcdllx		
		White	Amber	Red
0° U 5° L & R	30°	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 mcdllx		
		White	Amber	Red
0° U 6° L & R	30°	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 'A'. 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 D4280. Its colour may be white, red, yellow, green or blue or combination as directed by the Engineer. Its water resistance shall meet the requirements of IP 65 in accordance with IS:12063:1987 Category 2 for protection against water ingress. The dimensions of solar studs shall not be less than 100 mm x 100 mm x 10 mm. It shall have super bright LEDs so as to provide long visibility from a distance of more than 800 m. Its flashing rate shall not be less than 1 Hz. Its should be able to give the prescribed performance in the temperature range of -40°C to +55°C. Its life shall be not less than 3 years.

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 130 mm. The base of the marker shall be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from a flat surface. All road studs shall be legibly marked with the name, trade mark or other means of identification of the manufacturer.

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.

Item No. 13 Direction (Junction) Sign :-Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminium composite Panel); size 244x122 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 reflective sheeting 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 foreach 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

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 aluminum sheet, aluminum composite panel, fiber glass sheeting, or sheet moulding compound. Aluminum sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminum alloy conforming to IS:736-Material Designation 24345 or 1900. Aluminum Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low-Density Polyethylene (LDPE) between two thick skins/sheets of aluminum with overall thickness and 3 mm or 4 mm (as specified in the Contract), and aluminum skin of thickness 0.5 mm and 0.3 mm respectively on both sides.

The mechanical proportion of ACM and that of aluminum 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 Aluminum Composite Material (ACM)

S. No.	Description	Specification	
		Standard Test	Acceptable Value
A	Mechanical Properties of ACM		

1)	Peel off strength with retro reflective sheeting (Drum Peel Test)	ASTM D903	Min. 4 N/mm
2)	Tensile strength	ASTM E8	Min. 40 N/mm 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. 30 N/mm ²
B	Properties of Aluminum Skin		
1)	Tensile strength (Rm)	ASTM E8	Min. 65 N/mm ²
2)	Modulus of elasticity	ASTM E8	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 Aluminum and 3 mm thick with Aluminum Composite Material. All other signs be at least 2 mm thick with Aluminum and 4 mm thick with Aluminum 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 Sheeting

801.3.2.1 High Intensity Grade (Type III)

This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic having a smooth surface or as an unmetallised micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in Table 800-2.

**Table 800-2: Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Grade Sheeting (Type III) (Encapsulated Lens Type)
(Candelas Per Lux Per Square Meter)**

Observation Angle in degree's	Entrance Angle in Degrees	White	Yellow	Orange	Green	Red	Blue	Brown
0.1 ^{0B}	-4 ⁰	300	200	120	54	54	24	14
0.1 ^{0B}	+30 ⁰	180	120	72	32	32	14	10
0.2 ⁰	-4 ⁰	250	170	100	45	45	20	12
0.2 ⁰	+30 ⁰	150	100	60	25	25	11	8.5
0.5 ⁰	-4 ⁰	95	62	30	15	15	7.5	5.0
0.5 ⁰	+30 ⁰	65	45	25	10	10	5.0	3.5

A minimum of Coefficient of Retro-reflection (RA) cd/fc/ft² (cd-Ix-1 m²).

B Values for 0.11 observation angles are supplementary requirements that shall apply only when specified by the purchaser in the Contract or order. When totally wet, the sheeting shall show not less than 90 percent, of the values of retro reflectance indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

801.3.3 High Intensity Micro-Prismatic Grade Sheeting (HIP) (Type IV)

This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in Table 800-3.

**Table 800-3: Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Micro-Prismatic Grade Sheeting (Type IV)
(Candelas Per Lux Per Square Metre)**

Observation Angle in degree's	Entrance Angle in Degrees	White	Yellow	Orange	Green	Red	Blue	Brown
0.1 ^{0B}	-4 ⁰	500	380	200	70	90	42	25
0.1 ^{0B}	+30 ⁰	240	175	94	32	42	20	12
0.2 ⁰	-4 ⁰	360	270	145	50	65	30	18
0.2 ⁰	+30 ⁰	170	135	68	25	30	14	8.5
0.5 ⁰	-4 ⁰	150	110	60	21	27	13	7.5
0.5 ⁰	+30 ⁰	72	54	28	10	13	6	3.5

A Minimum Coefficient of Retro reflection (RA) cd/fc/ft2 (cd-lx-1 m2).

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 Meter)

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow// Green	Fluorescent Yellow/	Fluorescent Orange
0.1 ^{0B}	-4 ⁰	1000	750	375	100	150	45	30	800	600	300
0.1 ^{0B}	+30 ⁰	460	345	175	46	69	21	14	370	280	135
0.2 ⁰	-4 ⁰	700	525	265	70	105	32	21	560	420	210
0.2 ⁰	+30 ⁰	325	245	120	33	49	15	10	260	200	95
0.5 ⁰	-4 ⁰	250	190	94	25	38	11	7.5	200	150	75
0.5 ⁰	+30 ⁰	115	86	43	12	17	5	3.5	92	69	35

A Minimum Coefficient of Retro reflection (RA) cd/fc/ft² (cd-lx-1 m²).

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 Meter)

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow// Green	Fluorescent Yellow/	Fluorescent Orange
0.1 ^{0B}	-4 ⁰	600	500	250	66	130	130	530	400	200
0.1 ^{0B}	+30 ⁰	370	280	140	37	74	17	300	220	110

0.2°	-4°	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	-4°	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-4°	80	60	30	8.0	16	3.6	64	48	24
1.0°	+30°	45	34	17	4.5	9.0	2.0	36	27	14

A Minimum Coefficient of Retro reflection (RA) cd/fc/ft² (cd-Ix-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 X!)

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 Xl) (Candelas Per Lux per Square Meter)

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow// Green	Fluorescent Yellow/	Fluorescent Orange
0.1° ^B	-4°	830	620	290	83	125	37	25	660	500	250
0.1° ^B	+30°	325	245	115	33	50	15	10	260	200	100

0.2°	-4°	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°	-4°	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°	-4°	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 Coefficient of Retro-reflection (RA) cd/fc/ft² (cd-Ix-1 m²).

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 sing 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	0.425	0.496	0.460	0.540	60	--
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	45	--
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	25	--

The colours shall be durable and uniform in acceptable hue when viewed in day light or under normal headlights at night.

801.3.8.4 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 aluminum 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

Item No. 14 Cautionary Warning Sign :-Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminium composite Panel); size 90 x 90 x 90 cms. equilateral triangle 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 High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T. Specifications; 3.6mtr long stand post of Iron Angle 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 7 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.

The work of providing and fixing Cautionary Warning sign board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in numbers of Cautionary Warning sign board supplied and fixed in position.

Item No. 15 Hazard Marker Sign :-*Providing and fixing sign boards made out of 2.0 mm aluminium sheet / 4 mm ACP (Aluminium 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 High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T. Specifications; 1.8mtr long stand post of Iron Angle 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 7 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.*

The work of providing and fixing Hazard Marker sign board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in numbers of Hazard Marker sign board supplied and fixed in position.

Item No. 16 Village name Sign :-*Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminium 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*

High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T. Specifications; 3.3mtr long stand post of Iron Angle 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 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 7 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.

The work of providing and fixing Village name sign board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in numbers of Village name sign board supplied and fixed in position.

Item No. 17 Facility Informatory Sign :-*Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminium 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 High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T. Specifications; 3.6mtr long stand post of Iron Angle 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 7 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.

The work of providing and fixing Informatory Name sign board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in numbers of Informatory Name sign board supplied and fixed in position.

Item No. 18 Regulatory / Mandatory Sign :-*Providing and fixing sign boards made out of 2mm aluminium sheet / 4mm ACP (Aluminium 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 High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T.Specifications; 3.6mtr long stand post of Iron Angle 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 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 7 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.*

The work of providing and fixing Regulatory Name sign board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in **numbers** of Regulatory Name sign board supplied and fixed in position.

Item No. 19 Chevron sign :-Providing and fixing sign boards made out of 1.5mm aluminium sheet / 3mm ACP (Aluminium composite Panel); size 60x50cm 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 High Intensity Prismatic Grade retro reflectivesheeting of Type-4 as per ASTM D-4956 and latest M.O.S.T.Specifications; 3.3 mtr long stand post of Iron Angle 75 x 75 x 6mm / 65NB Circular MS Pipe as required and frame fabricated from suitable size iron angle of 35x35x3mm; painted with best quality 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 7 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.

The work of providing and fixing Chevron board shall be executed as per relevant specifications of **Item No. 13** of this contract. The measurement shall be in **numbers** of Chevron sign board supplied and fixed in position.

Item No. 20 Providing and fixing ordinary kilometer stone of precast C.C. 1:2:4 including necessary reinforcement as per I.R.C. type design in C.C. 1:4:8 including painting and lettering etc. complete.

1. Kilometer stone shall be of approved quality and shall be of precast 1:2:4 R.C.C. as specified in the item.
2. The dimensions of the stone and the size, colour, arrangement of letters and scripts shall be as per IRC:8 "Type design for Highway kilometer stone". The stones 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 stones shall be as indicated in the drawings or in the relevant IRC Specifications or as directed by the Engineer. The fixing of K.M. stone shall be carried out in ordinary concrete of grade specified in the item using hand broken metal field metal or gravel.
3. The measurement for payment shall be made per No. of K.M. stone fixed in position.

Item No. 21 Providing and fixing hectometer as per I.R.C. type design including painting lettering etc. complete fixing in C.C. 1:5:10.

1. Hectometer stone shall be of approved quality and as per I.R.C. 26 (Type design for 200-meter stones) and shall be fixed in C.C. 1:5:10 which will consist of one part of cement, five part of good sand and ten parts of machine crushed metal 40 mm nominal size. Rate includes all labour and curing etc. necessary for concrete.
2. The measurement for payment shall be made per No. of Hectometer stone fixed in position.
3. Unit rate for hectometer stone includes the cost of all materials, labour, tools, fixing, finishing curing, lettering and painting as directed by the Engineer-in-charge.

Signature of Contractor	Deputy Executive Engineer Bardoli (R&B) Sub Division, Bardoli	Executive Engineer Surat (R&B) Division No.2, Surat
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HEDULE FOR TESTING OF MATERIALS: -

For ensuring quality control and workmanship Various tests prescribed below for materials shall be taken at periodical intervals as stipulated below. The materials shall be got tested at Government recognized Laboratory (R&B) or field Laboratory of GERI (R&B) for which 1% of the estimated amount put to tender shall be recovered from the contractor from the RA bills and final bills and the testing charges shall be paid to the GERI by the Government. However, if the charges increase over 1% no excess recovery shall be made from the contractor as per resolution of B & C department dated 10th May 1985 vide TNC/ 1085/ (4)/ S

It. No. as per schedule "B"	Brief description of materials to be tested	Qty of material	Prescription of test which shall be carried out	Frequency at which test shall be carried out	Total No of test to be taken.
1]	Coarse Aggregate	4813.00	- Gradation test - Impact value - Flakiness and elongation	1 to 100 cm 1 test 100 to 500 cm 3 tests 500 to 1500 cm 5 tests 1500 to 5000 cm 7 tests Minimum 1 test/ work	10
2]	Grit	6381.00	- Stripping value	As above	13
4]	quarry spall	1118.00	- Silt content - Gradation - CBR test	One test per work/ season One test per 200 cmt. One test per work	6
5]	Sand	13592.00	- Silt content - Gradation - CBR test	One test per work/ season One test per 200 cmt. One test per work	68
7]	Cement	6.01	- Consistency - Setting time - Compressive strength - Fineness - Chemical analysis - Soundness	Up to 50 MT 1 test 100 MT 2 tests 200 MT 3 tests 300 MT 4 tests 500 MT 5 tests 800 MT 6 tests 1300 MT 7 tests and 8 test for larger consignment	1
9]	Water	--	- Chemical test	Once for approval of source of supply	1
12]	Prime coat/ Tack coat	21.37	- Quality of binder	Number of samples per lot and test as per IS:73	5

It. No. as per schedule "B"	Brief description of materials to be tested	Qty of material	Prescription of test which shall be carried out	Frequency at which test shall be carried out	Total No of test to be taken.
			- Binder temperature for application - Rate of spread of binder	At regular close intervals Two tests per 500 m ² and not less than two test per day	
11]	B.M.	906.40	- Quality of binder	Number of samples per lot and test as per IS:73	5
			Impact Value	One test per 200.0 Cu.mt	
			Flakiness and Elongation Index	One test per 350.0 Cu.mt	
			Striping Value	One test per source	
			- Grading	1 test on individual contents and mix aggregate from the dryer for each 100 tonnes of mix subject to minimum of two test per plant per day	
			Soundness	One test per source	
			- Temperature of binder	At regular close intervals	
			- Binder content vide 45 IMD 2172	One test for each 100 tonnes of mix subject to mini. of Two per day	
			- Rate of spread of mix materials	Regular control through checks on layer thickness	
			Plasticity index	One test per source	
			Stability and Flow	Three tests per 400.0 Cu.mt/ one test per day	
11]	B.C.	6219.00	- Quality of binder	Number of samples per lot and test as per IS:73	31
			Impact Value	One test per 200.0 Cu.mt	
			Flakiness and Elongation Index	One test per 350.0 Cu.mt	
			Striping Value	One test per source	
			- Grading	1 test on individual contents and mix aggregate from the dryer for each 100 tonnes of mix subject to minimum of two test per plant per day	
			Soundness	One test per source	

It. No. as per schedule "B"	Brief description of materials to be tested	Qty of material	Prescription of test which shall be carried out	Frequency at which test shall be carried out	Total No of test to be taken.
			- Temperature of binder	At regular close intervals	
			- Binder content vide 45 IMD 2172	One test for each 100 tonnes of mix subject to mini. of Two per day	
			- Rate of spread of mix materials	Regular control through checks on layer thickness	
			Plasticity index	One test per source	
			Stability and Flow	Three tests per 400.0 Cu.mt/ one test per day	
12]	D.B.M.	9828.20	- Quality of binder	Number of samples per lot and test as per IS:73	48
			Impact Value	One test per 200.0 Cu.mt	
			Flakiness and Elongation Index	One test per 350.0 Cu.mt	
			Striping Value	One test per source	
			- Grading	1 test on individual contents and mix aggregate from the dryer for each 100 tonnes of mix subject to minimum of two test per plant per day	
			Soundness	One test per source	
			- Temperature of binder	At regular close intervals	
			- Binder content vide 45 IMD 2172	One test for each 100 tonnes of mix subject to mini. of Two per day	
			- Rate of spread of mix materials	Regular control through checks on layer thickness	
			Plasticity index	One test per source	
			Stability and Flow	Three tests per 400.0 Cu.mt/ one test per day	

The Number of tests will be as per Manual of quality control or latest Govt. G.R./Circular and it will be considered final

The contractor shall have to pay 1% of the estimated cost put to tender towards all testing of materials and the same shall be deducted from their bills for the works.

Testing charges of GERI shall be borne by Govt. No refund be made nor extra charges over 1% shall be recoverable from the contractor.

If directed by the Engineer in charge, the materials intended to be used for the work but not included in the above schedule shall also be got tested at Government recognized Laboratory or field Laboratory.

Signature of Contractor

**Deputy Executive Engineer
Bardoli (R&B) Sub Division,
Bardoli.**

**Executive Engineer
Surat (R&B) Division No.2,
Surat.**