SCHEDULE OF RATES

VOLUME - III

GOVERNMENT OF WEST BENGAL

PUBLIC WORKS DEPARTMENT

ROAD & BRIDGE WORKS – 2018

(WITH EFFECT FROM – 30/08/2018)

GOVERNMENT OF WEST BENGAL
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VOLUME - III

FOR ROAD AND BRIDGE WORKS

2018

PREFACE

In continuation of U.O. No. 332/SPW/2013 dated 31.11.2013 of the Principal Secretary of PWD and subsequent U.O. No. 1143-ENC/13 date 02.12.2013 & No. 1167-ENC/13 dated 05.12.2013 of the Engineer-in- Chief & Ex-officio Secretary of PWD, the Combined Schedule of Rates in 3 (three) Volumes was published on 01.07.2014.

Again, it was felt that PWD (Volume –III) Schedule of Rates need to be republished after amalgamation of all addenda & corrigenda published till 29.08.2018 in order to avoid handling problem and reducing the probability of committing error during preparation of estimates, as well.

This will take effect on & from 30.08.2018.

All efforts have been taken for keeping this publication error free. However, effective suggestion for any correction, addition & alteration is always welcome for any further betterment.

At last, we on behalf of the Schedule committee would like to convey our sincere thanks to those Engineer Officers who have co-operated with suggestions and also expect fruitful comments & suggestions from all corners in future, as ever.

30/08/18

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PREAMBLE

1. The items in the Schedule of rates for Road and Bridge works are framed mostly in accordance with the specifications laid down in the "Specifications for Road and Bridge Works (5th Revision)" by The Ministry of Road Transport and Highways (MORT&H) and "Specifications for Rural Road" by Ministry of Rural Development (MORD).

   In This Volume, here in after, Specification of MORT&H means "Specifications for Road and Bridge Works (5th Revision)" and Specification of MORD means "Specifications for Rural Roads".

2. The rates of the items have been derived mostly from "Standard Data Book for analysis of rates" by MORT&H and Standard data book for analysis of rates for Rural Roads" by MORD. Though rates of few items have also been derived following CPWD's analysis of rates. Where the above documents are found to be inadequate to analyse the rate of an item, method of analysis, generated in house based on feedback from construction sites, has been adopted.

3. Contractors profit has been considered as 10% and Overhead Charges have been considered as 5%, 15% and 30% for road works, Bridge works and Repair of Bridge works respectively. Overhead charge is inclusive of all the items as stated in serial no. 3, in basic approach of "standard data book of analysis of rates" by MORT&H.

4. The rates of steel materials have been taken from SAIL and RINL of Govt. of India, Department of steel as on 1st, July 2018. The rates of Cements have been obtained from ECSC, Govt. of West Bengal as on 2nd week of December'2013.

5. Price of Bitumen (VG grade), Emulsion and CRMB has been obtained from IOCL as on 1st July, 2018.

6. Prices of major construction materials like Stone materials, Bricks, Sand, etc. have been mostly obtained from market or supplied by different Construction Divisions of this Department.

7. Prices of Bearings, Expansion joints, etc. have obtained from Original producer or enlisted /registered supplier of MORT&H and Govt. of India.

8. Rates of some minor construction materials have been taken from SOR of PWD of other states.

9. Machinery usages rates have been taken from Standard Data Books of MORT&H, MORD, CPWD and Other State PWDs as has been found appropriate.

10. For construction and maintenance of major roads having high traffic volume, items have been selected and analyzed according to STANDARD DATA BOOK for analysis of road and bridge works by MORT&H.

    For medium trafficked roads, items have been analyzed following Standard data book for analysis of rates for Rural Road by MORD and for roads having low traffic conventional items involving traditional machineries have been retained as usual so as to provide the user wide variety of items to select according to site conditions.

11. As the utility shifting and environment have become vital issues in present day two chapters namely 'Site clearance' and 'Horticulture' have been dedicated in the SOR as per Standard Data Book.

12. Since, now a day, concrete pavement and geo-synthetic are gaining more and more importance, two separate chapters have been provided for 'Concrete-pavement' and 'Geo-synthetic, in this volume of SOR.

13. For construction of good road, good embankment and sub grade and good drainage are very essential, therefore, greater emphasis has been given to frame the chapter - II, i.e. 'Earthwork, Erosion control and drainage'.

14. Since Traffic sign and road furniture's are very important for the safety of road traffic a new chapter namely, 'Traffic sign, road safety and appliances' has been introduced in this volume of the SOR for Road and Bridge works.

15. Another new chapter called 'River training works and erosion control' has been included in this volume of SOR of PWD.

16. Some conventional maintenance items and common items for Road works, Culverts and Bridges works (including maintenance of Wooden and Steel bridges) and for construction and maintenance of ancillary structures including road side amenities, have been grouped under the head 'Miscellaneous'

17. In most of the items, construction wing is required to add the cost of required cement, steel stone chips or bitumen as per design and specification to arrive at the complete rate.

18. In some items, rates are inclusive of cost of cement and steel materials. In such cases departmental issue rates have considered in the analysis of rates of items.

19. The rates of major construction materials used in the items have been duly taken into account in the Analysis of Rate and need not be considered further.

20. Finally, The Rates of the items provided in this volume of SOR of PWD are tentative and for estimation purpose only.

21. The rates finally arrived at after adding the cost of materials as stated is complete rate including all taxes, overheads and Contractor's Profit but does not include Labour Welfare Cess & GST.

22. (i) Construction Wing should add G.S.T. as applicable, to derive the cost.

    (ii) Construction Wing should add Labour Welfare Cess (in terms of Clause 3 of Building & Other Construction Workers' Welfare Cess Rules, 1998) @ 1% to derive the final cost.

CONTENTS

GENERAL CONDITIONS

1.1. The Schedule of Rates (Vol. III) is divided into different Sub-sections, according to the nature of the works involved. For contracts made specifically for Carriage works, the Sub-section dealing with carriage items will be operative. In all other cases for contracts in respect of Road works, Bridge and Culvert works etc. the entire Schedule (including the Sub-section dealing with carriage items) will be operative.

For contracts made specifically for Building works, P.W.D. Schedule, Volume I & II will only be operative.

1.2. The Engineer-in-Charge shall mean the Executive Engineer of the Division concerned. The Sub Divisional Officers concerned is authorised to carry out general supervision, issue of day to day instructions and to approve materials and workmanship on behalf of the Engineer - in - Charge.

1.3. All materials, tools and plants besides those to be supplied by the Govt. for the work, all labour (skilled and unskilled) including their housing, sanitation, procurement of food stuff, medical aid, drinking water, etc. are to be arranged by the Contractor. Cost for transportation of labour, materials and all items aforesaid shall have to be borne by the Contractor unless otherwise specified in the contract. The expenditure deemed to be covered under Overhead charges.

1.4. Arrangement for water for mixing concrete and mortar and for soaking and curing concrete, bricks, bats and other materials, construction of platforms and vats including cost thereof are to be borne by the Contractor.

1.5. All rates quoted will be inclusive of labour, materials and profit except specifically mentioned otherwise, will include all charges as may have to be incurred by the Contractor for getting the respective items of works executed to proper order and complete and finish. Unless specifically mentioned otherwise in the description of the item itself no extra charge will be paid for scaffolding (including stage, scaffolding) centering, shuttering, curing etc. Rates are to be deemed to be inclusive of the same and also of the cost of any helping materials necessary for satisfactory completion of the work.

1.6. Renewal works include dismantling and taking out of old work and mending good damages after renewal and clearing the worksite of all spoils and dismantled materials, as per direction of the Engineer-in-Charge.

1.7. Tools & Plants:

(a) The Contractor is to make his own arrangements for necessary tools and plants. If possible, the tools and plants as stated in Table: 1-1, belonging to the State may however be rented out to the Contractor depending on availability and on payment of hire charges as mentioned against each. No extension of time will be granted due to non-availability of departmental tools & plants.

Table: 1-1: List of Tools & Plants

(i)	Power Roller (8 Ton or above)	₹ 750.00 per day plus ₹ 400.00 per day (As wages of operating staff)
(ii)	Tar boiler (upto 400 gallons)	₹ 100.00 per day

N.B.: Per day shall mean a day of eight working hours. Hire charges shall be payable for the full period from the date of issue to the date of return (both days inclusive).

(b) All stores, fuels, lubricants etc. for running the tools and plants lent out by the Department are to be supplied by the Contractor; quality of which however, must be approved by the Engineer-in-Charge.

(c) Tools and plants should be taken delivery of and returned at Departmental godown in consultation with E.I.C. The expenditure on carriage of such plants/equipment from the departmental custody to the place of work and its return to the place as directed by Department should be borne by the Contractor. In case the Contractor does not return the machinery by the due date, hire charges at double the issue rate will be recovered from the party for the number of days such machineries are detained. In case the machineries have to be carried and taken back to the godown by the Department engaging his own agency due to fault on the part of the Contractor, the expenditure incurred on this account will be recovered from the Contractor.

(d) The machinery is to be handed over to the Contractor in running condition and should also be received back in the same condition from the Contractor.

(e) The Contractor will be solely responsible for the safe custody and guarding of the machine during the period the machine remains with the Contractor. During this period the Contractor will be held responsible for any pilferage, theft or loss to the machine.

The roller will be driven by the Departmental driver as long as it remains in the custody of the Contractor. The Contractor must not give any direction to the roller driver which is detrimental to the life of the roller. If any damage occurs to the roller due to such direction, the Contractor will be held solely responsible for it.

(f) The machine must be well protected from storm and rain.

(g) All kinds of repairs, maintenance will be done by the Department However, in case of emergency minor or running repairs within ₹ 500/- on each occasion can be done by the Contractor after taking prior approval of the Department and also getting the materials approved by the Department In such cases the cost will be reimbursable to the Contractor.

(h) The inspection of the machinery will be open to the Department at any time even if the machinery remains in the custody of the Contractor.

(i) Hire charges will be realised per day of 8 hours. The hire charges for the machinery working for a part of a day i.e. less than 8 hours will also be charged for the full day.

(j) All risks on account of carriage of machineries etc. by railway, road transport or ferry lies with the Contractor and charges for loss or damages to the same will have to be borne by the Contractor.

(k) When the machine is given to parties other that Govt. body like Municipality, Corporation, Club etc. 50% of the hire charges will be levied extra.

1.8. All materials shall be brought to the site after due approval of the Engineer-in-Charge. Rejected materials must be removed by the Contractor from the site within 24 hours of the issue of orders to that effect. In case of non-compliance with such orders the Engineer-in-Charge shall have the authority to remove the same at the cost and expense of the Contractor and the Contractor shall not be entitled to any loss or damage on that account.

Departmental materials shall be issued to the Contractor to the extent of requirements as assessed and in small instalments as decided by the Engineer-in-Charge. Issue of departmental materials may be of two categories :-

(A) Materials for which value is to be recovered from the Contractor.
(B) Materials which are issued direct to work (in respect of items the rates of which do not include the cost of these materials).

For materials under Category (A) the value of the materials is issued to the Contractor on usual hand receipts, shall be recovered from the bills of the Contractor in one installment, or in successive instalments as may be decided by the Engineer-in-Charge.

For materials under Category (B), the Contractor will act as the custodian of the Department and he shall take charge of the materials against appropriate receipts signed by him. The Contractor shall remain responsible for the proper storage and safe custody of such materials. The rates for relevant items of work shall deemed to be inclusive of reasonable consideration for such duties and responsibilities as the custodian.

Necessary carriage from the nearest Departmental godown to the site of work including loading, unloading and stacking will have to be done by the Contractor at his own cost in case of cement.

All materials whatever be the category thereof shall be properly stored by the Contractor in suitable godown near the site of work. Under no circumstances, whatsoever, shall any materials be removed from the site of work without prior permission of the Engineer-in-Charge. The Contractor shall be responsible for any damage or loss of such materials unless he can satisfy the Engineer-in-Charge that the reasons for such damage or loss are due to circumstances beyond his control.

The Contractor shall also have to satisfy the Engineer-in-Charge regarding the proper utilization of such materials. The value of any materials, which cannot be satisfactorily accounted for, shall be recovered from the Contractor's bills or other dues as specified in P.W. Deptt's Order No. 2809 (3) A dt. 27.4.71 as reproduced below. The quantities of materials for which such value is to be recovered shall be decided by the Engineer-in-Charge. In case of dispute, the decision of Superintending Engineer of the Circle concerned shall be final and binding. Any materials under category (A) which may be surplus on completion of the work may at sole direction of the concerned Superintending Engineer be taken back provided the same be of non-perishable nature and has not been damaged in any way. Surplus materials under category (B) shall be returned to the Engineer-in-Charge in good condition.

EXCERPT FROM GOVT ORDER NO 2809 (3) A. dt. 27th April, 1971

Additional Conditions of Contract for Departmental Materials:

(a) The Value of materials supplied by the Department for use on the work shown in the schedule on page II of the contract form (West Bengal Form No. 2911) in respect of items of work for which the Contractor's rates are inclusive of the cost of such materials will be debited to him in his accounts at the rates specified in the schedule.

(b) Regarding materials in respect of items of work for which the Contractor's rates are not inclusive of the cost of such materials, the Contractor shall only act as custodian on behalf of the Govt. and the value of such materials will not be charged to him except under sub-clause (f) and (g) hereof.

(c) When the contract provides for use of certain specified materials to be supplied by the Department the Contractor shall not obtain such materials from other sources unless authorised in writing by the Engineer-in-Charge of the works.

(d) Materials supplied for a particular work or a part thereof shall not be used elsewhere except with the written permission of the Engineer-in- Charge.

(e) Materials shall be supplied to the Contractor in such instalments as may be decided by the said Engineer-in-Charge.

(f) The Contractor shall be held responsible for any misuse, loss or damage of the materials issued or handed over to him by the Engineer-in-Charge. In default, the cost of such materials shall be recovered from the Contractor according to the terms of the provisions made in sub-clause (g) and (h) hereof.

(g) In the following cases, the materials issued or handed over to the Contractor shall be deemed to have been misused by him.

- *(i) Materials lost or damaged due to negligence on the part of the Contractor and / or defective storage by him.*
- *(ii) Materials used in excess of the requirements as shown in Table 3.1-1.*
- *(iii) Materials used without permission of the Engineer-in-Charge in temporary works (e.g. Coffer dams, embankments, shoring etc.) or in the construction on Contractor's godown, site office, labour hutments etc.*

The value of materials misused as above (in which case the decision of the Engineer-in-Charge shall be final and binding) shall be recovered at 50 per cent in excess of the highest of the following three rates:

- *(i) Issue rate as specified in the contract.*
- *(ii) Department stock rate at the time of recovery of value.*
- *(iii) Market Rate at the time of recovery of value.*

(h) In cases of loss or damage of materials issued or handed over to the Contractor other than under the circumstances mentioned in sub-clause (g), the materials so lost or damaged shall be replaced by the Engineer-in-Charge at the cost of the Contractor and the certificate of the Engineer-in-Charge as to the cost of replacement shall be final and binding on the Contractor.

(i) Where so specified and in any case in respect of cement, steel and bituminous materials supplied by the Department a stock register shall be maintained by the Contractor and the daily receipts, issues and balance of such materials shall be shown therein. This register shall be produced by the Contractor to the Engineer-in-Charge or his representative whenever required for verification of stock.

(j) Whenever asked for by the Engineer-in-Charge during the progress of work and also with the final bill, the Contractor shall submit to the former a statement showing.

- *(i) The total quantity of materials received by the Contractor from the Department..*
- *(ii) Consumption thereof item by item in the work; and*
- *(iii) The balance in hand.*

(k) Whenever by computing the consumption of materials of any description in any item or group of items of work requiring use of such materials.

(i) It is found that the Contractor has used less materials than are required by the specification and / or are shown in Table 3.1-1, the value of the quantity of materials less used shall be recovered from the Contractor at 50 (fifty) per cent in excess of the issue rate of such materials. In such an event the Contractor shall not be entitled to claim or receive the materials, the cost of which has been thus recovered ; or

(ii) If it is found that the Contractor has used any materials in excess of the requirement the value of the material used in excess shall be recovered from the Contractor as provided in sub-clause (g) hereof;

(iii) Provided that recovery of materials used less or in excess as indicated in paragraphs (i) and (ii) of the sub-clause shall be subjected to the decision of the Engineer-in-Charge who may allow variation according to para 1 of consumption chart.

1.9. Subject to condition as aforesaid, the following materials, if available under category (A) shall be issued to the Contractor at issue rate noted in Table I-1 in 'Basic Cost of Materials' of this Schedule. The materials shall be issued from any Sub-Divisional godown or godowns where such materials may be available and for this purpose a stacking yard shall also be deemed as a godown. The Contractor shall be responsible for carriage of the materials except bitumen and bitumen emulsion from the place of issue to the site of work including loading, unloading and stacking at his own cost and the rate quoted will be deemed to be inclusive of carriage cost.

Steel materials of all categories and in sections and sizes as available in stock as stated below to be consumed actually in the finished work. Cut pieces of steel material left surplus on completion of work shall not be taken back if the same be considered as unsuitable for utilisation in other works.

If in the interest of the work, any material other than those mentioned above be issued under category (A), the issue rate of such materials shall be based on the then market rate or the stock issue rate, whichever is higher. Such issue rates shall be decided by the Engineer-in-Charge and his decision shall be binding.

1.10. Value of departmental stones issued to Contractor at site of work in hills will be recovered from the Contractor's bills as follows :

(a)	Rough dressed stones received from dismantled work.	To be determined by the Superintending Engineer concerned.
(b)	Undressed stones received from hard rocks blasting, re-cutting.	
(c)	Dressed stones received from old D.R.M. or C.R.M. work. (in case of C.R.M. work stripping of old mortar will not be paid extra)	
(d)	Boulders.	

1.11. Materials obtained by digging at site or dismantling of Govt. structures or part thereof shall remain the property of Govt. The Contractor shall sort out and stack materials at site as per direction except in case of maintenance work of road and building in which case the materials obtained after dismantling should be carried and stacked in the Department godown. He shall also dispose of the unserviceable rubbish etc. as per instructions of the Engineer-in-Charge or his representative. The Contractor shall remain the custodian of such dismantled materials till the charge of the same is taken over by the Engineer-in-Charge or his representative. Consideration for assumption of such responsibilities shall be deemed to have been included in the rates for the relevant items of work.

1.12. In case of collection of road metals etc. from quarry, the Contractor will have to pay royalty and other incidental charges for quarry and blasting to the respective authorities as may be required. As and when demanded they shall have to produce evidence in support of payment of such Royalties. The Sub-Divisional Officer, P.W. (Roads) Department in-Charge will write to respective Divisional Forest Officer and Tea Garden Managers, if necessary, giving the quantities of stone, stone chips and sand required to be collected for different Government works from the forest or teagarden areas concerned mentioning the name of the quarries. In all cases stone, stone chips, and sand must be of the best variety and obtained from the quarry as specified by the Engineer-in-Charge as available.

No quarrying of stone or sand should be done in any Jhora or road side land within a length as directed by the Engineer-in-Charge.

1.13. Contractor's rate for steel reinforcements (or reinforced concrete work) and for other M.S. work should include cost of straightening the coils of rods, kinks in flats and angles etc. and for this no extra payment will be made.

1.14. All works are to be carried out with due regard to the convenience of the occupants, if any, of premises or of road users, and in close co-operation with other Contractors who may be working in the area. All arrangement and programme of work must be adjusted accordingly. All precautions must be taken to guard against chances of injury or accident to the occupants, users and workers. The Contractor must see that all damages to any property which in the opinion of the Engineer-in-Charge are due to the work of the Contractor are promptly rectified as per his direction and to his satisfaction.

In case of roads or in such portion of roads which are open to traffic, replacement of existing culvert, bridge, the construction of work must be done in such a way as not to dislocate the traffic. Whenever the Engineer-in-Charge feels that the traffic cannot be run during construction over the existing road, necessary diversion road has to be made and maintained for all kinds of traffic. Land required for providing diversion will have to be arranged by Contractor where departmental land is not available. Provision in the schedule of items of the tender is to be kept for such diversion road and its maintenance.

During construction works on roads open to traffic, suitable barriers are to be kept to segregate, the area of work. Red lights are to be provided at such barriers at night during poor visibility on account of fog or otherwise. Night Chowkiders are also to be maintained. *All these will be considered to be included in the rates quoted by Contractor for construction works.*

Prominent signs (in boards measuring nearly 100 cm. x 60 cm.) indicating in black letters on a primrose yellow background "Road-up, use at your own risk / works undergoing" on the side facing vehicles approaching the disturbed area and the sign "clear" on the reverse side of the board, are to set up at about 100 m. distance on either side of the area so disturbed. Similar board with the sign "You have been warned" shall be similarly fixed at about 10m.distance at either end of the said disturbed area. In addition, other suitable direction or guiding boards are to be fixed in proper positions to guide traffic to diversions etc. Unless specifically stipulated otherwise, all the above shall be done at the cost and expense of the Contractor. *It must be clearly understood that the Government is indemnified by the Contractor against payment of any compensation or award on account of any accident injuries and if any such payment has to be made by the Government under orders of appropriate authorities the same shall be recovered from the Contractor.*

1.15. Except when specifically mentioned in the description of the item itself, the rate for any item of work will apply equally to all floors in any position and upto any height. In respect of concrete work etc. where the rate is on the basis of volume the item shall apply to all cases, irrespective of the thickness, unless a specific item appears in the schedule for the particular type of work.

1.16. The rates for items of works in Chapter 4,5,6,10 and items in Chapter 11 to 18 as provided in this Schedule are to be enhanced *excluding the cost of Government material issued as below:*

All the islands situated under North and South 24 Parganas, which are not connected by major bridges from the main land, the Schedule rates shall be enhanced by 20%. The carriage cost involved for the execution of works shall be based on shortest distance.

1.17. The site must be cleared by the Contractor of rubbish etc. from time to time as these accumulate. On completion of work all temporary diversion, barrier board and other structures of obstruction (including sunk pile or similar underground work, if any) must be removed. All scars of construction shall be obliterated and the whole site left in a clean workmanlike manner to the satisfaction of the Engineer-in-Charge. No separate payment shall be made for these, the cost thereof being deemed to have been included in the rates of various items of works.

ADDITIONAL INFORMATION

1.18. Public Utilities:

1.18.1 Drawings scheduling the affected services like water pipes, sewers, oil pipelines, cables, gas ducts etc. owned by various authorities including Public Undertakings and Local Authorities included in the Contract Documents shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

The Contractor shall notify all utility agencies who may have installation in the work area and secure their assistance in locating and identifying all utilities before starting any work that may cause any damage to such utilities.

The Contractor shall schedule work in such a manner as to protect existing utility facilities until they are relocated, abandoned or replaced.

The Contractor shall ensure that all utilities encountered within the Right of Way i.e. OFC Cable, telephone, power, water supply, sewerage or any others, remain operational at all times. Any utility, if damaged, due to construction operation, shall be promptly repaired by the Contractor at his cost.

1.18.2 Notwithstanding the fact that the information on affected services may not be exhaustive, the final position of these services within the works shall be supposed to have been indicated based on the information furnished by different bodies and to the extent the bodies are familiar with the final proposals. The intermediate stages of the works are, however, unknown at the design stage, these being dictated by the Contractor's methods of working. Accordingly, the Contractor's programme must take into account the period of notice and duration of diversionary works of each body as given on the Drawings and the Contractor must also allow for any effect of these services and alterations upon the Works and for arranging regular meetings with the various bodies at the commencement of the Contract and throughout the period of the Works, the Contractor shall have no objection if the public utility bodies vary their decisions in the execution of their proposals in terms of programme and construction, provided that, in the opinion of the Engineer, the Contractor has received reasonable notice thereof before the relevant alterations are put in hand.

1.18.3 No removal of or alterations to the utility shall be carried out unless written instructions are issued by the Engineer.

1.18.4 Any services affected by the Works must be temporarily supported by, the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the Works.

1.18.5 The Contractor may be required to carry out certain works for and on behalf of various bodies, which he shall provide, with the prior approval of the Engineer.

1.18.6 The work of temporarily supporting and protecting the public utility services during execution of the Works shall be deemed to be part of the Contract and no extra payment shall be made for the same.

1.18.7 The Contractor shall be responsible to co-ordinate with the service providers for cutting of trees, shifting of utilities, removal of encroachments etc. to make site unencumbered for completion of work. This will include frequent follow-up meetings. Co¬ ordination for making project site unencumbered shall be deemed to be part of the Contract and no extra payment shall be made for the same.

1.18.8 In some cases, the Contractor may be required to carry out the removal or shifting of certain services/utilities on specific orders from the Engineer for which payment shall be made to him. Such works, however, shall be taken up by the Contractor only after obtaining clearance from the Engineer and ensuring adequate safety measures.

1.19. Precautions for safeguarding the Environment:

1.19.1 General

The Contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall abide by all laws, rules and regulations in force governing pollution and environmental protection that are applicable in the area where the works are situated.

1.19.2 Borrow pits for Embankment Construction

Borrow pits shall be selected only after testing the suitability of materials for use in construction and shall not normally be dug in the right-of-way of the road. The stipulations in Section 305.2.2 shall govern. The borrow pits shall not be left in a condition likely to cause hazard to human and animal life. The Contractor shall seek prior approval from the concerned authorities for operating the borrow pits.

1.19.3 Pollution from Plants and Batching Plants

Stone crushing and screening plants, bituminous hot-mix plants, concrete batching plants etc. shall be located sufficiently away from habitation, agricultural operations or industrial establishments. The locations shall be as permissible under the laws governed by local bodies/ administration of the area. The Contractor shall take every precaution to reduce the levels of noise, vibration, dust and emissions from his plants and shall be fully responsible for any claims or damages caused to the owners of property, fields and residences in the vicinity and violation of pollution control norms, if any.

1.19.4 Substances Hazardous to Health

The Contractor shall not use or generate any materials in the works which are hazardous to the health of persons, animals or vegetation. Where it is necessary to use some substances which can cause injury to the health of workers, the Contractor shall provide protective clothing or appliances to his workers.

1.19.5 Use of Nuclear Gauges

Nuclear gauges shall be used only where permitted by the Engineer. The Contractor shall provide the Engineer with a copy of the regulations governing the safe use of nuclear gauges he intends to employ and shall abide by such regulations.

1.19.6 Occupational Health and Safety of the Workforce

The Contractor shall prepare and submit to the Engineer the Occupational Health & Safety Procedures/ Practices for the workforce in all quarry sites, plant sites, work sites, camp sites, etc., in accordance with the applicable laws.

1.20. Arrangement of Traffic during construction:

1.20.1 General

The Contractor shall at all times, carry out work on the highway in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all works involving improvements to the existing highway, the Contractor shall, in accordance with the directives of the Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement or along a temporary diversion constructed close to the highway. Before taking up any construction or maintenance operation, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the Engineer for prior approval. This plan should include inter alia:

i) Provision of a qualified safety officer with support staff to serve as a site safety team

ii) Provision of traffic safety devices and road signs in construction zones as per IRC:SP:55 and other relevant IRC Codes and para 112.4.

iii) Safety measures for the workers engaged including personal protection equipment

iv) First aid and emergency response arrangements

v) Details and drawings of arrangements in compliance with other sub Sections of this Section.

1.20.2 Passage of Traffic along a Part of the Existing Carriageway under Improvement

For widening/strengthening existing carriageway where part width of the existing carriageway is proposed to be used for passage of traffic, treated shoulders shall be provided on the side on which work is not in progress. The treatment to the shoulder shall consist of providing at least 150 mm thick granular (Wet Mix Macadam/Water Bound Macadam) base course covered with bituminous surface dressing in a width of at least 1.5 m and the treated shoulder shall be maintained throughout the period during which traffic uses the same to the satisfaction of the Engineer. The continuous length, in which such work shall be carried out, would be limited normally to 500 m at a place. However, where work is allowed by the Engineer in longer stretches passing places at least 20 m long with additional paved width of 2.5 m shall be provided at every 0.5 km interval.

In case of eccentric widening of existing two-lane to four-lane, the additional two-lanes would be constructed first and the traffic diverted to it and only thereafter the required treatment to the existing carriageway would be carried out. In case of concentric widening, stipulations as in paragraph above shall apply.

After the works are completed, with the approval of the Engineer, the treated shoulder shall be dismantled, the debris disposed of and the area cleared as per the direction of the Engineer.

1.20.3 Passage of Traffic along a Temporary Diversion

In stretches where it is not possible to pass the traffic on part width of the carriageway, a temporary diversion shall be constructed with 7 m carriageway and 2.5 m earthen shoulders on each side (total width of roadway 12 m) with the following provision for road crust in the 7 m width:

i) Earthwork
ii) 200 mm (compacted) Granular sub-base
iii) 225 mm (compacted) Granular base course
iv) Priming and Tack Coat and
v) Premix carpet with Seal Coat/Mix Seal Surfacing

The location of such stretch, alignment and longitudinal section of diversion including junctions and temporary cross drainage provision shall be as approved by the Engineer.

1.20.4 Traffic Safety and Control

The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, marking, flags, lights and flagmen as per the traffic management plan submitted by the Contractor and approved by the Engineer, referred to in Sub-Section 112.1. Before taking up any construction, an agreed phased programme for the diversion of traffic on the highway shall be drawn up in consultation with the Engineer.

All construction equipment working or parked on or within the traffic lanes or shoulders under "Traffic maintained" conditions shall be equipped with flashing yellow beacons.

The Contractor shall conduct all operations to minimize any drop-offs (abrupt changes in roadway) exposed to traffic. Drop-offs in the travelled way shall be protected by a wedge of compacted stable material capable of carrying traffic (the wedge being 1 vertical to 4 horizontal or flatter).

The Engineer shall authorize other methods, to protect drop-offs when conditions do not allow a wedge of compacted, stable material.

Warning signs, barricades, warning lights, and all other traffic control devices shall not be removed if the hazard has not been eliminated. Only upon receipt of specific written authorization from the Engineer, the Contractor may remove or cease to maintain warning signs, barricades, warning lights, and all other traffic control devices.

The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.

At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriageway) the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device to the directions of the Engineer. At night, the passage shall be delineated with lanterns or other suitable light source including solar energy bulbs.

One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

On both sides, suitable regulatory/warning signs as approved by the Engineer shall be installed for the guidance of road users. On each approach, at least two signs shall be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs shall be of approved design and of reflective type, as directed by the Engineer.

1.20.5 Maintenance of Diversions and Traffic Control Devices

Signs, lights, barriers and other traffic control devices, adequate lighting and other arrangements, as well as the riding surface of diversions and treated shoulders shall be maintained in a satisfactory condition till such time they are required and as directed by the Engineer. The temporary travelled way shall be kept free of dust by frequent applications of water, if necessary.

GENERAL SPECIFICATION

2.1 MATERIALS

All materials used in the works shall be of the best kind and to the approval of the Engineer-in-Charge. All materials shall comply with the relevant Bureau of Indian Standard Specification.

2.1.1 BRICKS *(cl.1003 of MORT&H)*

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

2.1.2 STONES AND BLOCKS *(cl. 1004 of MORT&H)*

2.1.2.1 Stones

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

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

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

2.1.2. 2 Concrete Blocks

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

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

2.1.3 CAST IRON *(cl. 1005 of MORT&H)*

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

2.1.4 CEMENT *(cl. 1006 of MORT&H)*

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

a) Ordinary Portland cement, 33 Grade, conforming to IS: 269.
b) Ordinary Portland cement, 43 Grade, conforming to IS: 8112.
c) Ordinary Portland cement, 53 Grade, conforming to IS: 12269.
d) Sulphate resisting Portland cement, conforming to IS: 12330.
e) Portland Pozzolana cement (fly ash based) conforming to IS:1489 (Part I)
f) Portland slag cement conforming to IS:455
g) Rapid Hardening Portland cement, conforming to IS: 8041.
h) Low heat Portland cement conforming to IS: 12600

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

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

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

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

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

Total chloride content shall be 0.1 percent by mass of cement for the cement to be used in structures other than prestressed concrete structures and 0.05% by mass of cement in prestressed concrete structures. Also, total sulphur content calculated as sulphuric anhydride (S03) shall in no case exceed 3.5 percent.-

Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with C3A content from 5 to 8 percent shall be preferably used in concrete, instead of sulphate resisting cement.

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

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

i) Compressive strength.
ii) Setting time.

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

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

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

2.1.5 COARSE AGGREGATES FOR CONCRETE WORK *(cl. 1007 of MORT&H)*

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

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

Maximum nominal size of coarse aggregate for various structural components in PCC, RCC or PSC, shall conform to Section 1700 of these Specifications. The maximum value for flakiness index for coarse aggregate shall not exceed 35 percent. The coarse aggregate shall satisfy the requirements of grading as given in Table 1000-1 of MoRT&H:

Table 1 : Grading Requirements of Coarse Aggregate *(Table 1000-1of MORT&H)*

IS Sieve Size	Percentage Passing for Graded Aggregate of Nominal Size		
	40 mm	20 mm	12.5 mm
63 mm	–	–	–
40 mm	95-100	100	–
20 mm	30-70	95-100	100
12.5 mm	–	–	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0- 10	0-10

2.1.6 FINE AGGREGATES FOR CONCRETE WORKS *(cl. 1008 of MORT&H)*

For masonry work, sand shall conform to the requirements of IS: 2116.

Natural sand, crushed stone sand or crushed gravel sand or a suitable combination of natural sand, crushed stone or gravel, shall be used as fine aggregates in plain, reinforced and pre stressed concrete works. The fine aggregates shall be dense, durable, clean and free from veins and adherent coating and other deleterious substances. They shall not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Mechanised sand washing machines should be used to remove impurities from sand. Fine aggregates having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Fine aggregate for structural concrete shall conform to the following grading requirements:

Table 2 : Grading Requirements of Fine Aggregates *(Table 1000-2 of MORT&H)*

IS Sieve Size	Percent Passing for		
	Grading Zone I	Grading Zone II	Grading Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

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

2.1.7 STEEL *(CL. 1009 of MORT&H)*

2.1.7.1 Cast Steel

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

2.1.7.2 Steel for Pre stressing

a) The pre stressing steel shall conform to any one of the following standards:
b) Plain hard drawn steel wire conforming to IS: 1785 (Part I) and IS:1785 (Part II)
c) Cold drawn indented wire conforming to IS:6003
d) High tensile steel bar conforming to IS:2090
e) Uncoated stress relieved strands conforming to IS:6006
f) Uncoated stress relieved low relaxation seven ply strand conforming to IS:14268

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

2.1.7.3 Reinforcement/Un tensioned Steel

2.1.7.3.1 Reinforcing Bars

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

2.1.7.3.2 Hot Dipped Galvanized Bars

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

2.1.7.4 Steel Forgings

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

2.1.7.5 Structural Steel

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

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

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

2.1.8 WATER *(CL. 1010 of MORT&H)*

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

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

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

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

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

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

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

a) To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. For details of test refer IS:3025(Part 22).

b) To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal. H_2SO_4. For details of test refer IS: 3025(Part 23).

c) The Permissible limit's for solids shall be as follows :

		Tested as per	Permissible Limit max.
Organic	:	IS: 3025 (Pt. 18)	200 mg per liter
Inorganic	:	IS: 3025 (Pt. 18)	3000 mg per liter
Sulphates (SO4)	:	IS: 3025 (Pt. 28)	400 mg per liter
Chloride (Cl)	:	IS: 3025 (Pt. 32)	2000 mg per liter for concrete work not containing embedded steel and 500 mg/lit for prestressed / reinforced concrete work
Suspended matters	:	IS: 3025 (Pt. 17)	2000 mg per liter

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

2.1.9 TIMBER *(cl. 1011 of MORT&H)*

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

2.1.10 CONCRETE ADMIXTURES *(cl. 1012 of MORT&H)*

2.1.10.1 Mineral Admixtures

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

Fly ash : conforming to of IS: 3812-3

Granulated slag: Ground granulated slag obtained by grinding granulated slag conforming toIS:12089.

Silica fume: Silica fume is very fine, non- crystalline SiO_2, obtained as a by-product of Silicon and Ferro - Silicon alloy industries and shall conform to IS: 15388

2.1.10.2 Chemical Admixtures

2.1.10.2.1 Information Required from the Manufacturer

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

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

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

2.1.10.2.2 Physical and Chemical Requirements

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

a) "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".

b) Except where resistance to freezing and thawing and to disruptive action of deicing salts is required, the air content of freshly mixed concrete in accordance with the pressure method given in IS:1199, shall not be more than 2 percent higher than that of the corresponding control mix and in any case not more than 3 percent of the test mix.

c) The chloride content of the admixtures shall not exceed 0.2 percent when tested in accordance with IS: 6925. In addition, the maximum permissible limit of chloride content of all the constituents as indicated in Section 1700 of these Specifications shall also not be exceeded.

d) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

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

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

ii) Ash content : within 1 percent of the value stated by the manufacturer.

iii) Relative Density (for liquid admixtures) : within 2 percent of the value stated by the manufacturer.

e) All tests relating to concrete admixtures shall be conducted periodically at an independent laboratory and the results compared with the data given by the manufacturer.

2.1.11 REINFORCED AND PRESTRESSED CONCRETE PIPES *(cl. 1013 of MORT&H)*

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

2.1.12 Prestressing Materials *(cl. 1014.6 of MORT&H)*

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

a) **Tendons** : Wires, strands and bars from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances shall tendon material be subjected to any welding operation or on site heat treatment or metallic coating such as galvanizing. Storage facilities and the procedures for transporting material into or out of the store, shall be such that the material does not become kinked or notched. Wires or strands shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 3 m dia without breaks or joints shall be obtained from manufacturer. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.

b) **Anchorage Components** : The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The corrosion of the gripping and securing system shall be prevented. The use of correctly formulated oils and greases or of other corrosion preventing material, shall be guaranteed by the producer to be non-aggressive and non-degrading.

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

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

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

2.1.13 SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES *(cl. 520 of MORT&H)*

2.1.13.1 Scope

This Clause shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates and stone filler for subsequent use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual Specification Clause for the actual work, given elsewhere in these Specifications. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Specification Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective Specification Clauses for the individual items given elsewhere in these Specifications.

2.1.13.2 Sizes of Stone Aggregates

The stone aggregates shall be designated by their standard sizes in the Contract and shall conform to the requirements shown in Table 500-49.

2.1.13.3 Stacking

2.1.13.4 Coarse Aggregates

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

Table 3 : Size Requirements for Coarse Stone Aggregates *(Table 500-49 of MORT&H)*

S. No.	Nominal Size of Aggregate	Designation of Sieve Through which the Aggregates shall Wholly Pass	Designation of Sieve on which the Aggregates shall be Wholly Retained
1)	75 mm	106 mm	63 mm
2)	63 mm	90 mm	53 mm
3)	45 mm	53 mm	26.5 mm
4)	26.5 mm	45 mm	22.4 mm
5)	22.4 mm	26.5 mm	13.2 mm
6)	13.2 mm	22.4 mm	11.2 mm
7)	11.2mm	13.2 mm	6.7 mm
8)	6.7 mm	11.2 mm	2.8 mm

2.1.13.5 Fine Aggregate

As stated in the individual relevant Specification Clauses.

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

The dimensions of the stockpiles and their locations shall be approved by the Engineer. Where the material is improperly stacked, the Engineer shall direct complete re-stacking of the materials in an approved manner at the Contractor's cost.

Stone filler shall be supplied in a dry state in bags or other suitable containers approved by the Engineer and shall be protected from the environment, so as to prevent deterioration in quality.

Table 4 : Percent Reduction In Volume of Aggregates *(Table 500-50 of MORT&H)*

Sl. No.	Standard Size of Aggregates	Percentage Reduction in Volume Computed by Stack Measurements to Arrive at the Volume to be Paid for
1)	75 mm and 63 mm	12.5
2)	45 mm and 26.5 mm	10.0
3)	22.4 mm, 13.2 mm, 11.2 mm and 6.7 mm	5.0
4)	Fine aggregate	5.0

Unless otherwise directed by the Engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the Engineer.

Stone filler as delivered to the site shall be measured in tonnes.

2.1.14 Bitumen

The Bureau of Indian Standards (BIS) introduced paving grade bitumen specifications (IS: 73-1950) for the first time in the year 1950 and classified it on penetration. The specifications were revised in the years 1962 and 1992. To improve the quality of Bitumen, BIS revised IS-73-1992 specifications based on Viscosity (Viscosity at 60°C) in July 2006. As per these specifications, there are four grades VG-10, VG-20, VG-30 & VG-40. A few qualification tests like specific gravity, water content, ductility, loss on heating & Farass breaking point were removed from IS: 73-1992 specifications as these tests do not have any relationship either with the quality or performance of the product.

According to viscosity (degree of fluidity) grading, higher the grade, stiffer the Bitumen. Tests are conducted at 60° C and 135° C, which represent the temperature of road surface during summer (hot climate, similar to northern parts of India) and mixing temperature respectively. The penetration at 25° C, which is annual average pavement temperature, is also retained.

2.1.14.1 Different Grades of Bitumen marketed by Indian Oil :

VG-10 Bitumen : VG-10 is widely used in spraying applications such as surface-dressing and paving in very cold climate in lieu of old 80/100 Penetration grade. It is also used to manufacture Bitumen Emulsion and Modified Bitumen products.

VG-20 Bitumen : VG-20 is used for paving in cold climate & high altitude regions

VG-30 Bitumen : VG-30 is primarily used to construct extra heavy duty Bitumen pavements that need to endure substantial traffic loads. It can be used in lieu of 60/70 Penetration grade.

VG-40 Bitumen : VG-40 is used in highly stressed areas such as intersections, near toll booths and truck parking lots in lieu of old 30/40 Penetration grade. Due to its higher viscosity, stiffer Bitumen mixes can be produced to improve resistance to shoving and other problems associated with higher temperature and heavy traffic loads.

Table 5 : Viscosity Grade (VG) Bitumen Specification As Per IS 73:2006

Characteristics	VG-10	VG-20	VG-30	VG-40
Absolute Viscosity, 60°C, poises, min	800	1600	2400	3200
Kinematic Viscosity, 135°C, CST, min	250	300	350	400
Flash point, C, min	220	220	220	220
Solubility in trichloroethylene, %, min	99.0	99.0	99.0	99.0
Penetration at 25°C	80-100	60-80	50-70	40-60
Softening point, C, min	40	45	47	50
Tests on residue from thin film over test / RTFOT:				
i. Viscosity ratio at 60°C, max	4.0	4.0	4.0	4.0
ii. Ductility at 25°C, cm, min, after thin film over test	75	50	40	25

Table 6 : Use of Viscosity Grade Bitumen as per IS: 73-2006 in replacement of Penetration Grade Bitumen as per IS: 73 -1992 (As amended in 2002)

Bitumen Grade as per IS:73-2006	Use	Reference
VG-10	May be used in spraying application in very cold climate in lieu of old 80/100 penetration grade.	Memo No KDO/C/Bit dated 17.06.2009 of Senior Divisional Consumer Sales Manager, Kolkata Divisional Office, Indian Oil Corporation Limited.
VG-20	May be used for paving in cold climate in high altitude regions.	
VG-30	May be used for construction of heavy duty bitumen pavements that need to endure substantial traffic load. It can be used in lieu of 60/70 penetration grade.	
VG-40	May be used in highly stressed area such as intersection, near toll booth, truck parking lots in lieu of old 30/40 penetration grade.	

2.1.14.2 MODIFIED BINDER

2.1.14.2.1 Scope

Modified binders comprise a base binder, to which is added either natural rubber, crumb rubber or a polymer such as Styrene-Butadiene-Styrene (SBS), Ethylene-Vinyl-Acetate (EVA) or Low Density Polyethylene (LDPE). The purpose is to achieve a high performance binder with improved properties, particularly at extremes of temperature.

(a) Modifier

The modifier shall be a natural rubber, crumb rubber or any other polymer which is compatible with the base binder and which allows the properties as given in following Table to be achieved. For further details, IRC: SP-53 may be referred to. The modifier, in the required quantity shall be blended at the refinery or at the site plant capable of producing modified binder.

Table 7 : Bitumen – CRMB, IS 15462: 2004

Characteristics	Grade and Requirements			Method of Test, Ref. To	
	CRMB 50	CRMB 55	CRMB 60	IS No.	Annex
Penetration at 25 Deg. C, 0.1 mm, 100g, 5s	<70	<60	<50	1203	-
Softening Point, (R&B), Deg. C Min.	50	55	60	1205	-
Flash Point, COC, Deg. C. Min.	220	220	220	1209	-
Elastic recovery of half thread in ductilometer at 15 Deg. C, percent Min. or	50	50	50	-	A
Separation, difference in softening point (R&B) Deg. C Max.	4	4	4		B
Viscosity at 150 Deg. C, Poise	1-3	2-6	3-9	1206 (Part 1)	-
Thin film oven tests and test on residue : a. Loss in mass, percent b. Increase in softening point, Deg. C. Max.	 1.0 7	 1.0 6	 1.0 5	 9382 1205	- -
c. Reduction in penetration of residue, at 25 Deg. C, percent Max.	40	40	40	1203	-
d. Elastic recovery of half thread in ductilometer at 25 Deg. C, percent Min.	35	35	35	-	A

Table 8 : Bitumen Emulsion (Cationic Type) – IS 8887: 2004 (Second Revision)

Characteristics	Grades of Emulsion					Method of Test, Ref to	
	RS-1	RS-2	MS	SS-1	SS-2	1:No.	Annex of This standard
Residue on 600 micron IS Sieve, percent by mass, Max	0.05	0.05	0.05	0.05	0.05	-	B
Viscosity by saybolt furol viscometer, seconds:						3117	-
1) At 25 Deg. C	-	-	-	20-100	30-150		
2) At 50 Deg. C	20-100	100-300	50-300	-	-		
Coagulation of emulsion at low temperature C	Nil	Nil	Nil	Nil	Nil	-	C
Storage stability after 24 h, percent, Max	2	1	1	2	2	-	D
Particle charge	Positive	Positive	Positive	Weak Positive	Positive	-	E
Coating ability and water resistance:							
1. Coating, dry aggregate	-	-	Good	-	-	-	F
2. Coating, after spraying	-	-	Fair	-	-		
3. Coating, wet aggregate	-	-	Fair	-	-		
4. Coating, after spraying	-	-	Fair	-	-		
Stability to mixing with cement (percentage coagulation), Max	-	-	-	2	2	-	G
Miscibility with water	No coagulation	No coagulation	No coagulation	-	No coagulation		H

Characteristics	Grades of Emulsion					Method of Test, Ref to	
	RS-1	RS-2	MS	SS-1	SS-2	1:No.	Annex of This standard
Tests on residue:							
1. Residue by evaporation, percent, Min.	60	67	65	50	60	-	-
2. Penetration 25 Deg. C/100g/5 sec	80-150	80-150	60-150	60-350	60-120	1203	-
3. Ductility 27 Deg. C/cm, Min.	50	50	50	50	50	1208	-
4. Solubility : In trichloro-ethylene, Percent by mass, Min.	98	98	98	98	98	1216	-
Distillation in percent, by volume at							
1. 190 Deg. C	-	-	-	20-55	-	-	-
2. 225 Deg. C	-	-	-	30-75	-	-	-
3. 260 Deg. C	-	-	-	40-90	-	-	-
4. 315 Deg. C	-	-	-	60-100	-	-	-
Water content, percent by mass, Max.	-	-	-	20	-	-	-

2.1.15.1 Testing and Approval of Material

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

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

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

2.1.15.2 Sampling of Materials

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

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

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

2.1.15.3 Rejection of Materials not conforming to the Specifications.

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

2.1.15.4 Testing and Approval of Plant and Equipment

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

2.2 GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENT

2.2.1 General

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant Sections read in conjunction with the General Conditions of Contract. The same shall not, however, apply in the case of lump sum contracts.

2.2.2 Measurement of Pavement Thickness for Payment on Volume Basis

The finished thickness of sub-bases, base and bituminous layers and concrete courses to be paid on volume basis shall be computed in the following manner:

Levels shall be taken before and after construction, at the grid of points 10m centre-to-centre longitudinally in straight reaches and 5 m centre-to-centre at curves. Normally, on two-lane roads, the levels shall be taken at four positions transversely, at 0.75 m and 2.75 m from either edge of the carriageway and on single-lane roads, these shall be taken at two positions transversely, being at 1.25 m from either edge of the carriageway. For multi-lane roads, levels shall be taken at two positions transversely for each lane. The transverse position for levels shall be 0.75 m from either edge of the carriageway and the remaining locations shall be at equi-distance in the balance portion of carriageway. For paved shoulder an additional level shall be taken at the centre of the shoulder.

Suitable references for the transverse grid lines should be left in the form of embedded bricks on both ends or by other means so that it is possible to locate the grid points for level measurements after each successive course is laid.

For pavement courses laid only over widening portions, at least one line of levels shall be taken on each strip of widening, or more depending on the width of widening as decided by the Engineer.

Notwithstanding the above, the measurements may be taken at closer intervals also, if so desired by the Engineer, the need for which may arise particularly in the case of estimation of the volume of the material for profile corrective course (levelling course). The average thickness of the pavement course in any area shall be the arithmetic mean of the difference of levels before and after construction at all the grid points falling in that area, provided that the thickness of finished work shall be limited to those shown on the drawings or approved by the engineer in writing.

As supplement to level measurements, the Engineer shall have the option to take cores/ make holes to check the depth of construction. The holes made and the portions cut for taking cores shall be made good by the Contractor by laying fresh mix/material including compacting as required at his-own cost immediately after the measurements are recorded.

2.2.3 Checking of Pavement Thickness for Payment on Area Basis

Where payment for any bituminous course in Section 500 is allowed to be made on the area basis, the Engineer may have its thickness checked with the help of a suitable penetration gauge at regular intervals or other means as he may decide.

2.2.4 Mode of Measurement

The modes of measurements of Brick / Concrete (Plain or Reinforced) Works, Reinforcement, Plaster, Painting, Metal, Chips, Boulders, Bats, Sand, Lime, Carried Earth etc. will be as per (C) Mode of Measurement under General Specifications vide Page B 38 of P W D Schedule (Volume I).

2.3 FIELD LABORATORY *(cl. 120 of MORT&H)*

2.3.1 Scope

The work covers the provision and maintenance of an adequately equipped field laboratory as required for site control on the quality of materials and the works.

2.3.2 Description

The Contractor shall arrange to provide fully furnished and adequately equipped field laboratory. The field laboratory shall preferably be located adjacent to the site office of the Engineer and provided with amenities like water supply, electric supply etc. as for the site office of the Engineer as described in this Section.

The layout and size of the field laboratory shall be as indicated in the drawings. In case no drawings is furnished, the laboratory shall include space for the storage of samples, equipment, laboratory tables and cupboards, working space for carrying out various laboratory tests, a wash basin, toilet facility and a curing tank for the curing of samples, around 4 m x 2 m x 1 m in size and a fume chamber. Wooden/concrete working table with a working platform area of about 1 m x 10 m shall be provided against the walls. Wooden cupboards above and below the working tables shall be provided to store accessories such as, sample moulds etc. At least 4 racks of slotted angles and M.S. sheets the size 1800 mm x 900 mm x 375 mm and at least 6 stools for laboratory test operators shall also be provided.

The items of laboratory equipment shall be provided in the field laboratory depending upon the items to be executed as per Table 100-2.

2.3.3 Ownership

The field laboratory building and equipment shall be the property of the Contractor. The Employer and the Engineer shall have free access to the laboratory.

2.3.4 Maintenance

The Contractor shall arrange to maintain the field laboratory in a satisfactory manner until the issue of Taking over Certificate for the completed work. Maintenance includes all activities described in Section 120.4.

Table 9 : List of Laboratory Equipment *(Table 100-2 of MORT&H)*

Sl. No	Name of the Project	Number
A)	**GENERAL**	
1)	Weigh Balances	
	a) 5 - 20 kg capacity Electronic type -Accuracy 1 gm	1 No.
	b) 500 gm capacity-Electronic Type Accuracy 0.01 gm	1 No.
	c) Electronic 5 kg capacity Accuracy 0.5 gm	1 No.
	d) Platform Balance scale-300 kg capacity	1 No.
	e) Chemical Balance 100 gm capacity-accuracy 0,001 gm	-
2)	Oven-electrically operated, thermostatically controlled (including thermometer), stainless steel interior	
	From 0°C to 220°C Sensitivity 1°C	1 No
3)	Sieves : as per IS:460-1962	
	a) I.S. sieves 450 mm internal dia of sieve sets as per BIS of required sieve sizes complete with lid and pan	1 set
	b) IS sieve 200 mm internal dia (brass frame and steel/or brass wire cloth mesh) consisting of sieve sets of required sieve sizes complete with ltd	2 sets
4)	Sieve shaker capable of taking 200 mm and 450 mm dia sieves-electrically operated with time switch	1 No
5)	200 tonnes compression testing machine	1 No
6)	Stop watches 1/5 sec. accuracy	1 No
7)	Glassware comprising beakers, pipettes, dishes, measuring cylinders (100 to 1000 cc capacity) glass rods and funnels, glass thermometers range 0°C to 100°C and metallic thermometers range upto 300°C.	2 No. each
8)	Hot plates 200 mm dia (1500 watt.)	1 No
9)	Enamel trays	
	a) 600 mm x 450 mm x 50 mm	2Nos
	b) 450 mm x 300 mm x 40 mm	2 Nos
	c) 300 mm x 250 mm x 40 mm	2 Nos
	d) Circular plates of 250 mm dia	2 Nos
10)	Water Testing Kit	1 No
B)	**FOR SOILS**	
1)	Water still	-
2)	Liquid limit device with ASTM grooving tools as per IS:2720	1 No
3)	Sampling pipettes fitted with pressure and suction inlets, 10 ml. Capacity	1 set
4)	Compaction apparatus (Proctor) as per IS:2720 (Part 7) complete with collar, base plate and hammer and all other accessories	1 No
5)	Modified AASHTO Compaction apparatus as per IS:2720 (Part 8) 1974 or Heavy Compaction Apparatus as per IS complete with collar, base plate hammer and all other accessories	1 No
6)	Sand pouring cylinder with conical funnel and tap and complete as per IS: 2720 {Part 28) 1974 including modern equipment.	2Nos
7)	Ennore Standard Sand	As required
8)	Sampling tins with lids 100 mm dia x 75 mm ht. ½ kg capacity and miscellaneous items like moisture tins with lid 50 grams etc.	4 Nos
9)	Lab CBR testing equipment for conducting CBR testing, load frame with 5 Tonne capacity, electrically operated with speed control as per IS:2720 (Part 16) and consisting of following:	1 Set
	a) CBR moulds 150 mm dia- 175 mm ht.	6 No
	b) Tripod stands for holding dial gauge holder	4 Nos
	c) CBR plunger with settlement dial gauge holder	1 No
	d) Surcharge weight 147 mm dia 2.5 kg wt.	6 Nos
	e) Spacers disc 148 mm dia 47.7 mm ht. with handle	2 Nos
	f) Perforated plate (Brass)	2 Nos
	g) Soaking tank for accommodating 6 CBR moulds	2 Nos
	h) Proving rings of 1000 kg, 2500 kg capacity	1 No each
	i) Dial gauges 25 mm travel - 0.01 mm/division	2 No
10)	Standard penetration test equipment	1 No
11)	Nuclear moisture Density meter or equivalent	-
12)	Speedy moisture meter complete with chemicals	1 No
13)	Unconfined Compression Test Apparatus	1 No

Sl. No	Name of the Project	Number
C)	**FOR BITUMEN AND BITUMINOUS MIXES**	
1)	Constant temperature bath for accommodating bitumen test specimen, electrically operated, and thermostatically controlled (to accommodate minimum six Specimens)	1 No
2)	Penetrometer automatic type, including adjustable weight arrangement and needles as per IS:1203-1958	1 No
3)	Soxhlet extraction or centrifuge type apparatus complete with extraction thimbles with solvent and filter paper	1 No
4)	Bitumen laboratory mixer including required accessories (20 ltrs.)	1 No
5)	Marshall compaction apparatus automatically operated as per ASTM 1559-62 T complete with accessories (with 180 N Marshall Moulds)	1 set
6)	Furol viscometer	1 No
7)	Ductility meter	1 No
8)	Softening point (Ring and ball app)	1 No
9)	Distant reading thermometer	-
10)	Rifle box	-1 No
11)	Automatic Asphlat content Meter	-1 No
12)	Thin film over test apparatus for modified binder either with PMB or CRMB	—
13)	Mastic Asphalt Hardness testing equipment	-
14)	Sand Equivalent test apparatus	1 set
15)	Core cutting machine suitable for upto 150 mm dia core	1 set
16)	Thermometers	4 Nos
D)	**FOR CEMENT, CEMENT CONCRETE AND MATERIALS**	
1)	Water still	1 No
2)	Vicat needle apparatus for setting time with plungers as per IS:269-1967	1 No
3)	Moulds	
	a) 150 mm x 300 mm ht. Cylinder with capping component along with the capping set and compound as per IS	As reqd.
	b) Cube 150 mm, and 100 mm (each size)	As reqd.
4)	Concrete permeability apparatus	-
5)	High frequency mortar cube vibrator for cement testing	-
6)	Concrete mixer power driven, 1 cu.ft. capacity	-
7)	Variable frequency and amplitude vibrating table size 1 m x 1 m as per the relevant British Standard	-
8)	Flakiness index test apparatus	1 No
9)	Aggregate impact test apparatus as per IS:2386 (Part 4) 1963	1 No
10)	Los-angeles abrasion test apparatus as per IS:2386 (Part 4) 1963	1 No
11)	Flow table as per IS:712-1973	-
12)	Equipment for slump test	1 No
13)	Equipment for determination of specific gravity or fine and coarse aggregate as per IS:2386 (Part 3) 1963	1 No
14)	Compression and Flexural strength testing machine of 200 T capacity with additional dial for flexural testing	1 No
15)	Core cutting machine with 10 cm dia diamond cutting edge	1 no
16)	Needle vibrator	2 Nos
17)	Air entrainment meter	-
18)	0.5 Cft, 1 Cft cylinder for checking bulk density of aggregate with tamping rod	As reqd.
19)	Soundness testing apparatus for cement (Lee chattlier)	1 set
E)	**FOR CONTROL OF PROFILE AND SURFACE EVENNESS**	
1)	Total Station	1 No
2)	Precision automatic level with micrometer attachment	1 set
3)	Distomat or equivalent	1 set
4)	Theodolite - Electronically operated with computerised output attachment	1 set
5)	Precision staff	2 sets
6)	3 meter straight edge and measuring wedge	1 set
7)	Camber template 2 Lane	
	a) Crown type cross-section	1 set
	b) Straight run cross-section	2 sets
8)	Steel tape	
	a) 5 m long	2Nos
	b) 10 m long	2Nos
	c) 20 m long	2 Nos
	d) 30 m long	2Nos
	e) 50 m long	1 No
9)	Roughometer (Bump Integrator)	1 No. (when reqd.)

Note: The items and their numbers listed above in this Section are indicative and shall be decided by the Engineer as per requirements of the Project and modified accordingly.

2.4 SUPPLY OF PROJECT RECORD *(cl. 121 of MORT&H)*

2.4.1 Scope

The work covers the supply digital record of project events in digital format (DVD/Flash Drive) including coloured photographs both in digital format as well as mounted on albums to serve as a permanent record of the work needed for an authentic documentation, as approved by the Engineer.

2.5 SITE CLEARANCE

2.5.1 CLEARING AND GRUBBING *(cl. 201 of MORT&H)*

2.5.1.1 Description

This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, rubbish, top organic soil, etc. to an average depth of 150 mm in thickness, which in the opinion of the Engineer-in-Charge 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-in-Charge. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials with all leads and lifts. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of Specifications for Road & Bridge Works of MoRT&H (5th Revision).

2.5.1.2 Preservation of Property/Amenities

Roadside trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all highway facilities within or adjacent to the highway which are not to be disturbed shall be protected from injury or damage.

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-in-Charge 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 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).

2.5.1.3 Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer-in-Charge and which will not affect any property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the bottom of the subgrade. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/ subgrade shall be removed between fill lines to the satisfaction of the Engineer-in-Charge. All branches of trees extending above the roadway shall be trimmed as directed by the Engineer-in-Charge.

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.

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

2.5.1.4 Disposal of Materials

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

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

2.5.2 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES / PAVEMENTS *(cl. 202 of MORT&H)*

2.5.2.1 Scope

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

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

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

2.5.2.2 Dismantling Culverts and Bridges

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

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

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

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

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

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

2.5.2.3 Dismantling Pavements and Other Structures

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

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

2.5.2.4 Back-filling

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

2.5.2.5 Disposal of Materials

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

2.6 EMBANKMENT CONSTRUCTION *(cl. 305 of MORT&H)*

2.6.1 Description

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

2.6.2 Materials and General Requirements

2.6.2.1 Physical Requirements

2.6.2.1.1 The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment.

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

a) Materials from swamps, marshes and bogs;

b) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498;

c) Materials susceptible to spontaneous combustion;

d) Materials in a frozen condition;

e) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; and

f) Materials with salts resulting in leaching in the embankment.

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

2.6.2.1.3 Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO_3) per litre when tested in accordance with BS: 1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementitious material.

Materials with a total sulphate content (expressed as SO_3) exceeding 0.5 percent by mass, when tested in accordance with BS: 1377, Part 3 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

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

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

Table 10 : Density Requirements of Embankment and Sub-grade Materials *(Table 300-1 of MORT&H)*

Sl. No.	Type of Work	Maximum laboratory dry unit weight when tested as per IS:2720 (Part 8)
1)	Embankments up to 3 m height, not subjected to extensive flooding	Not less than 15.2 kN/cu.m
2)	Embankments exceeding 3 m height or embankments of any height subject to long periods of inundation	Not less than 16 kN/ cu.m
3)	Subgrade and earthen shoulders/verges/ backfill	Not less than 17.5 kN/cu.m

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

2) The material to be used in subgrade shall be non-expansive and shall satisfy design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer shall be followed.

2.6.2.2 General Requirements

2.6.2.2.1 Borrow Materials

The arrangement for the source of supply of the material for embankment and sub-grade and compliance with the guidelines, and environmental requirements, in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable shall be the sole responsibility of the Contractor.

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

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

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

2.6.2.2.2 Fly-Ash

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

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

2.6.2.2.3 Compaction Requirements

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

Table 11: Compaction Requirements for Embankment and Sub-grade *(Table 300-2 of MORT&H)*

S. No.	Type of work/material	Relative compaction as percentage of max. laboratory dry density as per IS:2720(Part8)
1)	Subgrade and earthen shoulders	Not less than 97%
2)	Embankment,	Not less than 95%
3)	Expansive Clays a) Subgrade and 500 mm portion just below the subgrade b) Remaining portion of embankment	Not allowed 90-95%

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

i) The values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 8), appropriate for each of the fill materials he intends to use.

ii) A graph of dry density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

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

2.6.3 Construction Operations

2.6.3.1 Setting Out

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

2.6.3.2 Dewatering

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

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

2.6.3.3 Stripping and Storing Topsoil

When so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily subjected to traffic either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

2.6.3.4 Compacting Ground Supporting Embankment/Sub-Grade

Where necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling in accordance with Clauses 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the sub-grade level (top of the sub-grade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density (as given in Table 300-2), the ground shall be loosened upto a level 0.5 m below the sub-grade level, watered and compacted in layers in accordance with Clauses 305.3.5 and 305.3.6 to achieve dry density not less than 97 percent relative compaction as given in Table 300-2.

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

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the Engineer. Where the ground on which an embankment is to be built has any of such material types (a) to (f) in Clause 305.2.1.1 at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

2.6.3.5 Spreading Material in Layers and Bringing to Appropriate Moisture Content

2.6.3.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self-propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, etc., of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the required compaction. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for the site trials shall be submitted to the Engineer for approval.

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

Each layer of the material shall be thoroughly compacted to the densities specified in Table 300-2. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture/density gauge used in accordance with agreed procedure and provided the gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/earthen shoulders, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

2.6.3.7 Repairing of Damages Caused by Rain/Spillage of Water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 305.3.6. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery/equipment for the purpose.

2.6.3.8 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders/verge/ roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the surface tolerance described in Clause 902. Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier (Clauses 301.3.2 and 305.3.3) shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with Clause 307. If seeding and mulching of slopes is prescribed, this shall be done to the requirements of Clause 308.

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

2.6.3.9 Earthwork for Widening Existing Road Embankment

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

Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of light weight vibratory roller, double drum walk behind roller, vibratory plate compactor or vibratory tamper or any other appropriate equipment approved by the Engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

2.6.3.10 Earthwork for Embankment and Sub-Grade to be Placed against Sloping Ground

Where an embankment/subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed/scarified as required in Clause 305.4.1 before placing the embankment/sub-grade material. Extra earthwork involved in benching or due to ploughing/ scarifying etc. shall be considered incidental to the work.

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

Where the Contract requires construction of transverse subsurface drain at the cut-fill interface, work on the same shall be carried out to Clause 309 in proper sequence with the embankment and sub-grade work as approved by the Engineer.

2.6.3.11 Earthwork over Existing Road Surface

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

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

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

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

2.6.3.12 Embankment and Sub-Grade around Structures

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

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

The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to !S:2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in IRC:78. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 300-2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in Clause 2504 unless otherwise specified in the Contract.

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

2.6.3.13 Construction of Embankment over Ground Incapable of Supporting Construction Equipment

Where embankment is to be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the

embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in Clause 305.3.

2.6.3.14 Embankment Construction under Water and Waterlogged Areas

2.6.3.14.1 Embankment Construction under Water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the Engineer. Acceptable granular material shall be of GW, SW, GP, SP as per IS: 1498 and consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

2.6.3.14.2 Embankment Construction in Waterlogged and Marshy Areas

The work shall be done as per IRC: 34.

2.6.3.15 Earthwork for High Embankment

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

Where provided, stage construction of embankment and controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

Where required, the Contractor shall surcharge embankments or other areas of fill with approved material for the periods specified in the Contract. If settlement of surcharged fill results the Contractor shall bring the resultant level up to formation level with acceptable material for use in fill.

2.6.4 Sub-grade Strength

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

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

2.7 TURFING WITH SODS *(cl. 307 of MORT&H)*

2.7.1 Scope

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

2.7.2 Materials

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

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

2.7.3 Construction Operations

2.7.3.1 Preparation of the Earth Bed

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

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

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the drawings. After spreading, the materials shall be incorporated in the soil by using disc harrow or other means to the depths shown on the drawings.

2.7.3.2 Placing the Sods

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

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

2.7.3.3 Staking the Sods

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

2.7.3.4 Top Dressing

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

2.7.3.5 Watering and Maintenance

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

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

2.8 SEEDING AND MULCHING *(cl. 308 of MORT&H)*

2.8.1 Scope

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

2.8.2 Materials

2.8.2.1 Seeds

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

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

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

2.8.2.2 Topsoil

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

2.8.2.3 Bituminous Emulsion

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

2.8.2.4 Netting

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

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

2.8.3 Seeding Operations

2.8.3.1 Seed-Bed Preparation

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

2.8.3.2 Fertilizer Application

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

2.8.3.3 Planting of Seeds

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

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

2.8.4 Mulching, Applying Bituminous Emulsion and Jute Netting / Geonetting / Netting of Coir

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 litres per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting/geonetting or netting of coir shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the drawings or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting/Geonetting /coir netting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil.

2.9 Sub-Surface Drains *(cl. 309.3 of MORT&H)*

2.9.1 Scope

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

2.9.2 Materials

2.9.2.1 Pipe

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

2.9.2.2 Backfill Material

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

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

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

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

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

2.9.3 Trench Excavation

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the drawings provided that width of trench at pipe level shall not be less than 450 mm. The excavation shall begin at the outlet end of the drain and proceed towards the upper end. Where unsuitable material is met with at the trench bed, the same shall be removed to such depth as directed by the Engineer and backfilled with approved material which shall be thoroughly compacted to the specified degree.

2.9.4 Laying of Pipe and Backfilling

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

Table 12 : Grading Requirements for Filter Material Percent Passing by Weight *(Table 300-3 of MORT&H)*

Sieve Designation	Class I	Class II	Class III
53 mm	-	-	100
45 mm	-	-	97-100
26.5 mm	-	100	-
22.4 mm	-	95-100	58-100
11.2 mm	100	48-100	20-60
5.6 mm	92-100	28-54	4-32
2.8 mm	83-100	20-35	0-10
1.4 mm	59-96	-	0-5
710 micron	35-80	6-18	-
355 micron	14-40	2-9	-
180 micron	3-15	-	-
90 micron	0-5	0-4	0-3

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

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

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

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

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

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

2.9.5 Use of Geosynthetics in Laying of Pipe and Backfilling

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

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

2.9.6 Drain Outlet

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

2.9.7 Aggregate Drains

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

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

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

Table 13 : Grading Requirements for Aggregate Drains *(Table 300-4 of MORT&H)*

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

2.10 PREPARATION AND SURFACE TREATMENT OF FORMATION *(cl. 310 of MORT&H)*

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

a) Full formation, after reinstatement of any soft areas to the required Specifications shall be well cleaned and freed of all mud and slurry.
b) The surface shall be compacted to the required density by a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required.
c) the formation shall be finished to the requirements of Clause 305.3.9.

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

2.11 GRANULAR SUB-BASE *(cl. 401 of MORT&H)*

2.11.1 Scope

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

2.11.2 Materials

2.11.2.1 The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the gradings given in Table 400-1 and physical requirements given in Table 400-2. Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

2.11.2.2 If the water absorption of the aggregates determined as per IS: 2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for Wet Aggregate Impact Value (AIV) (IS: 5640). Soft aggregates like Kankar, brick ballast and laterite shall also be tested for Wet AIV (IS: 5640).

401.2.1 **Table 14 : Grading for Granular Sub-base Materials** *(Table 400-1 of MORT&H)*

IS Sieve Designation	Percent by Weight Passing the IS Sieve					
	Grading I	**Grading II**	**Grading III**	**Grading IV**	**Grading V**	**Grading VI**
75.0 mm	100	-	-	-	100	-
53.0 mm	80-100	100	100	100	80-100	100
26.5 mm	55-90	70-100	55-75	50-80	55-90	75-100
9.50 mm	35-65	50-80	-	-	35-65	55-75
4.75 mm	25 - 55	40-65	10-30	15-35	25-50	30-55
2.36 mm	20-40	30-50	-	-	10-20	10-25
0.85 mm	-	-	-	-	2-10	-
0.425 mm	10-15	10-15	-	-	0-5	0-8
0.075 mm	<5	<5	<5	<5	-	0-3

Table 15 : Physical Requirements for Materials for Granular Sub-base *(Table 400-2 of MORT&H)*

Aggregate Impact Value (AIV)	IS:2386(Part4) or IS:5640	40 maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at IS:2720-Part 8)	IS:2720(Part5)	Minimum 30 unless otherwise specified in the Contract

2.11.3 Construction Operations

2.11.3.1 Preparation of Sub-grade

Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 as applicable shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary and rolled with two passes of 80-100 kN smooth wheeled roller.

2.11.3.2 Spreading and Compacting

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS: 2720 (Part 8). The mix shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

Moisture content of the mix shall be checked in accordance with IS: 2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer up to 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall or on super elevation. For carriageway having cross fall on both sides, rolling shall commence at the edges and progress towards the crown.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and cross fall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

2.12 LIME TREATED SOIL FOR IMPROVED SUB-GRADE/SUB-BASE *(cl. 402 of MORT&H)*

2.12.1 Scope

This work shall consist of laying and compacting an improved sub-grade/lower sub-base of soil treated with lime on prepared sub-grade in accordance with the requirements of these Specifications and in conformity with the tines, grades and cross-sections shown on the drawings or as directed by the Engineer. Lime treatment is generally effective for soils which contain a relatively high percentage of clay and silty clay.

2.12.2 Materials

2.12.2.1 Soil

Except when otherwise specified, the soil used for stabilization shall be the local clayey soil having a plasticity index greater than 8.

2.12.2.2 Lime

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

2.12.2.3 Quantity of Lime in Stabilized Mix

Quantity of lime to be added as percentage by weight of the dry soil shall be as specified in the Contract. The quantity of lime used shall be related to its calcium oxide content which shall be specified. Where the lime of different calcium oxide content is to be used, its quantity shall be suitably adjusted with the approval of the Engineer so that equivalent calcium oxide is incorporated in the work. The mix design shall be done to arrive at the appropriate quantity of lime to be added, having due regard to the purity of lime, the type of soil, the moisture-density relationship, and the design CBR/Unconfined Compressive Strength (UCS) value specified in the Contract. The laboratory CBR/UCS value shall be at least 1.5 times the minimum field value of CBR/UCS stipulated in the Contract.

2.12.3 Construction Operations

2.12.3.1 Weather Limitations

Lime-soil stabilisation shall not be done when the air temperature in the shade is less than 10°C.

2.12.3.2 Degree of Pulverisation

For lime-soil stabilisation, the soil before addition of stabilizer shall be pulverized using agricultural implements like disc harrows (only for low volume roads) and rotavators to the extent that it passes the requirements set out in Table 400-3 when tested in accordance with the method described in Appendix-3.

Table 16 : Soil Pulverisation Requirements for Lime Stabilisation (Table 400-3 of MORT&H)

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

2.12.3.3 Equipment for Construction

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

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

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

2.12.3.4 Mix-in-place Method of Construction

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

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

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

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

2.12.3.5 Construction with Manual Means

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

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

2.12.3.6 Addition of Lime

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

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

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

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

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

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

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

2.12.3.7 Moisture Content for Compaction

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

2.12.3.8 Rolling

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

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

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

2.12.3.9 Curing

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

2.12.4 Strength

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

2.13 CEMENT TREATED SOIL AND CEMENT-FLYASH TREATED SUB-BASE/BASE *(cl. 403 of MORT&H)*

2.13.1 Scope

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

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

2.13.2 Materials

2.13.2.1 Material to be Treated

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

2.13.2.2 Cement

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

Table 17 : Grading Limits of Material for Stabilisation with Cement *(Table 400-4 of MORT&H)*

IS sieve size	Percentage by mass passing Sub-Base/Base within the range
53.00 mm	100
37.5 mm	95-100
19.0 mm	45-100
9.5 mm	35-100
4.75 mm	25-100
600 micron	8-65
300 micron	5-40
75 micron	0-10

2.13.2.3 Flyash

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

Table 18 : Chemical Requirements for Fly Ash as Pozzolana *(Table 400-5 of MORT&H)*

Sl. No.	Characteristics	Requirements for Fly Ash		Method of Test
		Anthracitic Fly ash	Lignite Fly ash	
1)	SiO_2+Al_2O_3+Fe_2O_3 in percent by mass, Min	70	50	IS:1727
2)	SiO_2 in percent by mass, Min	35	25	IS:1727
3)	MgO in percent by mass, Max	25	5.0	IS:1727
4)	SO_3 in percent by mass, Max	2.75	3.5	IS:1727
5)	Available alkalies as Na_2O/K_2O in percent by mass, Max,	1.5	1.5	IS:4032
6)	Total chlorides in percent by mass, Max	0.05	0.05	IS:1727
7)	Loss on ignition in percent by mass, Max	5.0	5.0	IS:1727

Table 19 : Physical Requirement for Fly Ash as a Pozzolona *(Table 400-6 of MORT&H)*

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

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

2.13.2.4 Quantity of Cement in Cement-Soil Stabilised Mix

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

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

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

2.13.2.6 Weather Limitations

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

2.13.2.7 Degree of Pulverisation

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

2.13.2.8 Moisture Content for Compaction

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

2.13.2.9 Rolling

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

2.13.2.10 Curing

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

2.13.2.11 Surface Finish

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

2.14 WATER BOUND MACADAM SUB-BASE/BASE *(cl. 404 of MORT&H)*

2.14.1 Scope

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

2.14.2 Materials

2.14.2.1 Coarse Aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag, over burnt (Jhama) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Materials other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel /shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in **Table 400-8.** The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part 5).

Table 20 : Physical Requirements of Coarse Aggregates for Water Bound Macadam for Sub-base/Base Courses
(Table 400-8 of MORT&H)

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

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

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

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

2.14.2.2 Crushed Slag

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

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

2.14.2.3 Over burnt (Jhama) Brick Aggregates

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

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

2.14.2.4 Screenings

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

Table 21 : Grading Requirements of Coarse Aggregates *(Table 400-9 of MORT&H)*

Grading No.	Size Range	IS Sieve Designation	Percent by weight Passing
1)	63 mm to 45 mm	75 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
2)	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

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

Screenings shall conform to the grading set forth in Table 400-10. The quantity of screenings required for various grades of stone aggregates are given in Table 400-11. The Table also gives the quantities of materials (loose) required for 10 m^2 for sub-base/base compacted thickness of 75 mm.

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

2.14.2.5 Binding Material

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

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m^3 per 10 m^2.

Table 22 : Grading For Screenings *(Table 400-10 of MORT&H)*

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

Table 23 : Approximate Quantities of Coarse Aggregates and Screenings Required for 75 mm Compacted Thickness of Water Bound Macadam (WBM) Sub-Base/Base Course for 10 m^2 Area *(Table 400-11 of MORT&H)*

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

- The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction etc.
- Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

2.14.3 Construction Operations

2.14.3.1 Preparation of Base

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

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

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

2.14.3.2 Inverted Choke / Sub-surface Drainage Layer

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

2.14.3.3 Lateral Confinement of Aggregates

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

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

2.14.3.4 Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly and evenly upon the prepared sub-grade/ sub-base in the required quantities from the stockpiles to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 75 mm. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed base be permitted. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimize the need for manual rectification afterwards.

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

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

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

2.14.3.5 Rolling

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

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

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

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

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

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

2.14.3.6 Application of Screenings

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

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

2.14.3.7 Sprinkling of Water and Grouting

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

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

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

2.14.3.8 Setting and Drying

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

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

2.14.3.9 Reconstruction of Defective Macadam

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

2.15 WET MIX MACADAM SUB-BASE/BASE *(cl. 406 of MORT&H)*

2.15.1 Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub- base/ base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Engineer.

2.15.2 Materials

2.15.2.1 Aggregates

2.15.2.1.1 Physical Requirements

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400-12.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

Table 24 : Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/Base Courses
(Table 400-12 of MORT&H)

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

* To determine this combined proportion, the flaky stone from a representative sample

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

2.15.2.1.2 Grading Requirements

The aggregates shall conform to the grading given in Table 400-13 of MORT&H.

Table 25 : Grading Requirements of Aggregates for Wet Mix Macadam *(Table 400-13 of MORT&H)*

IS Sieve Designation	Percent by weight passing the IS Sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25^0
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-5

Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

2.15.3 Construction Operations

2.15.3.1 Provision of Lateral Confinement of Aggregates

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 404.3.3.

2.15.3.2 Preparation of Mix

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. The plant shall have following features:

i) For feeding aggregates- three/ four bin feeders with variable speed motor
ii) Vibrating screen for removal of oversize aggregates
iii) Conveyor Belt
iv) Controlled system for addition of water
v) Forced/positive mixing arrangement like pug-mill or pan type mixer
vi) Centralized control panel for sequential operation of various devices and precise process control
vii) Safety devices

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

2.15.3.3 Spreading of Mix

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.

ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.

iii) Automatic levelling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted. Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

2.15.3.4 Compaction

After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the center line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the center parallel to the center line of the road uniformly overlapping each of the preceding tracks by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceeds 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross fall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

2.15.3.5 Setting and Drying

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

2.15.4 Opening to Traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

2.15.5 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and re-compacted in accordance with Clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

2.16 SHOULDERS, ISLANDS AND MEDIANS *(cl. 408 of MORT&H)*

2.16.1 Scope

The work shall consist of constructing shoulder (hard/paved/earthen with brick or stone block edging) on either side of the pavement, median in the road dividing the carriageway into separate lanes and islands for channelising the traffic at junctions in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

2.16.2 Materials

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

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

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

2.16.3 Size of Shoulders/Medians/Islands

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

2.16.4 Construction Operations

2.16.4.1 Shoulders

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

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

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

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

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

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

2.16.4.2 Median and Islands

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

2.16.4.3 Brick/Stone Block Edging

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

2.16.5 Surface Finish and Quality Control of Works

The surface finish of construction shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900.**

2.17 CEMENT CONCRETE KERB AND KERB WITH CHANNEL *(cl. 409 of MORT&H)*

2.17.1 Scope

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

2.17.2 Materials

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

2.17.3 Type of Construction

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

2.17.4 Equipment

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

2.17.5 Construction Operations

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

2.18 GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS *(cl. 501 of MORT&H)*

2.18.1 General

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

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

2.18.2 Materials

2.18.2.1 Binder

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

i) Modified bitumen from refinery sources or blended at approved central plant or at site using appropriate industrial process and plant with high shear mill, and testing facilities to achieve stable and homogenous mix shall be used. The use of high shear mixer or any other device capable of producing a homogeneous blend is essential when the modifier is in powder form.

ii) Transportation tanks and storage tanks shall be insulated and equipped with effective heating system and circulation/agitating device to maintain the specified temperature, homogeneity and viscosity of the bitumen during transit and storage.

iii) Separation, difference in softening point (R&B), shall not be more than 3°C for any type of specified modified bitumen when tested as per Annex B of IS: 15462.

Table 26: Selection of Binder for Bituminous Mixes *(Table VII-1 of IRC: 37-2012)*

Maximum Average air Temperature °C	Traffic (CVD)	Bituminous Course	Grade of Bitumen to be used
≤ 30°C	≤ 1500 commercial vehicles per day	BM, DBM and BC	VG 10/VG20
< 40°C	For all types of traffic	BM, DBM, SDBC and BC	VG 30
≥ 40°C	Heavy Loads, Expressways msa>30msa	DBM, SDBC, BC	VG 40 bitumen for wearing course as well as binder course, Modified bitumen may be used for the wearing course.

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

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

Table 27: Selection Criteria for Viscosity-Graded (VG) Paving Bitumen's Based on Climatic Conditions
(Table 500-1 of MORT&H)

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

Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Tables 500-5 and 500-6 can be obtained for the weather station nearest to the project site ᶜrom the Indian Meteorological Organization (IMO). This daily mean high temperature on a specific day is the same as daily 'normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day in May or June) is used in Tables 500-5 and 500-6. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMO. Since these are mean temperatures based on the average of 30-40 years data, these temperatures are significantly lower than the absolute maximum temperatures, which may have occurred in a specific year.

2.18.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall demonstrate through test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The Engineer may approve such a source and, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, at the cost of the Contractor.

Where crushed gravel is proposed for use as aggregate not less than 90 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces, except that in the case of bituminous concrete the requirement in this regard shall be 95 percent. .

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

2.18.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder and wearing courses.

However, natural sand upto 50 percent of the fine aggregates may be allowed in base courses. Fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part 37). The plasticity index of the fraction passing 0.425 mm shall not exceed 4 when tested in accordance with IS: 2720 (Part 5). The fine aggregates shall satisfy the physical requirements set forth in the individual relevant-clause for the material in question.

2.18.2.4 Sources of Material

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

2.18.3 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 28 : Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celcius) *(Table 500-2 of MORT&H)*

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.

2.18.4 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.

2.18.5 Laying

2.18.5.1 Weather and Seasonal Limitations

Laying shall be suspended:

i) In presence of standing water on the surface;
ii) When rain is imminent, and during rains, fog or dust storm
iii) When the base/binder course is damp;
iv) When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen;
v) When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

2.18.5.2 Cleaning of Surface

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

2.18.5.3 Spreading

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

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

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

2.18.5.4 Cleanliness and Overlaying

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

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

2.18.6 Compaction

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

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these Specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and unidirectionally cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8-10 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.

2.18.7 Joints

2.18.7.1 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 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.

2.18.7.2 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.

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

2.18.8 Preparation of Surface

2.18.8.1 Scope

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

2.18.8.2 Materials

2.18.8.2.1 For Scarifying and Re-laying the Granular Surface

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

2.18.8.2.2 For Patching Potholes and Sealing Cracks

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

2.18.8.2.3 For Profile Corrective Course

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

2.18.8.3 Construction Operations

2.18.8.3.1 Preparing Existing Granular Surface

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

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

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

2.18.8.3.2 Scarifying Existing Bituminous Surface

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

2.18.8.3.3 Patching of Potholes and Sealing of Cracks

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

2.18.8.3.4 Profile Corrective Course

a) Application of Profile Corrective Course

i) A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings.

ii) Any high spots in the existing black-topped surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the Engineer

iii) Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer, adopting such construction procedures and using such equipment as approved by the Engineer, to lay the specified type of material, to thickness and tolerance as specified for the course to be provided.

iv) The profile corrective course shall be laid to tolerances and densities as specified for wearing course if it is laid integral with the wearing course. The profile corrective course shall be laid to tolerances and densities as specified for base course, if it is to be covered with a wearing course layer.

b) Laying on Granular Base : After preparing the granular surface in accordance with Clauses 501.8.3.1 and 501.8.3.2, the profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4 (a), or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.

c) Laying on Existing Bituminous Surface : The existing bituminous surface shall be prepared in accordance with Clause 501.8.3.3, and after applying a tack coat conforming to Clause 503. the bituminous profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4(a) and compacted to the requirements of the Specification.

d) Correction of Local Depressions, Camber and Super-Elevation : Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the Engineer, which should be laid in accordance with Fig. 500-1. Normally, the maximum layer thickness at any point should not exceed 100 mm. In placing multiple lifts, they should be arranged according to the correct method as illustrated.

2.19 PRIME COAT OVER GRANULAR BASE *(cl. 502 of MORT&H)*

2.19.1 Scope

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

2.19.2 Materials

2.19.2.1 The primer shall be cationic bitumen emulsion SS1 grade conforming to IS: 8887 or medium curing cutback bitumen conforming to IS:217 or as specified in the Contract.

2.19.2.2 Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in Table 500-3.

Table 29 : Quantity of Bitumen Emulsion for Various Types of Granular Surfaces *(Table 500-3 of MORT&H)*

Type of Surface	Rate of Spray (kg/sq.m)
WMM/WBM	0.7-1.0
Stabilized soil bases/Crusher Run Macadam	0.9-1.2

2.19.2.3 Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given in Table 500-4.

Table 30 : Type and Quantity of Cutback Bitumen for Various Types of Granular Surface (Table 500-4 of MORT&H)

Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
WMM/WBM	MC30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC70	0.9-1.2

2.19.2.4 The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

2.19.3 Weather and Seasonal Limitations

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 100C. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

2.19.4 Construction

2.19.4.1 Equipment

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

2.19.4.2 Preparation of Road Surface

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

2.19.4.3 Application of Bituminous Primer

After preparation of the road surface as per Clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

No heating or dilution of SS1 bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively though the jets of the spray and to cover the surface uniformly.

2.19.4.4 Curing of Primer and Opening to Traffic

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiies to evaporate before any subsequent surface treatment or mix is laid, Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

2.20 TACK COAT *(cl. 503 of MORT&H)*

2.20.1 Scope

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

2.20.2 Materials

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

2.20.3 Weather and Seasonal Limitations

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

2.20.4 Construction

2.20.4.1 Equipment

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

2.20.4.2 Preparation of Base

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

2.20.4.3 Application of Tack Coat

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

Table 31 : Rate of Application of Tack Coat *(Table 500-5 of MORT&H)*

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

2.20.4.4 Curing of Tack Coat

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

2.21 BITUMINOUS MACADAM *(cl. 504 of MORT&H)*

2.21.1 Scope

This work shall consist of construction in a single course having 50 mm to 100 mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications. Since the bituminous macadam is an open-graded mix, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer (shoulders) should have proper drainage quality to prevent moisture-induced damage to the BM.

2.21.2 Materials

2.21.2.1 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.

2.21.2.2 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.

2.21.2.3 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 32 : Physical Properties of Coarse Aggregate *(Table 500-6 of MORT&H)*

Property	Test	Requirement	Test method
Cleanliness	Grain size analysis	Max. 5% passing 0.075 micron	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max. 35%	IS:2386Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 40% Max. 30%	IS:2386Part IV IS:2386Part IV
Durability	Soundness (Sodium or Magnesium) Sodium Sulphate Magnesium Sulphate	5 cycles Max. 12% Max. 18%	IS:2386 Part V IS:2386PartV
Water absorption	Water absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate	Min. Retained Coating 95%	IS;6241
Water sensitivity	Retained Tensile strength*	Min. 80%	AASHTO 283

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

2.21.2.4 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.

2.21.2.5 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.

2.21.3 Construction Operation

2.21.3.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

Table 33 : Aggregate Grading and Bitumen Content *(Table 500-7 of MORT&H)*

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**	3.4**

* Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

** Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where highest daily mean air temperature is 30°C or lower and lowest daily mean air temperature is -10°C or lower, the bitumen content may be increased by 0.5 percent.

2.21.3.2 Preparation of the Base

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clauses 501.8 and 902.3 as appropriate, and a prime coat, shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

2.21.3.3 Tack Coat

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

2.21.3.4 Preparation and Transportation of the Mix

The provisions of Clauses 501.3 and 501.4 shall apply.

2.21.3.5 Spreading

The provisions of Clause 501.5.3 shall apply.

2.21.3.6 Rolling

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

Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 903.

2.22 DENSE BITUMINOUS MACADAM *(cl. 505 of MORT&H)*

2.22.1 Scope

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

2.22.2 Materials

2.22.2.1 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.

2.22.2.2 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 shsil produce test result that with the use of anti-stripping agents, the stripping value is improved to satisfy the specflcation 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.

2.22.2.3 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 upto 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).

2.22.2.4 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.

2.22.2.5 Aggregate Grading and Binder Content

2.22.2.5.1 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 34: Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam *(Table 500-8 of MORT&H)*

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386PartI
Particle shape	Combined Flakiness and Elongation Indices*	Max 35%	IS:2386 Parti
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35% Max 27%	IS:2386 Part IV
Durability	Soundness either : Sodium Sulphate or Magnesium Sulphate	 Max 12% Max 18%	IS:2386PartV
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength**	Min. 80%	AASHTO 283

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

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

Table 35 : Grading Requirements for Mineral Filler *(Table 500-9 of MORT&H)*

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

Table 36 : Composition of Dense Graded Bituminous Macadam *(Table 500-10 of MORT&H)*

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer thickness	75- 100 mm	50 - 75 mm
IS Sieve (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,

2.22.2.5.2 Bitumen content indicated in Table 500-10 is the minimum quantity. The quantity shall be determined in accordance with Clause 505.3.

2.22.3 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.

2.22.3.1 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 37 : Requirements for Dense Graded Bituminous Macadam *(Table 500-11 of MORT&H)*

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 T 245
Marshall flow (mm)	2 - 4	2 . 5 - 4	3 . 5 - 5	AASHTO T 245
Marshall Quotient $\left(\frac{\text{Stability}}{\text{Flow}}\right)$	2 - 5	2 . 5 - 5		MS-2 and ASTM D 2041
% 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			

2.22.3.2 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 diametre 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 38 : Minimum Percent Voids In Mineral Aggregate (VMA) *(Table 500-12 of MORT&H)*

Nominal Maximum Particle Size[1] (mm)	Minimum VMA Percent Related to Design Percentage Air voids		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Note : Interpolate minimum voids in the mineral aggregate (VMA) for designed percentage air voids values between those listed.

2.22.3.3 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.

2.22.3.4 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 ngredients 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 39 : Permissible Variations in the Actual Mix from the Job Mix Formula *(Table 500-13 of MORT&H)*

Description	Base/binder Course
Aggregate passing 19 mm sieve or larger	±8%
Aggregate passing 13.2 mm, 9.5 mm	±7%
Aggregate passing 4.75 mm	±6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%
Aggregate passing 0.3 mm, 0.15 mm	±4%
Aggregate passing 0.075 mm	±2%
Binder content	± 0.3%
Mixing temperature	±10°C

2.22.3.5 Laying Trials

Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and compacted all in accordance with Clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100 sq.m of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density equal to or more than 92% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction in accordance with ASTM D 2041.

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

2.22.4 Construction Operations

2.22.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

2.22.4.2 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.

2.22.4.3 Geosynthetics

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

2.22.4.4 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.

2.22.4.5 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.

2.22.4.6 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.

2.22.4.7 Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3 and 501.4 shall apply. Table 500-2 gives the mixing, laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

2.22.4.8 Spreading

The provisions of Clauses 501.5.3 and 501.5.4 shall apply.

2.22.4.9 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

2.22.5 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.

2.23 SAND ASPHALT BASE COURSE *(cl. 506 of MORT&H)*

2.23.1 Scope

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

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

2.23.2 Materials

2.23.2.1 Bitumen

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

2.23.2.2 Sand

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

Table 40 : Sand Grading and Physical Requirements *(Table 500-14 of MORT&H)*

Sieve Size (mm)	Cumulative Percentage by Weight of Total Aggregate Passing
9.5	100
4.75	85-100
2.36	80-100
1.18	70-98
0.60	55-95
0.30	30-75
0.15	10-40
0.075	4-10
Plasticity Index (%)	6 max.
Sand equivalent (IS:2720 Part 37)	30 min.
Los Angeles Abrasion Value (IS:2386, Part 4)	40 max.

Note : Maximum thickness for sand asphalt is 80 mm.

2.23.2.3 Filler

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

2.23.3 Mix Design

2.23.3.1 Requirements for the Mix

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-15.

2.23.3.2 Binder Content

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

Table 41: Requirements for Sand Asphalt Base Course *(Table 500-15 of MORT&H)*

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

2.23.3.3 Job Mix Formula

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

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

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

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

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

2.23.4 Permissible Variation from Job Mix Formula

The Contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-12, with the condition that the gradation after the variation remains within the gradation envelop. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).

2.23.4 Construction Operations

2.23.4.1 Weather and Seasonal Limitations

Clause 501.5.1 of Specifications for Road & Bridge Works of MoRT&H (5th Revision shall apply.

2.23.4.2 Preparation of Base

The surface on which Sand Asphalt Base course Material is to be laid shall be prepared, shaped and graded in the profile required for the particular layer in accordance with Clauses 501 and 902 as appropriate or as directed by the Engineer. The surface shall be thoroughly swept clean free from dust and foreign matter using a mechanical brush, and the dust blown off by compressed air. In confined locations where mechanical plant cannot get access, other methods shall be used as approved by the Engineer. A prime coat, where specified, shall be applied in accordance with Clause 502 of Specifications for Road & Bridge Works of MoRT&H (5th Revision) or as directed by the Engineer-in-Charge.

2.23.4.3 Tack Coat

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

2.23.4.4 Preparation and Transportation of the Mixture

The provisions of Clauses 501.3 and 501.4 shall apply.

2.23.4.5 Spreading

The provisions of Clauses 501.5.2 to 501.5.4 shall apply. Laying must be accomplished at a suitable temperature to ensure proper compaction. Guidance for mixing and compaction temperature for the particular bitumen may be taken from Table 500-3 and shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 poise (0.3 Pa.s) respectively, based on the original (unaged) bitumen properties.

2.23.4.6 Rolling

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

2.23.5 Opening to Traffic

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

2.24 SEMI-DENSE BITUMINOUS CONCRETE

2.24.1 Scope

This work shall consist of construction in single or multiple layers of semi-dense bituminous concrete on a previously prepared bituminous base. A single layer shall be 25 mm to 40 mm in thickness.

2.24.2 Materials

2.24.2.1 Bitumen

The bitumen shall be paving bitumen of penetration grade complying with IS: 73 and of the penetration indicated in Table 42, or modified bitumen as specified in the Contract.

2.24.2.2 Coarse Aggregates

The coarse aggregates shall be generally as specified in Clause 2.22.2.2, except that the aggregates shall satisfy the physical requirements of Table 43.

Table 42 : Physical Requirements for Coarse Aggregate for Semi-Dense 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 30%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35% Max 27%	IS:2386Part IV
Durability	Soundness either- Sodium Sulphate or Magnesium Sulphate	 Max 12% Max 18%	IS:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

2.24.2.3 Fine Aggregates

The fine aggregates shall be as specified in Clause 2.22.2.2.

2.24.2.4 Filler

Filler shall be generally as specified in Clause 2.22.2.2. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 42, 2% by total weight of aggregate of hydrated lime shall be added without additional cost.

2.24.2.5 Aggregate gradation

The mineral aggregate, including mineral filler, shall be so graded or combined so as to conform to grading set forth in Table 43.

Table 43 : Composition of Semi-Dense Bituminous Concrete Pavement Layers

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

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

** Only in exceptional circumstances, 80/100 penetration grade may be used, as approved by the Engineer-in-Charge.*

2.24.3 Mixture Design

2.24.3.1 Requirement of mixture

Apart from conformity with the grading and quality requirements for indivual ingredients the mixture shall meet the requirements set out in Table 44.

Table 44 : Requirements of Semi-Dense Bituminous Concrete Pavement Layers

Minimum stability (kN at 60°C)	8.2
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	
Percent voids in mineral aggregate (VMA)	See Table 38
Percent voids filled with bitumen (VFB)	65-78

The requirements for minimum per cent voids in mineral aggregates (VMA) are set out in Table *38*. [Minimum Per Cent Voids in Mineral Aggregate (VMA)]

2.24.3.2 Binder Content

The binder content shall be optimized to achieve the requirements or the mixture set forth in Table 43 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted.

2.24.4 Job Mix Formula

The procedure for formulating the job mix formula shall be generally specified in Clause 2.22.3.3 and the results of tests enumerated in Table 44 as obtained by the Contractor.

2.24.5 Permissible variation from Job mix formula

The contractor shall have the responsibility of ensuring proper proportions of materials in accordance with the approved job mix formula and producing a uniform mix. The permissible variations of the individual percentage of the various ingredients in the actual mix from the job mix formula may be within the limits as specified in Table 39 (Permissible variation from Job Mix Formula).

2.24.6 Construction operations

2.24.6.1 Weather and seasonal limitations

Relevant guidelines as per Clause 501.5.1, shall apply.

2.24.6.2 Preparation of base

The base on which semi-dense bituminous concrete is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-sections as directed by the Engineer-in-Charge. The surface shall be thoroughly swept and scrapped clean and free of dust and foreign matter.

2.24.6.3 Tack coat

Where specified in the Contract, a tack coat complying with Clause 503 shall be applied over the base. Application of tack coat shall, however not be necessary when laying follows soon after the provision of a bituminous base, without opening to traffic.

2.24.6.4 Preparation of mix

Semi-Dense Bituminous Concrete Mix shall be prepared in a Hot Mix Plant of adequate capacity and specification as laid down in Clauses 501.3 and 501.4 shall apply. The temperature of binder at the time of mixing shall be in the range of 150°C-177°C and of aggregates in the range 155°C-163°C. At no time the difference in temperature between the aggregates and the binder shall exceed 14°C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all the particles of the mineral aggregates are coated uniformly. The mix shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and the covered over in transit if so directed by the Engineer-in-Charge.

2.24.6.5 Spreading

Refer specification as per Clause 501.5.3.

2.24.6.6 Rolling

Refer specification as per Clause 501.6 and 501.7.

2.24.7 Opening to traffic

Traffic may be allowed immediately after completion of the final rolling when the mix has cooled down to the surrounding temperature.

2.25 BITUMINOUS CONCRETE *(cl. 507 of MORT&H)*

2.25.1 Scope

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

2.25.2 Materials

2.25.2.1 Bitumen

The bitumen shall conform to Clause 504.2.1 of MoRT&H.

2.25.2.2 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 45 : Physical Requirements for Coarse Aggregate for Bituminous Concrete *(Table 500-16 of MORT&H)*

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:2386Part IV
Durability	Soundness either- Sodium Sulphate or Magnesium Sulphate	 Max 12% Max 18%	IS:2386 PartV
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	1S:6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

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

2.25.2.3 Fine Aggregates

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

2.25.2.4 Filler

Filler shall be as specified in Clause 505.2.4.

2.25.2.5 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 46 : Composition of Bituminous Concrete Pavement Layers *(Table 500-17 of MORT&H)*

Grading	1	2
Nominal aggregate size*	**19 mm**	**13.2 mm**
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 5.4**

* 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.

2.25.3 Mix Design

2.25.3.1 Requirements for the Mix

Clause 505.3.1 shall apply.

2.25.3.2 Binder Content

Clause 505.3,2 shall apply.

2.25.3.3 Job Mix Formula

Clause 505.3.3 shall apply.

2.25.3.4 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 47: Permissible Variations in Plant Mix from **the Job Mix Formula** *(Table 500-18 of MORT&H)*

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%

2.25.3.5 Laying Trials

The requirements for laying trials shall be as specified in Clause 505.3.5. The compacted layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction in accordance with ASTM D2041.

2.25.4 Construction Operations

2.25.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

2.25.4.2 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.

2.25.4.3 Geosynthetics

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

2.25.4.4 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.

2.25.4.5 Tack Coat

The provisions as specified in Clause 504.4.6 shall apply.

2.25.4.6 Mixing and Transportation of the Mix

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

2.25.4.7 Spreading

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

2.25.4.8 Rolling

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

2.25.5 Opening to Traffic

Provisions in Clause 504.5 shall apply.

2.26 SURFACE DRESSING *(cl. 509 of MORT&H)*

2.26.1 Scope

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

2.26.2 Materials

2.26.2.1 Binder

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

2.26.2.2 Aggregates

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

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

Table 48 : Recommended Nominal Size of Aggregates (mm) (Table 500-20 of MORT&H)

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

Table 49 : Grading requirements for Aggregates used for Surface Dressing *(Table 500-21 of MORT&H)*

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

2.26.2.3 Rates of Spread of Binder and Chips

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

Table 50: Approximate Rate of Application of Binder and Aggregates *(Table 500-22 of MORT&H)*

Nominal Aggregate Size mm	Binder (Kg/m²)			Aggregates Cu.m/m²
	Uncoated Aggregates		Coated Aggregates	
	Bitumen	Emulsion	Bitumen	
19	1.2	1.8	1.0	0.014-0.015
13	1.0	1.5	0.8	0.009-0.011
10	0.9	1.3	0.7	0.007-0.009
6	0.75	1.1	0.6	0.003-0.005

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

2.26.2.4 Anti-Stripping Agent

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

2.26.3 Construction Operations

2.26.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

2.26.3.2 Preparation of Base

The base on which the surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Clause 501 or as directed by the Engineer. Prime coat, where needed, shall be provided as per Clause 502 or as directed by the Engineer. Where the existing surface shows signs of fatting up, the excess bitumen shall be removed as directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and/or compressed air, or any other approved equipment/method as specified in the Contract or directed by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be slightly damp).

2.26.3.3 Application of Binder

After preparation of base, paving grade binder heated to an appropriate temperature or bitumen emulsion shall be sprayed uniformly using mechanical sprayers. During the operation the ratio between truck speed and pump revolution shall be maintained constant with the help of automatic control. When work resumes, the binder shall not be sprayed on the earlier completed surface. This can be done by covering the completed work with bitumen impregnated paper. Excessive deposit of bituminous material shall be immediately removed. The equipment described in IRC:SP:34 with synchronized spraying and compaction shall be preferred for better control and uniformity in construction.

The spraying temperatures for binder are given below:

Binder Grade	Whirling Spray Jets		Slot Jets	
	Min°C	Max°C	Min°C	Max°C
VG 10	180	200	165	175

2.26.3.4 Application of Stone Chips

Immediately after application of the binder, clean, dry chips (in the case of emulsion the chippings may be slightly damp) shall be spread uniformly by means of a mechanical chip spreader on the surface so as to cover the surface completely with a single layer of chips.

2.26.3.5 Rolling

Rolling of the chips should preferably be carried out by a pneumatic tyre roller in accordance with Clauses 501.6 and 501.7. Rolling shall commence at the edges and progress towards the centre except in super-elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

2.26.3.6 Application of Second Coat of Surface Dressing

Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for two weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clauses 510.3.3 to 510.3.5.

2.26.4 Opening to Traffic

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

2.27 OPEN-GRADED PREMIX SURFACING *(cl. 510 of MORT&H)*

2.27.1 Open-Graded Premix Surfacing using Viscosity Grade Paving Bitumen

2.27.1.1 Scope

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

2.27.1.2 Materials

2.27.1.2.1 Binder

The binder shall be viscosity grade bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS:73. For selection of grade of bitumen guidance may be taken from Table 500-1.

2.27.1.2.2 Aggregates

The aggregates shall conform to Clause 504.2.2 except that the water absorption shall be limited to a maximum of 1 percent. The Polished Stone Value, shall not be less than 55, when tested as per BS:812-114.

2.27.1.2.3 Proportioning of Material

The materials shall be proportioned in accordance with Table 500-23.

Table 51 : Quantities of Materials Required for 10 m2 of Road Surface for 20 mm Thick Open-graded Premix Surfacing *(Table 500-23 of MORT&H)*

Materials		Quantity
Aggregates		
a)	Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve)	0.18 m^3
b)	Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve)	0.09 m^3
	Total	**0.27 m^3**
Binder		
a)	For 0.18 m^3 of 13.2 mm nominal size stone of 52 kg bitumen per m^3	9.5 kg
b)	For 0.09 m^3 of 11.2 mm nominal size stone of 56 kg bitumen per m^3	5.1 kg
	Total	**14.6 kg**

2.27.1.3 Construction Operations

2.27.1.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

2.27.1.3.2 Preparation of Surface

The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in accordance with Clause 502 as directed by the Engineer.

2.27.1.3.3 Tack Coat

A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

2.27.1.3.4 Preparation of Premix

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

The temperature of the binder and aggregate at the time of mixing, laying and compaction shall be in conformity with the temperature given in Table 500-3. The difference in temperature between the binder and aggregate shall at no time exceed 14°C. Mixing shall be thorough to ensure that a homogeneous mix is obtained in which all particles of the aggregates are coated uniformly.

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

2.27.1.3.5 Spreading and Roiling

The pre mixed material shall be spread on a previously prepared base to Clause 501 by a paver unless specified otherwise in the Contract to the desired thickness, grades and crossfall (camber). The cross-fall should be checked by means of camber boards and irregularities levelled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8-10 tonne rollers, smooth wheel tandem type or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

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

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below the rolling temperature indicated in Table 500-3.

2.27.1.3.6 Seal Coat

A seal coat conforming to Clause 511 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

2.27.1.4 Opening to Traffic

No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to Clause 511.4.

2.27.2 Open Graded Premix Surfacing Using Cationic Bitumen Emulsion

2.27.2.1 Scope

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

2.27.2.2 Materials

2.27.2.2.1 Binder

The binder for Premix wearing course shall be Cationic Bitumen emulsion of Medium Setting (MS) grade complying with IS:8887 or as specified in the Contract.

2.27.2.2.2 Aggregate

The requirements of Clause 511.1.2.2 shall apply.

2.27.2.3 Proportioning of Materials

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

Table 52 : Quantities of Aggregate for 10 m2 Area *(Table 500-24 of MORT&H)*

Aggregates		
a)	Coarse aggregate nominal 13.2 mm size, passing IS 22.4 mm sieve and retained on IS 11.2 mm sieve	0.18 m^3
b)	Coarse aggregate nominal 11.2 mm size; passing IS 13.2 mm sieve and retained on IS 5.6 mm sieve	0.09 m^3
	Binder	20 to 23 kg

2.27.2.4 Construction Operations

2.27.2.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply except that the minimum air temperature for laying shall be 10°C. Cationic bitumen emulsions shall not normally be stored below 0°C.

2.27.2.4.2 Preparation of Surface

The underlying surface on which the premix surfacing is to be laid shall be prepared, in accordance with the requirements of Clause 504.3.2 for a newly primed surface, and in accordance with Clause 505.4.2 where an existing bituminous surface is to be overlaid.

2.27.2.4.3 Preparation of Binder

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

2.27.2.4.4 Tack Coat

A tack coat complying with Clause 503, shall be applied over the surface preparatory to laying of the surfacing where specified in the Contract, as directed by the Engineer.

2.27.2.4.5 Preparation of Premix

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

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

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

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

2.27.2.4.6 Spreading and Rolling

The premixed cationic bitumen emulsion and aggregates shall be spread uniformly by a paver within 10 minutes of applying the tack coat. All levelling, raking etc. should be completed within 20 minutes of the time of mixing.

The mix shall be spread uniformly to the desired thickness, grades and crossfall (camber). The crossfall shall be checked by means of camber boards and irregularities levelled out. Too much raking is to be avoided.

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

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

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

2.27.2.5 Seal Coat

A seal coat, conforming to Clause 511, as specified in the Contract, shall be applied immediately after laying the premix carpet.

2.27.2.6 Opening to Traffic

Traffic should not be allowed over the premix surface till seal coat is laid. After the seal coat is laid, traffic may be allowed in accordance with Clause 511.4.

2.27.2.7 Surface Finish and Quality Control

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

2.27.2.8 Arrangements for Traffic

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

2.28 SEAL COAT *(cl. 511 of MORT&H)*

2.28.1 Scope

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

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

- **A.** Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.
- **B.** Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

2.28.2 Materials

2.28.2.1 Binder

The requirements of Clauses 510.1.2.1 and 510.2.2.1 shall apply.

The quantity of bitumen per 10 square metres, shall be 9.8 kg for Type A, and 6, 8 kg for Type B seal coat. Where bituminous emulsion is used as a binder, the quantities for Type A and Type B seal coats shall be 15 kg and 10.5 kg respectively.

2.28.2.2 Stone Chips for Type A Seal Coat

The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 percent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chips shall satisfy the quality requirements given in Table 500-8 except that the upper limit for water absorption value shall be 1 percent.

2.28.2.3 Aggregate for Type B Seal Coat

The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles, and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sqm area.

2.28.3 Construction Operations

2.28.3.1 Weather and Seasonal Limitations

The requirements of Clause 501.5.1 shall apply.

2.28.3.2 Preparation of Surface

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

2.28.3.3 Construction of Type A Seal Coat

The construction operations shall be the same as described in Clause 509.3.3 to 509.3.5.

2.28.3.4 Construction Type B Seal Coat

2.28.3.4.1 Using Paving Bitumen

The construction operations shall be the same as in Clause 510.1.3.

2.28.3.4.2 Using Emulsion

The construction operations shall be the same as in Clause 510.2.4.

2.28.4 Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day. In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases traffic shall be rigorously limited to 20 km per hour until the following day.

2.29 SLURRY SEAL *(cl. 512 of MORT&H)*

2.29.1 Scope

The work consists of design and laying a mixture of mineral aggregate, slow setting cationic bitumen emulsion, water and additives, if. needed, proportioned, mixed and uniformly spread over a previously prepared surface. The finally laid slurry seal shall have a homogenous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its surface life.

2.29.2 Type of Slurry Seals and Applications

Different types of slurry seal and their applications are given in Table 500-25. The type and application of the slurry seal shall be specified in the Contract.

Table 53 : Different Types of Slurry Seals *(Table 500-25 of MORT&H)*

Items	Type 1 (2 - 3 mm)	Type II (4 - 6 mm)	Type III (6-8 mm)**
Application	Filling of hair cracks	Filling of surface cracks 1 - 3 mm And preventive/ renewal treatment (upto 450 CVPD)***	Filling of surface cracks 3-6 mm and preventive/renewal treatment (upto 1500 CVPD)***
Quantity* of slurry (kg/m^2)	4.3 to 6.5	8.4 to 9.8	10.1 to 12
Residual binder (% by weight of dry aggregate)	10 to 16	7.5 to 13.5	6.5 to 12

* In terms by weight of dry aggregate Indicative only

** CVPD : Commercial Vehicles per day

2.29.3 Materials

The materials for slurry seal shall conform to the following requirements.

2.29.3.1 Bitumen Emulsion

The bitumen emulsion shall be a cationic slow setting type SS 2, conforming to the requirements ofIS:8887.

2.29.3.2 Aggregates

The mineral aggregates shall be crushed stone dust, clean, sharp, hard, durable and uncoated dry particles and shall be free from soft pieces and organic and other deleterious substances. The aggregate shall satisfy the requirement given in Table 500-26. The target grading shall conform to one of the three types given in Table 500-27.

Table 54 : Properties of Aggregates *(Table 500-26 of MORT&H)*

Properties	Test Method	Specification
Sand Equivalent Value	IS:2720 (Part 37)	Min 50 percent
Water absorption*	IS:2386 (Part 3)	Max 2 percent
Soundness with-	IS:2386 (Part 5)	
Sodium sulphate		Max 12 percent
Magnesium sulphate		Max 18 percent

* In case water absorption exceeds 2% but is less than 4%, same may be permitted subject to conformity of soundness test and wet stripping test

Table 55 : Aggregate Grading *(Table 500-27 of MORT&H)*

Sieve Size (mm)	Percentage by Mass Passing (Minimum Layer Thickness)		
	Type I (2-3 mm)	Type II (4-6 mm)	Type III (6-8 mm)
9.5	-	-	100
6.3	-	100	90-100
4.75	100	90-100	70-90
2.36	90-100	65-90	45-70
1.18	65-90	45-70	28-50
0.600	40-65	30-50	19-34
0.300	25-42	18-30	12-25
0.150	15-30	10-21	7-18
0.075	10-20	5-15	5-15

Tolerances : Percent passing each sieve shall not vary by more than the tolerance limit indicated in Table 500-28 and shall remain within the gradation band.

Table 56 : Tolerances for Slurry Seal *(Table 500-28 of MORT&H)*

Description	Tolerance
Aggregate passing 4.75 mm	±5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%
Aggregate passing 0.3 mm	±4%
Aggregate passing 0.15 mm	±3%
Aggregate passing 0.075 mm	±2%

If more than one nominal size aggregate is used to produce the required grading, the correct amount of each type of aggregate used shall be proportioned separately to meet the requirements of grading as per Table 500-27, prior to adding other materials in the mixture. After target gradation has been submitted, the percent passing each sieve shall not vary by more than the tolerance limits given in Table 500-29, and shall remain within the gradation band. The aggregate will be acceptable based on average of five gradation tests at the job location.

2.29.3.3 Filler

Mineral filler shall be Ordinary Portland Cement. The quantity of filler shall be in the range of 0.5 to 2 percent by weight of dry aggregate.

2.29.3.4 Water

Water shall be potable, free from harmful salt and contaminants. The pH of the water shall be in the range of 6 to 7.

2.29.3.5 Additives

Chemical additives may be used to accelerate or retard the break-set time of the slurry or to improve the resulting surface finish. The quantity of additive, if used, shall be decided by mix design and to be adjusted as per the site/climate conditions. The specifications for additive shall be supplied by the supplier of the emulsion. The additive and emulsion shall be compatible with each other.

2.29.4 Mix Design

The compatibility of aggregate, emulsion, filler and additive(if needed) shall be verified by mix design for a selected type and grading of aggregate as specified in Tables 500-27 and 500-28. the design criteria for slurry seal mixture is specified in Table 500-29. The proposed slurry seal mix shall conform to the specified requirements, when tested in accordance with tests specified in Table 500-30. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of the aggregates, additive usage (if any).

Table 57 : Mix Design Criteria for Slurry Seal Mix *(Table 500-29 of MORT&H)*

Requirement	Specifications	Test Method
Mix Time, minimum	180 seconds	Appendix 1 IRC:SP:81
Consistency, maximum	3 cm	Appendix 3 IRC:SP:81
Wet cohesion, pass % minimum	20 kg.cm	Appendix 4 IRC:SP:81
Wet striping, Pass %, minimum	90	Appendix 5 IRC:SP:81
Wet Track abrasion loss, (one hour soak), maximum	800 g/m^2	Appendix 6 IRC:SP:81

Aggregate, bitumen emulsion, water and additive including set control additive (if needed), shall be proportioned by weight utilizing the mix design approved by the Engineer. The final mixture, after addition of water and additive (if used) shall be such that the slurry seal mixture has proper workability and permit traffic within four hours (without leading to ravelling after placement). Trial mix shall be prepared and laid at site for the designed mix and observed for breaking and setting time. Indicative limits of various ingredients for job mix of slurry seal shall be as given in Table 500-30.

Table 58 : Indicative Quantity of Ingredients *(Table 500-30 of MORT&H)*

Ingredients	Limits (Percent by Weight of Dry Aggregates)
Cationic Bitumen Emulsion	10 to 16 for type I 7.5 to 13.5 for Type II 6.5 to 12 for Type III
Water	6 to 12
Filler	1.0 to 2.0
Additive	0.5 to 2.0

2.29.5 Construction

2.29.5.1 Weather and Seasonal Limitations

Laying of slurry seal shall not be undertaken, if either the pavement temperature or air temperature is below 10°C. However during a dry spell, slurry seal may be laid in rainy season also, even if the surface is wet but there is no stagnant water on the pavement surface.

2.29.5.2 Surface Preparation

The underlying surface on which the slurry seal is to be applied shall be cleaned of all loose material, mud spots, vegetation and extraneous matter and shall be prepared and shaped to the needed profile. It is essential to pre-treat cracks on the pavement surface with an appropriate crack sealing material prior to application of slurry seal, if it is used for preventive/ renewal treatment. The surface should be swept clean by removing caked earth and other foreign matter with wire brushes, sweeping with mechanical brooms and finally dusting with air jet or other means approved by the Engineer

2.29.5.3 Application of Tack Coat

Tack coat is not required normally for flexible pavements, unless surface is extremely hungry and dry. In case it is needed, Clause **503** shall apply.

2.29.5.4 Machine

The machine shall be specially designed and manufactured to lay slurry seal. It shall be self propelled equipment, truck mounted, consisting of following sub-assemblies used to manufacture and simultaneously spread these mixes on the surface:

i) Aggregate bin.
ii) Filler bin.
iii) Water and Emulsion Tanks.
iv) Additive Tanks.
v) Aggregates and filler conveyors to supply the mixer box.
vi) Pump or compressed air system to supply the emulsion/water.
vii) Mixer Box.
viii) Spreader box to place the mixed slurry on the job.

2.29.5.5 Calibration of Machine

Slurry seal laying machine shall be calibrated for flow of all the constituents as per the job mix in presence of Engineer. No machine shall be allowed to work on the project until the calibration has been completed and accepted by the engineer. 2 kg samples of slurry seal mix will be taken and verified for proportioning and mix consistency. The verification for application rate shall also be carried out in presence of the Engineer. The procedure for calibration and verification is as given in Appendix 7 of IRC:SP:81.

2.29.5.6 Application of Slurry Seal

A calibrated slurry seal machine, as per requirements of job mix, shall be used to spread the material. The surface shall be pre-wetted by fogging ahead of the spreader box (if required under hot weather conditions). The rate of application shall be adjusted during the day to suit temperature, surface texture and humidity. The mixture shall be agitated and mixed uniformly in the spreader box by means of twin shafted paddles or spiral augurs fixed in spreader box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The spreader box and real strike off shall be so designed and operated that a uniform consistency is achieved to produce free flow of material to the rear strike off, A secondary strike off shall have the same adjustment as the spreader box. The spreader box shall have the suitable means provided to side shift the box to compensate for variation in pavement geometry. Sufficient amount of material shall be carried in all parts of spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling and unmixed aggregates shall be permitted. No streak, caused by oversized aggregates shall be left on the finished surface. Longitudinal joints shall correspond with the edges of existing traffic lanes. Other patterns of longitudinal joints may be permitted, if pattern will not adversely affect the quality of finished surface, In case streak is formed, it shall be corrected immediately by fresh material and with use of squeeze. Longitudinal joints, common to two traffic lanes shall be butt joints with overlap not exceeding an average of 60-100 mm. The mixture shall be uniform and homogeneous after spreading on existing surfaces and shall not show separation of the emulsion and aggregates after setting.

2.29.5.7 Rate of Application

The rate of application shall be as per Table 500-26 (by weight of dry aggregates).

2.29.5.8 Rolling

Generally rolling is not required. Where rolling is felt necessary due to inadequate cohesion, a pneumatic tyred roller having individual wheel load between 0.75 to 1.5 tonne shall be used. Rolling shall commence as soon as the slurry has set.

2.29.6 Opening to Traffic

Surface shall be opened to traffic after slurry is in a completely set condition. The maximum setting time shall be 4 hours. Speed of traffic shall be restricted to 20 km per hour for next 12 hours.

2.30 FOG SPRAY *(cl. 513 of MORT&H)*

2.30.1 Scope

The work covers a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing, and to help reduce loosening of chips by traffic on newly finished surface dressing.

2.30.2 Material

The bitumen emulsion shall be as specified in the Contract or as instructed by the Engineer. The emulsion shall be SS-1 complying with the requirements of IS:8887.

2.30.3 Weather and Seasonal Limitations

Spraying shall not take place when the temperature is below 10°C, nor in windy or dusty conditions, nor when it is raining or the surface to be sprayed is wet (a damp surface is acceptable but refer to Clause 513.4.2.).

2.30.4 Construction Operations

2.30.4.1 Equipment

The fog spray shall be applied by means of a self-propelled or towed bitumen pressure sprayer complying with the requirements of the Manual for Construction and Supervision of Bituminous Works. The spray bar should be protected from gusts of wind by means of a hood.

2.30.4.2 Preparation of Surface

The surface on which the fog spray is to be applied shall be thoroughly cleaned with compressed air, scrubbers etc. The cracks shall be cleaned with a pressure air jet to remove all dirt, dust etc.

2.30.4.3 Application

The fog seal shall be applied at a rate of 0.5-1.0 litres/m^2, using equipment such as pressure tank, flexible hose and spray bar or lance.

2.30.5 Blinding

If specified in the Contract or ordered by the Engineer, the fog spray shall be blinded with graded grit of 3 mm size and under, coated with about 2 percent of the emulsion by weight. The pre coated grit shall be allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

2.30.6 Arrangements for Traffic

During the spraying operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112. The surface should not be opened to traffic for 24 hours after spraying. If pick-up does occur a light blinding of crusher dust or sand should be applied,

2.31 MICRO-SURFACING (*cl. 514 of MORT&H*)

2.31.1 Scope

The work shall consist of design, testing and construction of micro-surfacing composed of modified bitumen emulsion, mineral aggregate, water and necessary additives (if needed), proportioned, mixed and uniformly spread over a properly prepared surface for surface treatment of pavements in accordance with these Specifications.

2.31.2 Type of Mirco-Surfacing

Micro-surfacing is applied on an existing pavement surface which is structurally sound but the surface shows signs of premature ageing, aggregate loss, cracking, high degree of polishing etc, It may be used as surface sealing treatment to improve skid resistance, surface durability, to seal fine and medium cracks and for preventive maintenance and periodic renewal treatment on low and medium traffic roads. Types of micro-surfacing and rates of application are given in Table 500-31.

Table 59 : Types of Micro-Surfacing and Rate of Application (*Table 500-31 of MORT&H*)

Items	Type II (4 to 6 mm)**	Type III (6 to 8 mm)**
Application	Preventive and Renewal Treatment for Roads Carrying <1500 CVPD	Preventive and Renewal Treatment for Roads Carrying1500 to 4500 CVPD
Quantity of mix* (kg/m2)	8.4 to 10.8	11.1 to 16.3
Residual binder (percentage by weight of dry aggregate)	6.5 to 10.5	5.5 to 10.5

* By weight of dry aggregate. ** Indicative only.

2.31.3 Materials

2.31.3.1 Binder

The bitumen emulsion shall be a modified bitumen emulsion conforming to requirements specified in Table 500-32. The modifier shall be polymer/rubber, preferably synthetic or natural rubber latex.

Table 60 : Requirement of Modified Bitumen Emulsion for Micro-Surfacing *(Table 500-32 of MORT&H)*

Requirements	Specifications	Method of test
Residue on 600 micron IS sieve (percent by mass), maximum	0.05	IS: 8887
Viscosity by Say bolt Furol Viscometre, at 25°C, in second	20-100	IS :8887
Coagulation of emulsion at low temperature	Nil	IS :8887
Storage stability after 24 h (168 h), % maximum	2(4)	IS :8887
Particle charge, + ve/-ve	+ ve	IS :8887
Tests on residue:		
a) Residue by evaporation, % minimum	60	IS :8887
b) Penetration at 25°C/1 00 g/5 s	40-100	IS:1203
c) Ductility at 27°C, cm, minimum	50	IS :1208
d) Softening point, in °C, minimum	57	IS:1205
e) Elastic recovery*, %, minimum	50	IS: 15462
f) Solubility in tri-chloroethylene, % minimum	97	S:1216

* In case, elastic recovery is tested for Torsional Elasticity Recovery as per Appendix-8 of IRC:81, the minimum value shall be 20 percent.

2.31.3.2 Aggregates

As per Clause 2.29.3.2 (Type II and Type III Grading, Table 500-27).

2.31.3.3 Filler

As per Clause 2.29.3.3

2.31.3.4 Water

As per Clause 2.29.3.4.

2.31.3.5 Additives

As per Clause 2.29.3.5

2.31.4 Design and Proportioning of Micro-Surfacing Mix

2.29.4.1 The design criteria for micro-surfacing mixture is specified in Table 500-33. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of aggregates and additives used (if any). The set time shall be determined by the method given in Appendix-2 of IRC:SP:81.

Table 61 : Mix Design Criteria for Micro-Surfacing Mix *(Table 500-33 of MORT&H)*

Requirements	Specifications	Method of Test as given in IRC:SP:81
Mix time, minimum	120s	Appendix-1
Consistency, maximum	3 cm	Appendix-3
Wet Cohesion, within 30 min, minimum.	12 kg cm	Appendix-4
Wet Cohesion, within 60 min, minimum	20 kg cm	Appendix-4
Wet stripping, pass %, minimum	90	Appendix-5
Wet track abrasion loss (one hour soak), maximum	538 g/m2	Appendix-6

2.31.4.2 Aggregate, modified bitumen emulsion, water and additive (if used), shall be proportioned by weight of aggregate utilizing the mix design approved by the Engineer. If more than one type of aggregates is used, the correct amount of each type of aggregate used to produce the required grading shall be proportioned separately prior to adding other materials of the mixture, in a manner that will result in a uniform and homogenous blend. Final completed mixture, after addition of water and any additive, if used shall be such that the micro-surfacing mixture has proper workability and permit traffic within a short period depending upon the weather conditions without occurrence of ravelling and bleeding. Trial mixes shall be prepared and laid for the designed mix and observed for breaking time and setting time. The wet track abrasion test is used to determine the minimum residual bitumen content. Indicative limits of various ingredients for job mix of micro-surfacing shall be as given in.

Table 62 : Indicative ingredients in mix *(Table 500-34 of MORT&H)*

Ingredients	Limits (Percent Weight of Aggregate)
Residual bitumen	6.5 to 10.5 for type II and 5.5 to 10.5 for Type III
Mineral filler	0.5 to 3.0
Additive	As needed
Water	As needed

2.31.5 Construction

2.31.5.1 Weather and Seasonal Limitations

As per Clause 2.29.5.1

2.31.5.2 Surface Preparation

As per Clause 2.29.5.2

2.31.5.3 Application of Tack Coat

As per Clause 2.29.5.3

2.31.5.4 Machine

As per Clause 2.29.5.4

2.31.5.5 Calibration of Machine

As per Clause 2.29.5.5

2.31.5.6 Application of Micro-Surfacing

A calibrated micro-surfacing machine as per requirements of job mix shall be used to spread the material. The surface shall be pre-wetted (if required under extreme hot weather conditions) by spraying water ahead of the spreader box. The rate of application of spray shall be adjusted during the day to suit temperature, surface texture and humidity. The application of micro-surfacing shall be as per Clause 2.29.5.6.

2.31.5.7 Rate of Application

The micro-surfacing mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The quantities of micro-surfacing mix (by weight of dry aggregate) to be used shall be as given in Table 500-31.

2.31.5.8 Rolling

As per Clause 2.29.5.8

2.31.5.9 Quality Control and Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 of MORT&H shall apply.

2.31.6 Control of Traffic

Micro-surfacing mix requires about 2 hours to set. Traffic may be opened only after 2 hours restricting the speed to 20 km/h till 12 hours thereafter.

2.32 STONE MATRIX ASPHALT (SMA) *(cl. 515 of MORT&H)*

2.32.1 Scope

This work shall consist of construction in a single or multiple layer of fibre-stabilized SMA for use as wearing course/ binder course on a previously prepared bituminous bound surface. The 13 mm SMA in this Specification shall be used for wearing course with nominal layer thickness of 40 to 50 mm. The 19 mm SMA shall be used for binder (or intermediate) course with nominal layer thickness of 45 to 75 mm.

2.32.2 Materials

2.32.2.1 Bitumen

The bitumen for fibre-stabilized SMA shall be viscosity grade paving bitumen conforming to Indian Standard Specification IS:73 or Modified Bitumen complying with 15:15462 and IRC:SP:53 of appropriate type and grade capable of yielding the design mix requirements, and as per Table 500-2 of MORT&H.

2.32.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock retained on 2.36 mm sieve. It shall be clean, hard, durable, of cubical shape and free from dust and soft organic and other deleterious substances. The aggregates shall satisfy the physical requirements given in Table 500-35.

Table 63 : Physical Requirements for Coarse Aggregates for Stone Matrix Asphalt *(Table 500-35 of MORT&H)*

Property	Text	Method	Specification
Cleanliness	Grain Size Analysis	IS:2386(P-1)	< 2% passing0.075mm sieve
Particle Shape	Combined Flakiness and Elongation Index	IS:2386(P-1)	< 30%
Strength	Los Angeles Abrasion Value	IS:2386(P-4)	< 25%
	Aggregate Impact Value	IS:2386 (P-4)	< 18%
Polishing	Polished Stone Value	IS:2386 (P-114)	> 55%
Durability	Soundness (either Sodium or Magnesium) – 5 cycles		
	Sodium Sulphate	IS:2386 (P-5)	< 12%
	Magnesium Sulphate	IS:2386 (P-5)	
Water Absorption	Water Absorption	IS:2386 (P-3)	<2%

* Polishing requirement does not apply when the coarse aggregate is used for intermediate (binder) course.

2.32.2.3 Fine Aggregates

Fine aggregates (passing 2.36 mm sieve and retained on 0.075 mm sieve) shall consist of 100 percent crushed, manufactured sand resulting from crushing operations. The fine aggregate shall be clean, hard, durable, of fairly cubical shape and free from soft pieces, organic or other deleterious substances. The Sand Equivalent Test (IS:2720, Part 37) value for the fine aggregate shall not be less than 50. The fine aggregates shall be non plastic.

2.32.2.4 Mineral Filler

Mineral filler shall consist of finely divided mineral matter such as stone dust and/or hydrated lime. Fly ash shall not be permitted as a filler. The filler shall be graded within the limits indicated in Table 500-36.

Table 64 : Grading Requirement of Mineral Filler *(Table 500-36 of MORT&H)*

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

The filler shall be inert material free from organic impurities and shall have plasticity index not greater than 4. Plasticity index requirement will not apply if filler is hydrated lime. Where the complete SMA mixture fails to satisfy the requirement of Moisture Susceptibility Test (AASHTO T 283), at least 2 percent by total weight of aggregate of hydrated lime shall be used as filler and the percentage of fine aggregate reduced accordingly.

2.32.2.5 Stabilizer Additive

Only pelletized cellulose fibres shall be utilized. The dosage rate for cellulose fibres is 0.3 percent minimum by weight (on loose fibre basis) of the total mix. The dosage rate shall be confirmed so that the bitumen draindown does not exceed 0.3 percent when the designed mix is tested in accordance with ASTM D 6390.

2.32.2.6 The cellulose fibres to be used in pellets shall meet the following requirements:

Maximum fibre length : 8 mm
Ash content Oil : maximum of 20 percent nonvolatile
absorption Moisture : more than 4 times of the fibre weight content less than 5 percent by weight

When the Contractor submits the proposed job-mix formula for SMA for approval, it shall include the fibre manufacturer's most recently dated actual test data showing that the fibres meet the above requirements. The contractor shall protect the cellulose from moisture and contamination prior to incorporating it into the SMA.

2.32.3 SMA Mix Design

2.32.3.1 The combined grading of the coarse aggregate, fine aggregate and mineral filler (including hydrated lime if used) shall be within the limits shown in Table 500-37.

Table 65 : Composition of Stone Matrix Asphalt (Table 500-37 of MORT&H)

SMA Designation	13 mm SMA	19 mm SMA
Course where used	Wearing course	Binder (intermediate) course
Nominal aggregate size	13 mm	19 mm
Layer thickness	40-50 mm	45-75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	Cumulative % by weight of total aggregate passing
26.5	–	100
19	100	90-100
13.2	90-100	45-70
9.5	50-75	25-60
4.75	20-28	20-28
2.36	16-24	16-24
1.18	13-21	13-21
0.600	12-18	12-18
0.300	10-20	10-20
0.075	8-12	8-12

2.32.3.2 The SMA mixture will be designed using AASHTO MP8, Standard Specification for Designing Stone Matrix Asphalt and AASHTO PP 41, Standard Practice for Designing Stone Matrix Asphalt. The SMA mixture shall be compacted with 50 blows on each side using the Marshall procedure given in the Asphalt Institute MS-2 (Sixth edition). The designed mix shall meet the requirements given in Table 500-38.

Table 66 : SMA Mix Requirements *(Table 500-38 of MORT&H)*

Mix Design Parameters	Requirement
Air void content, percent	4.0
Bitumen content, percent	5.8 min
Celluloid fibres	0.3 percent minimum by weight of total mix
Voids in mineral aggregate (VMA), percent	17 min.
Voids in Coarse Aggregates (VGA) mix, percent	Less than VGA (dry rodded)
Asphalt drain down, percent ASTM D 6390 (Annex C of IRC:SP:79)	0.3 max.
Tensile Strength Ratio (TSR), per cent AASHTO T 283 (Annex E of IRC:SP:79)	85 min.

2.32.4 SMA Production

2.32.4.1 Mixing

The SMA mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate.

When viscosity grade bitumen is used, the mix temperature shall range from 150°C to 165°C. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to ensure uniform quality of mix, the plant shall be calibrated from time to time.

2.32.4.2 Handling Mineral Filler

Adequate dry storage will be provided for the mineral filler and provisions shall be made for proportioning the filler into the mixture uniformly and in the desired quantities. This is necessary because relatively large amounts of mineral filler are required in SMA mixes.

2.32.4.3 Fibre Additive

For batch plant, the fibre will be added directly into the weigh hopper above the pugmill. Adequate dry mixing time is required to disperse the fiber uniformly throughout the hot aggregate. Dry mixing time will be increased by 5 to 10 seconds. Wet mixing time shall be increased by at least 5 seconds. For drum mix plant, a separate fibre feeding system shall be utilized that can accurately and uniformly introduce fibre into the drum at such a rate as not to limit the normal production of mix through the drum. At no time shall there be any evidence of fibre in the baghouse/wasted baghouse fines.

2.32.5 SMA Placement and Compaction

2.32.5.1 Preparation of Existing Bituminous Surface

The existing bituminous surface shall be cleaned of all loose extraneous matter by means of mechanical broom and high-pressure air jet from compressor or any other approved equipment/method. Any potholes and/or cracks shall be repaired and sealed.

2.32.5.2 Tack Coat

Clause 503 of MORT&H shall apply.

2.32.5.3 Transportation

Clause 501.4 of MORT&H shall apply.

2.32.5.4 Laying

2.32.5.4.1 Weather and Seasonal Limitations

Clause 501.5.1 of MORT&H shall apply.

2.32.5.4.2 Spreading

Clause 501.5.3 of MORT&H shall apply.

2.32.5.5 Compaction

Clause 501.6 of MORT&H shall apply, except that the use of pneumatic roller shall not be permitted if there is a possibility of pick-up.

The density of the finished paving layer shall be determined by taking 150 mm diameter cores. The density of finished paving layer shall not be less than 94 percent of the average (sample size N=2) theoretical maximum specific gravity of the loose mix (Gmm) obtained on that day in accordance with ASTM D2041. That is, no more than 6 percent air voids shall be allowed in the compacted SMA mat.

2.32.5.6 Joints

Clause 501.7 of MORT&H shall apply.

2.32.6 Quality Control and Surface Finish

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

2.32.7 Control of Traffic

It shall be ensured that traffic is not allowed on the SMA surface until the paved mat has cooled to ambient temperature in its entire depth.

2.32.8 Arrangements for Traffic

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

2.33 MASTIC ASPHALT *(cl. 516 of MORT&H)*

2.33.1 Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogenous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and void less mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

2.33.2 Materials

2.33.2.1 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 67 : Requirements for Physical Properties of Binder *(Table 500-39 of MORT&H)*

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.

2.33.2.2 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 68 : Grade and Thickness of Mastic Asphalt Paving and Grading of Coarse Aggregates *(Table 500-40 of MORT&H)*

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) 19 13.2 2.36		13 mm Cumulative % passing by weight 100 88-96 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 69 : Grading of Fine Aggregate (Inclusive of Filler) *(Table 500-41 of MORT&H)*

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

2.33.3 Mix Design

2.33.3.1 Hardness Number

The mastic asphalt shall have a hardness number at the time of manufacture of 50 to 70 at 25^{D}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 ISM195-1978.

2.33.3.2 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 of MoRT&H.

Table 70 : Composition of Mastic Asphalt Blocks without Coarse Aggregate *(Table 500-42 of MORT&H)*

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

2.33.3.3 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.

2.33.4 Construction Operations

2.33.4.1 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.

2.33.4.2 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.

2.33.4.3 Tack Coat

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

2.33.4.4 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 of MoRT&H.

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.

2.33.4.5 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 :

a) 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.

b) 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 of MoRT&H.

c) 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.

2.33.4.6 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.

2.33.4.7 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.

2.33.5 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.

2.34 CRACK PREVENTION COURSES *(cl. 517 of MORT&H)*

2.34.1 Scope

The work shall consist of providing one or two coats of an elastomeric rubber membrane known as Stress Absorbing Membrane (SAM) over a cracked surface, followed by a covering of aggregate chips, and a Stress Absorbing Membrane Interlayer (SAMI), which is a material similar to SAM or which consists of a bitumen impregnated geotextile, as specified in the Contract.

2.34.2 Materials

2.34.2.1 Binder

Binder shall be a modified binder complying with the requirements of IS: 15462 and IRC:SP:53, according to the requirements of the Contract, except that viscosity grade VG 10 complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

2.34.2.2 Aggregate

The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of SAMI. Where required by the contract, aggregates shall be pre-coated by mixing them with 0.75 to 1.0 percent of paving bitumen by weight of chips in a suitable mixer, the chips being heated to 160°C and the bitumen to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non-sticky and can be spread easily.

2.34.2.3 Rates of Spread of Binder and Aggregate

The rate of spread of binder and aggregate shall be as given in Table 500-43, as required by the Contract.

2.34.2.4 Geo-textile

The geotextile as prescribed shall conform to the requirements of Clause 703.3 of MoRT&H.

2.34.3 Construction Operations

2.34.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

2.34.3.2 Preparation of Base

The base on which the SAM, SAMI or bitumen impregnated geotextile is to be laid shall be prepared, in accordance with Clause 501 and as directed by the Engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment/method approved by the Engineer. Dust removed in the process shall be blown off with compressed air.

2.34.3.3 Application of Binder

2.34.3.3.1 The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 160°-170°C. Binder for bitumen impregnated geotextile shall be applied according to Clause 703.4.4. The surface on which the binder is to be applied shall be dry.

Table 71 : Quantity of Materials Required for 10 sq.m of Road Surface for Stress Absorbing Membrane
Table 500-43 of MORT&H)

S. No.	Type and Width of Crack	Specification of SAM to be Applied	Quantity of Binder Kg/10m²	Quantity of Chipping
1)	Hair cracks and map cracks upto 3 mm width	Single coat SAM or 2nd coat of two coat SAM	8-10	0.10 m³ of 5.6 mm chips
2)	Map cracks or alligator cracks 3 mm to 6 mm width	Single coat SAM	10-12	0.11m³ of 5.6 mm chips
3)	Map cracks or alligator cracks 6 mm to 9 mm width	Two coat SAM 1st coat 2nd coat	 12 -14 8-10	0.12 m³ of 5.6 mm and 11.2 mm chips in 1:1 ratio 0.10 m³ of 5.6 mm chips
4)	Cracks above 9 mm width and cracked area above 50 percent	Two coat SAM 1st coat 2nd coat	 14-16 8-10	 0.12 m³ of 11.2 mm chips 0.10 m³ of 5.6 mm chips
5)	All types of cracks with crack width below 6 mm	Single coat SAM I	8-10	0.10 m³ of 5.6 mm chips
6)	All types of cracks with crack width above 6 mm	Single coat SAM I	10-12	0.10 m³ of 11.2 mm chips

2.34.3.3.2 Binder quantity for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 litres/m^2. Binder quantity outside this range is permitted according to the geotextile manufacturer's instructions and subject to the agreement of the Engineer.

2.34.3.4 Application of Aggregates

The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the modified binder, clean, dry aggregate shall be spread uniformly on the surface.

2.34.3.5 Sweeping

The surface of SAMs and SAM Is shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

2.34.3.6 Two Coat SAM or SAM I

Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first coat.

2.34.3.7 Geotextiie Placement

For bitumen impregnated geotextiie, the requirements of Clause 703.4.4 shall apply.

2.34.4 Opening to Traffic

Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20 km/h, until the following day. Speed control measures are to be approved by the Engineer, prior to laying. Traffic shall not be allowed on the bitumen impregnated geotextiie layer unless it is overlaid.

2.35 BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION) *(cl. 518 of MORT&H)*

2.35.1 The Design Mix

The work shall consist of providing a bituminous cold mix consisting of a mixture of unheated mineral aggregate and emulsified or cutback bitumen, laid in a single layer of 25-75 mm. The mix shall either be a design mix or a recipe mix.

2.35.2 Materials

2.35.2.1 Binder

The binder shall be a slow/ medium setting bitumen emulsion conforming to IS:8887 or a medium curing cut-back conforming to IS:217.

The final selection of the binder shall be made only after laboratory evaluation with the aggregates to be used. A general guide for the selection of the binder is given in the Manual for Construction and Supervision of Bituminous Works.

The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

2.35.2.1.1 Aggregates

The aggregates shall comply with the requirements of Clauses 505.2.2. and 505.2.3. If the aggregates are not properly coated with the binder, a small amount of hydrated lime on an approved antistripping agent (see Appendix 4) shall be proposed by the Contractor, for the approval of the Engineer.

2.35.2.1.2 Aggregate Grading and Binder Content

The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part I, (wet sieving method), shall fall within the limits shown in Table 500-44 of MoRT&H.

2.35.2.2 Mix Design

2.35.2.2.1 Requirements for the Mixture

Apart from conformity with the grading and quality requirements for individual ingredients, the mix shall meet the requirements set out in Table 500-45 of MoRT&H.

Table 72 : Aggregate Grading and Bitumen Content *(Table 500-44 of MORT&H)*

Nominal Maximum Size (mm)	**9.5**	**13.2**	**19.0**
Allowable Thickness (mm)	**25-35**	**36-50**	**51-75**
IS Sieve (mm)	**Cumulative % by weight of total aggregate passing**		
37.5	-	-	-
26.5	-	-	100
19.0	-	100	90-100
13.2	100	90-100	—
9.5	90-100	-	60-80
4.75	60-80	45-70	35-65
2.36	35-65	25-55	20-50
0.30	6-25	5-20	3-20
0.075	2-10	2-9	2-8
Cutback Emulsion	Binder content, percent by weight of total mix 4-6 7-10		

The binder content shall be determined by the modified Marshall Test.

Table 73 : Mix Requirements for Designed Cold Mix *(Table 500-45 of MORT&H)*

Parameter	**Emulsion[1]**	**Cutback[2]**
Minimum Stability	2.2 kN at 22.2°C for paving	2.2 kN at 25°C for maintenance 3.3 kN at 25°C for paving
Percent maximum stability loss on soaking	50[3]	25[4]
Minimum flow (mm)	2	2
Compaction level (number of blows)	50	75
Per cent air voids	3-5[5]	3-5
Per cent voids in mineral aggregate (VMA)	See Table 500-46	
Per cent minimum coating[6]	50	

Notes: [1] Using Marshall method for emulsified asphalt-aggregate cold mix design". Appendix F, MS-14

[2] Using "Marshall method for cut-back asphalt-aggregate cold mix design:, Appendix H, MS-14

[3] With vacuum saturation and immersion

[4] Four days soak at 25°C.

[5] Refers to total voids in the mix occupied by air and water

[6] Coating Test, Appendix F, MS-14.

Table 74 : Minimum Percent Voids in Mineral Aggregate (VMA) *(Table 500-46 of MORT&H)*

Nominal Maximum Particle Size IS Sieve (mm)	**Minimum VMA (Percent)**
9.5	16.0
12.5	15.0
19.0	14.0
25.0	13.0
37.5	12.0

2.35.2.2.2 Binder Content

The binder content shall be optimized by the Modified Marshall Test to achieve the requirements of the mix set out in Table 500-45. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

2.33.2.2.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of the work, the job mix formula proposed for use in the works together with the following details:

i) Source and location of all materials;

ii) Proportions of all materials expressed as follows where each is applicable:
   a) Binder, as percentage by weight of total mix;
   b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;
iii) A single definite percentage passing each sieve for the mixed aggregate;
iv) The results of tests enumerated in Table 500-46 as obtained by the Contractor;
v) Test results of the physical characteristics of the aggregates to be used;
vi) Spraying temperature of binder if appropriate.

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

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

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

2.35.2.2.4 Permissible Variation from the Job Mix Formula

It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Tables 500-13 and 500-18. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900 of MoRT&H Specifications.

2.35.2.3 Construction operations

2.35.2.3.1 Weather and Seasonal Limitations

Construction with cold mix must not be undertaken when ambient temperatures below 10°C are expected, during rain, in standing water, or generally when poor weather is predicted. Bitumen emulsions and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesion characteristics. Cold weather, rain and high humidity slow down the rate of curing. Extra manipulation may be required to remove volatiles in cool and humid conditions. Wind increases the rate of evaporation.

2.35.2.3.2 Preparation of the Base

The base on which cold mix is to be laid shall be prepared, shaped and levelled to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

2.35.2.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid where specified in the Contract.

2.35.2.3.4 Preparation and Transportation of the Mix

Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

a) rotary drum type concrete mixer for small jobs or asphalt cold mix plant;
b) batch or continuous type mixer without dryer

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site shall suit to the Contractor's proposed laying procedure methodology.

2.35.2.3.5 Spreading

Designed cold mix shall be placed by a paver or grader as specified in the Contract. The mix shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader shall have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mix.

If climatic conditions and aggregate grading do not permit evaporation of moisture or volatiles without aeration by manipulation, a grader shall be used to place designed cold mix.

Other methods of spreading may be used as approved by the Engineer.

2.35.2.3.6 Compaction

Initial compaction of the laid material shall preferably be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thickness being 25-100 mm and all compaction being in accordance with Clauses 501.6 and 501.7. Smooth tyres shall be used. Final rolling and smoothening of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

2.35.2.4 Opening to Traffic

Traffic shall not be allowed to run on new work until all the water or volatiles in the mix have evaporated, as determined by the Engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

2.36 DRY LEAN CEMENT CONCRETE SUB-BASE *(cl. 601 of MORT&H)*

2.36.1 Scope

2.36.1.1 The work shall consist of construction of (zero slump) dry lean concrete sub-base for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.

2.36.1.2 The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the drawings.

2.36.2 Materials

2.36.2.1 Sources of Materials

The Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the dry lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor later proposes to obtain the materials from a different source during the execution of main work, he shall notify the Engineer with relevant test data for his approval at least 45 days before such materials are to be used.

2.36.2.2 Cement

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

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

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

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

2.36.2.3 Fly-ash

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

2.36.2.4 Aggregates

2.36.2.4.1 Coarse Aggregates

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

2.36.2.4.2 Fine Aggregates

The fine aggregate shall comply with Clause 602.2.6.3 of MoRT&H.

2.36.2.4.3 The material after blending shall conform to the grading as indicated in Table 600-1 of MoRT&H.

Table 75 : Aggregate Gradation for Dry Lean Concrete *(Table 600-1 of MORT&H)*

Sieve Designation	Percentage by Weight Passing the Sieve
26.50 mm	100
19.0 mm	75-95
9.50 mm	50-70
4.75 mm	30-55
2.36 mm	17-42
600 micron	8-22
300 micron	7-17
150 micron	2-12
75 micron	0-10

2.36.3 Proportioning of Materials for the Mix

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

2.36.3.2 Moisture Content

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

2.36.3.3 Cement Content

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

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

2.36.3.4 Concrete Strength

The average compressive strength of each consecutive group of 5 cubes made in accordance with Clause 903.5.1.1 shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 MPa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer and demonstrated in the trial length construction.

2.36.4 Sub-grade

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

2.36.5 Drainage Layer

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

2.36.6 Construction

2.36.6.1 General

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

2.36.6.2 Batching and Mixing

The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with Clauses 602.9.2, 602.9.3.1 and 602.9.3.2 of MoRT&H.

The design features of Batching Plant should be such that the plant can be shifted quickly.

2.36.6.3 Transporting

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

2.36.6.4 Placing

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

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

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

2.36.6.5 Compaction

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

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

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

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

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

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

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

per km shall be cut to check deficiency in strength. The holes resulting from cores shall be restored by filling with concrete of the specified strength and compacted by adequate rodding.

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

2.36.6.6 Joints

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

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

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

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

2.36.6.7 Curing

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

a) Curing may be done by covering the surface by gunny bags/hessian, which shall be kept wet continuously for 7 days by sprinkling water.

b) The curing shall be done by spraying with approved resin based aluminized reflective curing compound conforming to ASTM-C 309-81 in accordance with Clause 602.9.12. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days. The rate of application shall be as recommended by the supplier.

c) Wax-based white pigmented curing compound with water retention index of not less than 90 percent shall be used to cure the dry lean concrete. The curing compound shall conform to BS: 7542. The compound shall be applied uniformly with a mechanical sprayer and with a hood to protect the *spray* from the wind. The curing compound shall be applied over the entire exposed surface of the Dry Lean Concrete, including sides and edges, at the rate of 0.2 litres/sq.m, or as recommended by the supplier.

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

2.36.7 Trial Mixes

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

If during the construction of the trial length, the optimum moisture content determined as above is found to be unsatisfactory, the Contractor may make suitable changes in the moisture content to achieve the satisfactory mix. The cube specimens prepared with the changed mix content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in ravelling of surface.

2.36.8 Trial Length

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

2.36.8.2 After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length and average of these densities shall be determined. The density holes shall not be made in the strip 500 mm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 percent. The field density of regular work will be compared with this reference density in accordance with Clauses 601.6.5.1 and 903.5, 1.2.

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

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

2.36.9 Traffic

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

2.37 CEMENT CONCRETE PAVEMENT *(cl. 602 of MORT&H)*

2.37.1 Scope

2.37.1.1 The work shall consist of construction of un-reinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer.

2.37.1.2 The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc. shall be as stipulated in the drawings.

2.37.2 Materials

2.37.2.1 Cement

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but preference shall be to use at least the 43 grade or higher.

S.No.	Type	Conforming to
i)	Ordinary Portland Cement 43 Grade	1S:8112
ii)	Ordinary Portland Cement 53 Grade	1S:12269
iii)	Portlant slag cement	IS:455
iv)	Portland Pozzolana Cement	IS:1489-Part I

If the soil around concrete pavement has soluble salts like sulphates in excess of 0.5 percent, the cement used shall be sulphate resistant and shall conform to IS: 12330.

Cement to be used may preferably be obtained in bulk form. If cement in paper bags is proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them off suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with Clause 1014. The cement shall be subjected to acceptance test.

Fly-ash upto 20 percent by weight of cementitious material may be used in Ordinary Portland

Cement 43 and 53 Grade as part replacement of cement provided uniform blending with cement is ensured. The fly ash shall conform to IS:3812 (Part I).

Site mixing of fly ash shall be permitted only after ensuring availability of the equipments at site for uniform blending through a specific mechanised facility with automated process control like batch mix plants conforming to IS:4925 and IS:4926. Site mixing will not be allowed otherwise.

The Portland Pozzolana Cement produced in factory as per IS:1489-Part I shall not have fly-ash content more than 20 percent by weight of cementitious material. Certificate from the manufacturer to this effect shall be produced before use.

2.37.2.2 Chemical Admixtures

Admixtures conforming to IS:9103 and IS:6925 shall be permitted to improve workability of the concrete and/or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in the trial length paving, (f air entraining admixture is used, the total quantity of air shall be 5±1.5 percent for 31.5 mm maximum nominal size aggregate (in air-entrained concrete as a percentage of the volume of the mix).

2.37.2.3 Silica Fumes

Silica fume conforming to a standard approved by the Engineer may be used as an admixture in the proportion of 3 to 10 percent of cement. Silica fume shall comply with the requirements given in IS:15388-2003, IS:456-2000, IRC:SP:76 and !RC:44-2008.

2.37.2.4 Fibres

Fibres may be used subject to the provision in the design/approval by the Engineer to reduce the shrinkage cracking and post-cracking. The fibres may be steel fibre as per IRC:SP:46 or polymeric Synthetic fibres within the following range of specifications:

Effective Diameter	10 micron - 100 micron
Length	6-48 mm
Specific gravity	more than 1.0
Suggested dosage	0.6-2.0 kg/cu.m (0.2 - 0.6% by weight of cement in mix) Usage will be regulated as stipulated in IRC:44/IS:456
Water absorption	less than 0.45 percent
Melting point of this fibre shall not be less than 160°C.	
The aspect ratio generally varies from 200 to 2000.	
These synthetic fibres will have good alkali and UV light resistance.	

When fibres are used, the mix shall be so designed that the slump of concrete at paving site is 25±15 mm.

2.37.2.5 Aggregates

2.37.2.5.1 Aggregates for pavement concrete shall be natural material complying with

IS:383 but with a Los Angeles Abrasion Test value not exceeding 35 percent. The limits of deleterious materials shall not exceed the requirements set out in Table 600-2 of MoRT&H.

Table 76 : Permissible Limits of Deleterious Substances in Fine and Coarse Aggregates *(Table 600-2 of MORT&H)*

S. No.	Deleterious Substance	Method of Test	Fine Aggregate Percentage by Weight, (Max)		Coarse Aggregate Percentage by Weight (Max)	
			Uncrushed	Crushed*	Uncrushed	Crushed*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Coal and lignite	IS:2386 (Part 11)-1963	1.0	1.0	1.0	1.0
ii)	Clay lumps	do	1.0	1.0	1.0	1.0
iii)	Materials finer than 75 u IS Sieve	IS:2386 (Part I)-1963	3.0	8.0	3.0	3.0
iv)	Soft fragments	IS:2386 (Part II)-1963	–	–	3.0	-
v)	Shale	IS:2386 (Part II)-1963	1.0	–	–	–
vi)	Total of percentages of all deleterious materials (except mica) including Sl No. (i) to (v) for col 4, 6 and 7 and Sl No. (i) and (ii) for col 5 only		5.0	2.0	5.0	5.0

* Crushed aggregate at least one face fractured

Note: The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are underway to determine the extent of the deleterious effect of mica. It is advisable, therefore, to investigate the mica content of fine aggregate and make suitable allowances for the possible reduction in the strength of concrete or mortar; in cases where the stretch of the project road passes through micacious belt.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalies in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 percent by weight and the total sulphate content expressed as sulphuric anhydride (SO_3) shall not exceed 0.25 percent by weight. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for atleast 72 hours before batching, as directed by the Engineer.

2.37.2.5.2 Coarse Aggregates

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 31.5 mm for pavement concrete. No aggregate which has water absorption more than 2 percent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS:2386 (Part-5). After 5 cycles of testing, the loss shall not be more than 12 percent if sodium sulphate solution is used or 18 percent if magnesium sulphate solution is used. The Los Angeles Abrasion value shall not exceed 35. The combined flakiness and elongation index of aggregate shall not be more than 35 percent.

2.37.2.5.3 Fine Aggregates

The fine aggregates shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37).

2.37.2.5.4 Combined Gradation of Fine and Coarse Aggregates

The combined gradation of fine and coarse aggregates shall be as per Table 600-3 of MoRT&H.

2.37.2.6 Steel for Dowels and Tie Bars

Steel shall conform to the requirements of IS:432 and IS:1786 as relevant. The dowel bars shall conform to !S:432 of Grade I. Tie bars shall be either High yield Strength Deformed bars conforming to IS: 1786 and grade of Fe 500 or plain bars conforming to IS:432 of Grade I. The steel shall be coated with epoxy paint for protection against corrosion.

2.37.2.7 Joint Filler Board

Synthetic Joint filler board for expansion joints shall be used only at abutting structures like bridges and shall be of 20-25 mm thickness within a tolerance of ± 1.5 mm and of a firm compressible material and complying with the requirements of IS: 1838, with a compressibility more than 25 percent. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not be less than one lane width. If two pieces are joined to make up full width, the joint shall be taped such that no slurry escapes through the joint. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

2.37.2.8 Joint Sealing Compound

The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide/ polyurethene/silicone type having flexibility, resistance to age hardening and durability as per IRC:57. Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard mentioned below. The samples shall meet the requirements as mentioned in IRC:57.

If sealant is of hot poured type, it shall conform to Hot applied sealant: IS:1834 or ASTM : 3406-95, as applicable Cold poured sealants shall be one of the following :

i)	polysulphide	IS:11433 (Part I), BS:5212 (Part II)
ii)	polyurethene	BS:5212
iii)	silicone	ASTM 5893-04

2.37.2.9 Preformed Seals

The pre-formed joint sealing material shall be a vulcanized elastomeric compound using polychloroprene (Neoprene) as the base polymer.

The joint seal shall conform to requirements of ASTM D 2628 as given in Table 600-4 of MoRT&H.

Table 77 : Requirement of Preformed Seals as per ASTM D 2628 *(Table 600-4 of MORT&H)*

S. No.	Description	Requirements	ASTM Test Methods
1)	Tensile strength, min	13.8 MPa	D412
2)	Elongation at break	Min. 250%	D412
3)	Hardness, Type A durometer	55 +/-5 points	D2240
4)	Oven aging, 70 h at 100°C Tensile strength loss	20% max	D573
5)	Elongation loss	20% max	
6)	Hardness Change Type A durometer	0 to + 10 points	D471
7)	Oil Swell, ASTM Oil 3, 70 h at 100°C Weight Change	45% max	D 1149
8)	Ozone resistance 20 percent strain, 300 pphm in air, 70h at 40°C	No cracks	D2240
9)	Low temperature stiffening, 7 days at -10°C Hardness Change type A durometer	0 to +15 points	
10)	Low temperature recovery, 22h at -10°C, 50% deflection	88% min	D2628
11)	Low temperature recovery, 22h at -29°C, 50% deflection	83% min	D2628
12)	Low temperature recovery, 70h at -100°C, 50% deflection	85% min	D2628
13)	Compression, deflection, at 80% of normal width (min)	613 N/m	D2628

2.37.3 Proportioning of Concrete

2.37.3.1 After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer vide Clause 602.3.4. The mix

design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IRC:44 or IS: 10262. The target mean strength for the design mix shall be determined as indicated in Clause 602.3.3.1. The mix design shall be based on the flexural strength of concrete.

2.37.3.2 Cement Content

When Ordinary Portland Cement (OPC) is used the quantity of cement shall not be less than 360 kg/cu.m. In case fly ash grade I (as per IS:3812) is blended at site as part replacement of cement, the quantity of fly ash shall be upto 20 percent by weight of cementitious material and the quantity of OPC in such a blend shall not be less than 310 kg/cu.m. The minimum of OPC content, in case ground granulated blast furnace slag cement blended, shall also not be less than 310 kg/m^3. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary by the contractor at his own cost.

2.37.3.3 Concrete Strength

2.37.3.3.1 The characteristic flexural strength of concrete shall not be less than 4.5 MPa unless specified otherwise. Target mean flexural strength for mix design shall be more than 4.5 MPa + 1.65s, where s is standard deviation of flexural strength derived by conducting test on minimum 30 beams. While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on specimens. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or as approved by the Engineer and the maximum free water cement ratio shall be 0.45 when only OPC is used and 0.50 when blended cement (Portland Pozzolana Cement or Portland Slag Cement or OPC blended with fly ash or Ground Granulated Blast Furnace Slag, at site) is used.

2.37.3.3.2 The ratio between the 7 and 28 day strength shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio "R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

If during the construction of the trial length or during some normal working, the average value of any four consecutive 7 day test results falls below the required 7 day strength as derived from the value of 'R' then the cement content of the concrete shall, without extra payment, be increased by 5 percent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for in conformity with the requirements as per Clause 602.3,3.1. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

2.37.3.4 Workability

2.37.3.4.1 The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum workability for the mix to suit the paving plant being used shall be determined by the Contractor and approved by the Engineer. The control of workability in the field shall be exercised by the slump test as per IS: 1199.

The workability requirement at the batching and mixing plant and paving site shall be established by slump tests carried during trial paving. These requirements shall be established from season to season and also when the lead from batching and mixing plant site to the paving site changes. The workability shall be established for the type of paving equipment available. A slump value in the range of 25 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the Engineer. These tests shall be carried out on every tipping truck/dumper at batching and mixing plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate tipping trucks or as per the instructions of the Engineer.

2.37.3.5 Design Mix

2.37.3.5.1 The Contractor shall carry out laboratory trials of design mix with the materials from the approved sources to be used as per IRC:44. Trial mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer. They shall be repeated, if necessary, until the proportions, that will produce a concrete which complies in all respects with these Specifications, and conform to the requirements of the design/drawings.

2.37.3.5.2 The proportions determined as a result of the laboratory trial mixes may be adjusted, if necessary, during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the Engineer.

2.37.3.5.3 Any change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length of length not less than 50 m unless approval is given by the Engineer for minor adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

2.37.4 Sub-base

The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and Specifications. It shall be ensured that the sub-base is not damaged before laying the concrete pavement. If the dry lean concrete sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired with fine cement concrete (aggregate size 10 mm and down) or bituminous concrete before laying separation membrane layer.

2.37.5 Separation Membrane

A separation membrane shall be used between the concrete slab and the sub-base. Separation membrane shall be impermeable PVC sheet 125 micron thick transparent or white in colour laid flat with minimum creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheathing shall be replaced at the Contractor's cost. The separation membrane may be nailed to the lower layer with concrete nails. The separation membrane shall be omitted when two layers of wax-based curing compound is used.

2.37.6 Joints

2.37.6.1 Transverse Joints

2.37.6.1.1 Transverse joints shall be contraction, construction and expansion joints constructed at the spacing described in the drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints.

i) Deviations of the performed filler board (IS: 1838) in the case of expansion joints from the intended line of the joint shall not be greater than ±10 mm.

ii) The best fit straight line through the joint grooves as constructed shall be not more than 25 mm from the intended line of the joint.

iii) Deviations of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.

iv) Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 602.10 of MoRT&H.

2.37.6.1.2 Contraction Joints

The contraction joints shall be placed transversely at pre-specified locations as per drawings/ design using dowel bars. These joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab.

Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and one-fourth to one-third depth of the slab ± 5 mm or as stipulated in the drawings and dowel bars complying with Clause 602.6.5 of MoRT&H.

Contraction joint shall be widened subsequently to accommodate the sealant as per Clause 602.10, to dimensions shown on drawings or as per IRC: 57.

2.37.6.1.3 Expansion Joints

The expansion joint shall consist of a joint filler board complying with Clause 602.2.9 and dowel bars complying with Clause 602.6.5 and as detailed in the drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances given in Clause 602.6.2.1. The adjacent slabs shall be completely separated from each other by the joint filler board.

2.37.6.2 Transverse Construction Joint

Transverse construction joint shall be placed whenever concreting is completed after a day's work or is suspended for more than 30 minutes. These joints shall be provided at location of contraction joints using dowel bars. If sufficient concrete has not been mixed to form a slab extending upto a contraction joint, and if an interruption occurs, the concrete placed shall be removed upto the last preceding joint and disposed of. At all construction joints, steel bulk heads shall be used to retain the

concrete. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulk head/stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be cut and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

After minimum 14 days of curing, in case OPC cement is used and 16 days of curing when flyash or blended cement is used, the construction joint shall be widened to accommodate the sealant as per Clause 602.10 to dimensions shown on drawing or as per IRC.57.

2.37.6.3 Longitudinal Joint

2.37.6.3.1 Tie Bars

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with Clause 602.6.6. The direction of the tie bars at curves shall be radial in the direction of the radius.

2.37.6.4 Dowel Bars

2.37.6.4.1 Dowel bars shall be mild steel rounds in accordance with Clause 602.2.8 with details/dimensions as indicated in the drawings and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. Any protrusions shall be removed by grinding the ends of the dowel bars. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

2.37.6.4.2 Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of ±20 mm, and centered equally about intended lines of the joint within a tolerance of ±25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within tolerances given here-in-under, the compliance of which shall be checked as per Clause 602.11.7 of MoRT&H.

i) For bars supported on cradles prior to the laying of the slab:
   a) All bars in a joint shall be within ±2 mm per 300 mm length of bar
   b) 2/3rd of the number of bars shall be within ±3 mm per 500 mm length of bar
   c) No bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane
   d) Cradles supporting dowel bar shall not extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joint.

ii) For all bars inserted after laying of the slab except those inserted by a Dowel Bar Inserter the tolerance for alignment may be twice as indicated in (i) above.

iii) The transverse joints at curves shall be radial in the direction of the radius.

2.37.6.4.3 Dowel bars, supported on cradles in assemblies, when subject to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and in both directions horizontally) shall conform to be within the limits given in Clause 602.6.5.2 of MoRT&H.

2.37.6.4.4 The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position:-

i) For expansion joints, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection after load shall be not more than 3 mm.

ii) The fixings for joint assembly shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.

iii) Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

2.37.6.4.5 Dowel bars in the contraction joints, construction joints and expansion joints shall be covered by a thin plastic sheath. The thickness of the sheath shall not exceed 0.5 mm and shall be tightly fitted on the bar for at least two-

thirds of the length from one end for dowel bars in contraction/construction joints and half the length plus 50 mm for expansion joints. The sheathed bar shall comply with the following pull-out tests:

Four bars shall be taken at random from stock and without any special preparation shall be covered by sheaths as required in this Clause, The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 mm x 150 mm x 600 mm, made of the same mix proportions to be used in the pavement, but with a maximum nominal aggregate size of 20 mm and cured in accordance with IS:516. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall not be greater than 0.14 MPa.

2.37.6.4.6 For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space (about 25 mm) at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry into the annular space between the sheathing and dowel bar shall be taped around its mouth,

2.37.6.5 Tie Bars

2.37.6.5.1 Tie bars in longitudinal joints shall be deformed steel bars of strength 500 MPa complying with IS: 1786 and in accordance with the requirements given in this Clause. The bars shall be free from oil, dirt, loose rust and scale.

2.37.6.5.2 Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint with the approval of the Engineer. The coating shall be dry when the tie bars are used. In the case of coastal region and high rainfall areas, tie bars shall be epoxy coated in their full length as per IS: 13620.

2.37.6.5.3 Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placements of the bars and recompaction of the concrete around the tie bars.

2.37.6.5.4 Tie bars shall be positioned to remain in the middle from the top or within the upper middle third of the slab depth as indicated in the drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of ±50 mm, and with a minimum cover of 30 mm below the joint groove. Spacing of tie bars on curves of radius less than 360 m shall not be less than 350 mm.

2.37.6.5.5 To check the position of the tie bars, one metre length, 0.5 m on either side of the longitudinal joint shall be opened when the concrete is green (within 20 to 30 minutes). The pit shall be refilled with the fresh concrete of same mix after checking.

2.37.6.5.6 Concreting during Monsoon Months

Concreting should be avoided during rainy season. However, when concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other waterproof cloth shall be provided along the line of the work. Any time when it rains, ail freshly laid concrete which had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directions of the Engineer.

2.37.7 Construction

2.37.7.1 General

A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities, indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work. This shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of atleast 500 m in one day. The paving speed of slip-form paver shall not be less than 1.0 m per minute. The concreting should proceed continuously without stops and starts.

2.37.7.2 Batching and Mixing

Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationary water tanks. This shall be located at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor.

2.37.7.2.1 Batching Plant and Equipment:

1) **General**: The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregates and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. There shall be a separate bin for flyash, if this additive is specified. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned. A continuous type of mixing plant can also be used provided the ingredients are weighed through electronic sensors before feeding.
2) **Automatic weighing devices** : Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The weighing devices shall have an accuracy within ±1 % in respect of quantity of cement, admixtures and water and ±2% in respect of aggregates and the accuracy shall be checked at least once a month.
3) **Mixer** : Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period, and of discharging the mix, without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed in 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.

   The mixer shall be cleaned at suitable intervals. The pick-up and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at midpoint of each blade are recommended. Batching Plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.
4) **Control cabin** : An air-conditioned centralized computer control cabin shall be provided for automatic operation of the equipment.

   The design features of the batching plant should be such that it can be shifted quickly.

2.37.7.2.2 Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i) spread, (ii) consolidate, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications. The paver shall be equipped with electronic sensor controls to control the line and grade from either one side or both sides of the machine.

Vibrators shall operate at a frequency of 8000-10000 impulses per minute under load at a maximum spacing of 600 mm. The variable vibration setting shall be provided in the machine.

2.37.7.3 Hauling and Placing of Concrete

2.37.7.3.1 Placing of Concrete

The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25°C and 90 minutes when the concrete temperature is between 25°C and 30°C. When the time between mixing and laying exceed these values, the concrete shall be rejected and removed from the site. Tipping trucks delivering concrete shall normally not run on plastic sheathing nor shall they run on completed slabs until after 28 days of placing the concrete.

The placing of concrete in front of the PQC paver should preferably be from the side placer to avoid damage to DLC by concrete tipping trucks. In case of unavoidable situation, truck supplying concrete to the paver may be allowed to ply on the DLC with the approval of the Engineer. The paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

2.37.7.4 Construction by Slip Form Paver

2.37.7.4.1 Tube Floating

Upon the instructions of the Engineer, Contractor shad scrape the concrete surface when in plastic state with a 3 m long tube float fixed with a long and stable handle before texturing. Tube float shall be of an alloy steel tube of 50 to 60 mm diameter with a long and stable handle. The length of tube float shall preferably be longer than half the length of slab i.e., half the distance between two transverse contraction joints. This operation shall be done to minimise surface irregularity caused due to varied causes like frequent stoppages of work, surface deformation due to plastic flow etc. The tube float shall be placed at the centre of the slab parallel to longitudinal joint and pulled slowly and uniformly towards the edges. After the use of float tube, it shall be frequently cleaned before further use. The slurry removed shall be discarded. This activity shall be advanced laterally by providing an overlap of half the length of tube float. The removal of the cement slurry from the surface shall be sufficient enough such that the texture is formed on a firm surface and is more durable. This operation, however, shall be carried out after removing bleeding water.

2.37.7.5 Construction by Fixed Form Paver

2.37.7.5.1 The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

2.37.7.5.2 The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the sub-base. The spreader shall be operated to strike off concrete upto a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be used adjacent to the side forms and edges of the previously constructed slab. The vibratory compactor shall be set to strike off the surface slightly high so that it is cut down to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by changes in slab thickness or crossfall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by over working.

2.37.7.6 Semi-mechanised Construction

Areas in which hand-guided methods of construction become indispensable shall be got approved by the Engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths. Work shall be carried out by skilled personnel as per methods approved by the Engineer. The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength, of concrete and all other quality control measures shall be the same as in the case of machine laid work. Guidelines on the use of plants, equipment, tools, hauling of mix, compaction floating, straight edging, texturing, edging etc. shall be as per IRC:15.

2.37.7.7 Surface Texture

2.37.7.7.1 Tining

After final floating and finishing of the slab and before application of the liquid curing membrane, the surface of concrete slabs shall be textured either in the transverse direction (i.e., at right angles to the longitudinal axis of the road) or in longitudinal direction (i.e., parallel to the centreline of the roadway). The texturing shall be done by tining the finished concrete surface by using rectangular steel tines. A beam or a bridge mounted with steel tines shall be equipped and operated with automatic sensing and control devices from main paver or auxiliary unit. The tining unit shall have facility for adjustment of the download pressure on the tines as necessary to produce the desired finish. The tining rakes shall be cleaned often to remove snots of slurry. The tines shall be inspected daily and all the damaged and bent tines shall be replaced before commencing texturing. Tined grooves shall be 3 mm wide and 3 to 4 mm deep. Before commencing texturing, the bleeding water, if any, shall be removed and texturing shall be done on a firm surface. The measurement of texture depth shall be done as per Clause 602.12 of MoRT&H.

a) **Transverse tining** : When the texturing is specified in transverse direction, a beam of at least 3 m length mounted with tines shall be moved in transverse direction to produce the texture. The grooves produced shall be at random spacing of grooves but uniform in width and depth. The spacing shall conform to a pattern shown below;

Random spacing in mm

10	14	16	11	10	13	15	16	11	10	21	13	10

b) The above pattern shall be repeated. Texturing shall be done at the right time such that the grooves after forming shall not close and they shall not get roughened. Swerving of groove patterns will not be permitted. The completed textured surface shall be uniform in appearance.

2.37.7.7.2 Brush Texturing

Alternatively on the instructions of the Engineer, the brush texturing shall be applied. The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide but wider brushes normally of 3 m length are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts placed at 10 mm centres. The tufts shall contain an average of 14 wires and initially be 100 mm long. The brush shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90 mm long.

The texture depth shall be determined by the Sand Patch Test as described in the Clause 602.12. This test shall be performed at least once for each day's paving and wherever the Engineer considers it necessary at times after construction as under:

Five individual measurements of the texture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

Texture depths shall not be less than the minimum required depth when measurements are taken as given in Table 600-5 nor greater than an average of 1.25 mm.

Table 78 : Texture Depth *(Table 600-5 of MORT&H)*

Time of Test		Number of Measurements	Required Texture Depth (mm)	
			Specified Value	Tolerance
1)	Between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles	An average of 5 measurements	1.00	±0.25
2)	Not later than 6 weeks before the road is opened to traffic	An average of 5 measurements	1.00	+0.25 - 0.35

After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over the length directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

2.37.7.8 Curing

2.37.7.8.1 Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminized reflective curing compound which hardens into an impervious film or membrane with the help of mechanical sprayer.

2.37.7.8.2 The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks of application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer's instructions checked during the construction of the trial length and subsequently whenever required by the Engineer. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying. The curing compound shall be sprayed in two applications to ensure uniform spread.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index not less than 90 percent in accordance with BS Specification No. 7542 or as per ASTM C-309-81 Type 2.

2.37.7.8.3 In addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavement with tents mounted on mobile trusses as described in Clause 602.7.2, during adverse weather conditions as directed by the Engineer. After three hours, the pavement shall be covered by moist hessian laid in two layers and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis.

2.37.7.8.4 The Contractor shall be liable at his cost to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint as per procedure in IRC:SP:83.

2.38 GEOSYNTHETICS FOR ROAD AND BRIDGE WORKS *(cl. 701 of MORT&H)*

2.38.1 Application and General Requirements

The specification covers the various applications of geosynthetic materials for use in road and bridge works including supplying and laying as per contract specifications.

Geosynthetic is a general classification for all synthetic materials used in geotechnical engineering application. It includes geotextiles, geogrids, geostrips, geomembranes, geonets, geocomposites, geocells, geosynthetic mats, paving fabric and glass grid etc. Geo fabrics made from natural fibres such as jute, and coir referred to herein under natural geotextites may also be used in different geotechnical engineering applications.

i) **Geotextiles** : Any permeable synthetic textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

The geotextile fabric shall be a woven, non-woven or knitted fabric consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene or polyester or any combination thereof formed into a stable network such that the filaments or yarns retain their relative position to each other.

There are several application areas for geotextiles requiring specific functions namely separation, filtration, drainage, reinforcement or a combination thereof.

ii) **Geogrids** : A deformed or non-deformed netlike polymeric material used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of human-made project, structure, or system.

Geogrids have relatively high strength, high modulus, and low-creep-sensitive polymers with apertures varying from 10 to 100 mm in size or more. The openings/holes in geogrids are either elongated ellipse, near squares with rounded corners, squares or rectangles. Geogrids can be of uni-axial grid, bi-axial grid or three dimensional grids. Geostrip is another form of geogrid, which is used in reinforced soil structures. It is primarily made of synthetic material in strips and is made from high tenacity polyester yarn and contained in a suitable polymer sheath.

These are used as reinforcement in pavements and reinforced soil slopes.

iii) **Geomembranes** : An essentially impermeable membrane (liner or barrier) used with foundation, soil, rock, earth, or in any other geotechnicai application as an integral part of human-made project, structure, or system, used to control fluid migration.

Geomembranes are made from PVC or polyethylene sheets, which are duly protected from ultraviolet exposure by carbon black or any antioxidants and thermal stabilizers.

These are used as capillary cut off in roads in water logged areas.

iv) **Geonets** : Geonets are used in combination with other types of geosynthetics. These are usually formed by continuous polymeric ribs at acute angle to one another. When the ribs are opened relatively large size apertures are formed in a net like configuration.

These are used in combination with other geosynthetic materials to form a composite material.

v) **Geocomposite** : A manufactured material, which could be a combination of any two or more synthetic materials like geotextiles, geogrids, geonets and geomembranes etc., in laminated or composite form. One of the popular forms of geocomposite is Drainage Composite. Drainage Composites are formed by combining geotextile or geomembrane with a core of geonet or seratted/corrugated polymeric materials.

Prefabricated Vertical Drains (PVD)/Band Drains and Fin Drains come under the category of geocomposites.

vi) **Geocell** : It is a three dimensional structure with interconnected cells. The geocells are made of polyester/polypropylene/high density polyethylene stabilized with carbon black.

Geocells may be used in erosion control of slopes.

vii) **Geosynthetic Mats** : These are two dimensional or three dimensional mats with specified thickness, made of multi-filaments, with apertures to allow vegetation growth for erosion control application. Geosynthetic mat consists of UV stabilized non-degradable polypropylene/polyethylene or similar polymer fibres that are extruded or heat bonded to provide a dimensionally stable matrix. A tension element like steel wire mesh or geogrid shall be included in these mats as reinforcement, where these mats are required to possess more strength against erosive forces, like in steep slopes or in heavy rainfall areas.

These are used for erosion protection of slopes.

viii) **Natural Geotextiles** : These geotextiles are made of natural fibres like jute or coir. The blankets/mats/mesh made of these fibres are sometimes further reinforced with polymeric nettings to enhance its tensile strength and for holding the fibres intact. The polymer netting is securely stitched on both sides of the fabric to form a strong quilted mat. These fabrics have excellent drapability and aid in quick growth of vegetation and are used for erosion control applications.

ix) **Paving Fabric and Glass Grids** : The paving fabrics are non-woven heat set material, consisting of at least 85% by weight of polyolefin, polyester or polyamides. They are heat bonded only on one side

Glass grids are either a composite glass fibre reinforced geogrid with continuous filament nonwoven geotextile chemically /mechanically bonded to the grid, or bituminous coated glass fibre geogrids with or without adhesive on one side of the grid.

The paving fabric, glass grids and composite of fabric and glass grids are used in bituminous pavements to act as stress relieving membrane and crack retarding layer within the pavement structure. The paving fabric also serves the function of water barrier.

2.38.2 Testing, Certification and Acceptance

2.38.2.1 Geosynthetic Materials Shall be Tested and Certified in the Following Manner.

a) The manufacturer shall have ISO or CE certification for manufacturing process and quality control.

b) The manufacturer shall provide manufacturer's test certificate for every lot supplied from the factory.

c) The supplier shall provide third party test reports from an independent laboratory with valid accreditation for all the test values in Manufacturer's test certificate.

2.38.2.2 Geosynthetics shall be tested in accordance with tests prescribed by BIS. In absence of IS codes, tests prescribed either by ASTM, EN, BS or ISO shall be conducted.

2.39 GEOTEXTILES FOR DRAINAGE, SEPARATION AND EROSION CONTROL

2.39.1 Scope

The work covers the use of geotextile materials for drainage, separation/filtration and erosion control works including supplying and laying as per design, drawing and these specifications.

For drainage/filtration function, geotextile shall be able to convey water across the plane of the fabric throughout its design life.

For separation function the geotextile shall prevent intermixing of two layers of dissimilar materials, throughout the design life of the structure.

The geotextile as a filter material below erosion control measures like stone pitching or stone filled mattresses over the slopes, shall allow the water to flow out and at the same time prevent the loss of soil under the protective measures.

2.39.2 Material

2.39.2.1 Strength Requirement

The minimum strength of geotextile in terms of MARV under different installation conditions shall be as specified in Table 700-1 of MoRT&H.

Table 79 : Minimum Geotextile Strength Property Requirements *(Table 700-1 of MORT&H)*

Installation Condition	Type	Strength Property Requirement (MARV)							
		Grab Strength in Newton (N) as per ASTM D 4632/ IS:13162 Part 5		Tear Strength in Newton (N) as per ASTM D 4533/ IS:14293		Puncture Strength In Newton (N) as per IS:13162 Part 4		Burst Strength in Newton (N) as per ASTM D 3786/ IS:1966	
		Elongation at Failure							
		<50 %	>50 %	<50 %	>50 %	<50 %	>50 %	<50 %	>50 %
Harsh installation condition	Type I	1400	900	500	350	500	350	3500	1700
Moderate Installation condition	Type II	1100	700	400	250	400	250	2700	1300
Less Severe Installation condition	Type III	800	500	300	180	300	180	2100	950

Note:

a) All numeric values in the above table represent Minimum Average Roll Value (MARV) in weaker principal direction. The MARV is derived statistically as the average value minus two standard deviations.

b) When the geotextiles are joined together by field sewing, the seam strength shall be at least 60 percent of the material's tensile strength. All field seams shall be sewn with thread as strong as the material in the fabric.

c) The puncture strength if determined in accordance with ASTM D 6241, the minimum requirement in terms of "Newton (N)" shall be as follows:

Installation condition	Strength property requirement (MARV)	
	Puncture Strength in Newton (N) as per ASTM D6241.	
	Elongation at Failure	
	< 50 %	> 50 %
Harsh installation condition	2800	2000
Moderate Installation condition	2250	1400
Less Severe Installation condition	1700	1000

2.39.2.2 Ultraviolet Stability Requirements

The material shall satisfy the ultraviolet stability requirements specified in Table: 700-2 of MoRT&H.

Table 80 : Requirements for Ultra Violet Stability *(Table 700-2 of MORT&H)*

S.No	Properties of Fabric	Requirements (Retained Strength)
1)	Grab Strength	Not less than 70% after 500 hours of exposure
2)	Tear Strength	
3)	Puncture Strength	
4)	Burst Strength	

2.39.2.3 Hydraulic Requirements for Various Applications

2.39.2.3.1 Subsurface Drainage

The geotextile shall conform to the physical requirements specified in Table 700-3 of MoRT&H.

Table 81 : Geotextile Requirements for Separation (Subgrades Soaked CBR >3) *(Table 700-4 of MORT&H)*

S.No.	Geotextile Property	Requirement
1)	Permittivity as per ASTM D 4491	0.02 sec^{1} (per sec)
2)	Maximum Apparent Opening Size as per ASTM D 4751	0.60 mm

Table 82 : Geotextile Requirements for Separation (Subgrades Soaked CBR <3) *(Table 700-5 of MORT&H)*

S.No.	Geotextile Property	Requirement
1)	Permittivity as per ASTM D 4491	0.05 sec^{1} (per sec)
2)	Maximum Apparent Opening Size as per ASTM D 4751	0.43

2.39.2.3.2 Erosion Control

The geotextile for erosion control shall conform to requirements given in Table 700-6 of MoRT&H.

Table 83 : Geotextile Requirements for Erosion Control *(Table 700-6 of MORT&H)*

In-situ Soil Passing 0.075 mm Sieve (%)	Permittivity, per sec ASTM D 4491	Maximum Apparent Opening Size, mm ASTM D 4751
<15	0.7	0.43
15 to 50	0.2	0.25
>50	0.1	0.22

2.39.3 Construction

2.39.3.1 General

Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

In trenches, after placing the backfill material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 300 mm for trenches greater than 300 mm wide. In trenches less than 300 mm wide, the overlap shall be equal to the width of the trench. The geotextile shall then be covered with the subsequent course.

Overlap at roll ends and at adjacent sheets shall be a minimum of 450 mm, except when placed underwater. In such instances, the overlap shall be a minimum of 1 m. Where seams are required in the longitudinal trench direction, they shall be joined by either sewing or overlapping. All seams and overlaps shall be subject to the approval of the Engineer.

Care shall be taken during installation so as to avoid any damage to the geotextile. Damages, if any, during installation shall be repaired by placing a geotextile patch over the damaged area and extending it 1 m beyond the perimeter of the tear or damage, or as approved by the Engineer.

2.39.3.2 Subsurface Drainage

Construction shall conform to Clause 309.3 of MoRT&H specifications.

2.39.3.3 Separation

After preparation of subgrade as per the specifications along the road alignment, geotextile shall be rolled out as indicated in the drawings. The entire roll shall be placed on the subgrade and unrolled as smoothly as possible. Wrinkles and folds in the fabric shall be removed by stretching as required.

Adjacent rolls of geotextiles shall be overlapped, sewn, or joined as required. For curves, the geotextile shall be folded or cut and overlapped in the direction of construction. Folds in the geotextile shall be stapled or pinned approximately 0.6 m centre-to-centre. Before covering, the condition of the geotextile shall be checked for damage (i.e., holes, nips, tears, etc) by the Engineer.

Before placing the, first lift of granular sub-base on the geotextile, a trial stretch of 100 m shall be laid as per roll width to establish a proper construction methodology of placing and compacting the sub-base in a manner that no damages are caused to the separation layer of geotextile.

2.39.3.4 Filter Layer under Stone Pitching for Erosion Control

The geotextile shall be placed in intimate contact of soil ensuring slight tension, to avoid wrinkles or folds and shall be anchored on a properly shaped surface as indicated in drawings and approved by the Engineer. It shall be ensured that the placement of the overlying material be placed in such a manner that it does not tear/puncture the geotextile. Anchoring of the terminal ends of the geotextile shall be accomplished as per drawings through the use of key trenches or aprons at the crest and toe of slope.

The geotextile shall be placed with the machine direction parallel to the direction of water flow. Adjacent geotextile sheets shall be joined by either sewing or overlapping.

The pitching shall begin at the toe and proceed up the slope. Big sized boulders shall not be allowed to roll down the slope.

Any geotextile damaged shall be either replaced or repaired with a patch, as directed by the Engineer, at the cost of the contractor.

2.40 GEOGRID *(cl. 703 of MORT&H)*

2.40.1 Scope

The work covers the use of geogrids in sub-base of pavement, erosion control of slopes, reinforced soil slopes and reinforced soil walls including supplying and laying as per design, drawing and these specifications.

The use of geogrids as a component for reinforced soil slopes and walls shall be as per Section 3100 of MoRT&H.

2.40.2 Materials

2.40.2.1 General

Geogrids shall be either made from high tenacity polyester yarn jointed at cross points by weaving, knitting or bonding process with appropriate coating or from polypropylene or polyethylene or any other suitable polymeric material by an appropriate process. Geogrids manufactured by extrusion process are integrally jointed, mono or bi-directionally oriented or stretched meshes, in square, rectangular, hexagonal or oval mesh form. The geogrids manufactured by weaving/knitting/bonding process shall be formed into a stable network such that ribs, filaments or yarns retain their dimensional stability relative to each other including selvages.

2.40.2.2 Sub-base Reinforcement

Geogrid for use as reinforcement of sub-base layers of flexible pavements shall meet the requirement as per the design subject to the minimum requirements as given in Table 700-7 of MoRT&H.

2.40.2.3 Erosion Control

The geogrid for erosion control application shall have the minimum tensile strength of 4 kN/m, when tested as per ASTM D 5035 (Minimum Average Roll Value in Machine Direction). The aperture opening size shall be minimum 20 mm x 20 mm and average grid thickness shall be minimum 1.0 mm. Geogrid for erosion control application shall be UV stabilized. The geogrid shall have ultraviolet stability of 70 percent after 500 hrs exposure as per ASTM D 4355.

Table 84 : Minimum Requirements for Geogrid for Sub-Base of Flexible Pavement *(Table 700-7 of MORT&H)*

Property	Test Method	Unit	Requirement
Stiffness at 0.5% strain	ISO-10319	kN/m	>350; both in machine and cross-machine direction
Tensile strength @2% strain	ASTM D6637	kN/m	>15% of T; both in machine and cross-machine direction
Tensile strength @5% strain	ASTM D6637	kN/m	>20% of T; both in machine and cross-machine direction
Junction Efficiency for extruded geogrids	GRI-GG2-87or ASTM-WK 14256	-	90% of rib ultimate tensile strength
Ultraviolet stability	ASTM D4355	-	70% after 500 hrs exposure

Note :

1) All numerical values in the Table represent MARV in the specified direction.

2) All geogrids shall be placed along machine direction parallel to the centre line of roadway alignment.

2.40.2.4 Reinforced Soil Slopes and Walls

The strength and other requirements shall be as per Section 3100.

2.40.2.5 Sub-base Reinforcement

Prior to laying of geogrid, the surface shall be properly prepared, cleaned and dressed to the specified lines and levels as shown on the drawings.

The geogrid shall be laid within the pavement structure as shown on the drawings.

Geogrid reinforcement shall be placed flat, pulled tight and held in position by pins or suitable means until the subsequent pavement layer is placed.

No vehicle shall be allowed on geogrid unless it is covered by at least 150 mm thick sub-base material.

2.40.2.6 Reinforced Slopes and Walls

The geogrid for reinforced slopes and walls shall be installed in accordance with the manufacturer's recommendation and as per Section 3100.

2.41 PAVING FABRICS/GLASS GRIDS *(cl. 708 of MORT&H)*

2.41.1 Scope

This work shall consist of laying geosynthetic materials either non-woven paving fabric or fibre glass coated grid over existing bituminous surface, including preparation of surface and joining, stitching or overlapping of geosynthetic fabric etc., as part of highway pavement strengthening in layers as shown on drawings or as directed by the Engineer.

2.41.2 Material Requirements

2.41.2.1 Paving Fabrics

The paving fabric will be a non-woven heat set material consisting of at least 85 percent by weight of polyolefins, polyesters or polyamides. The paving fabric shall be resistant to chemical attack, rot and mildew and shall have no tears or defects which will adversely alter its physical properties. The fabric shall be specifically designed for pavement applications and be heat bonded only on one side to reduce bleed-through of tack coat during installation. The fabric shall meet the physical requirements given in Table 700-16.

2.41.2.2 Glass Grids

These will be either a composite glass fibre reinforced geogrid with continuous filament non-woven Geotextile chemically or mechanically bonded to the grid; or bituminous coated glass fiber geogrid with or without adhesive on one side of the grid. The physical and mechanical properties of glass grid fabric shall conform to the requirements given in Table 700-17.

Table 85 : Properties of Glass Fibre Grids *(Table 700-17 of MORT&H)*

Property	Units	Requirement			
		Tensile Strength in Both Median and Cross-Machine Direction			
Tensile Strength	kN/m	ASTM D 6637	50	1000	200
% Elongation at break	%		>4	>4	>4
Minimum Mesh Size	mm		25x25	12.5x12.5	12.5x 12.5
Melting Point	°C	ASTM D 276	>250	>250	>250

2.41.2.3 Asphalt Reinforcing Geogrids

These shall be made of high modulus polyester yarns with low creep properties. The grid shall be connected to low weight non-woven polypropylene fabric. The composite shall have a bitumen finish. The properties shall conform to the requirements given in Table 700-18.

Table 86 : Properties of Asphalt Reinforcement Geogrids *(Table 700-18 of MORT&H)*

Property	Units	Test Method	Requirement		
			Tensile strength in both MD and CD, Not less than		
Tensile strength	kN/m	ISO-10319	25	50	100
% Elongation at break	%	ISO-10319	12.5%	12.5%	12.5%
Mesh Size			35x35 20x20	35x35 20x20	35x35 20x20
Melting Point	°C		> 190	> 190	> 190

2.41.2.4 Paving Fabric Placement

The paving fabric shall be placed onto the tack coat using mechanical or manual lay down equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. The paving fabric shall be placed before to the tack coat cools and loses tackiness. After laying the paving fabric, some loose bituminous premix material shall be sprinkled on it in the wheel path of the paver and the tipper to ensure that the fabric is not picked up between the wheels. Paving fabric shall not be installed in areas where the bituminous overlay tapers to a thickness of less than 40 mm. Excess paving fabric which extends beyond the edge of existing pavement or areas of tack coat application shall be trimmed and removed. When bitumen emulsions are used, the emulsion shall be allowed to cure properly such that no water/moisture remains prior to placing the paving fabric. Wrinkles or folds in excess of 25 mm shall be single-lapped in the direction of the paving operation. Brooming and/ or pneumatic rolling will be required to maximize paving fabric contact with the pavement surface. Additional hand-placed tack coat may be required at laps and repairs as determined by the Engineer to satisfy bitumen retention of the lapped paving fabric. All areas where paving fabrics have been placed shall be paved the same

day. No traffic except necessary construction equipment will be allowed to drive on the paving fabric. Turning of the paver and other vehicles shall be done gradually and kept to a minimum to avoid movement and damage to the paving fabric. Abrupt starts and stops shall also be avoided. Damaged fabric shall be removed and replaced with the same type of fabric. Overlaps shall be shingle-lapped in the direction of paving. Additional tack coat shall be placed between the overlap to satisfy saturation requirements of the fabric. Overlap shall be sufficient to ensure full closure of the joint but not exceed 150 mm. Transverse joints shall be overlapped in the direction of the pavement by 100 to 150 mm or as per the manufacturer's recommendations or as directed by the Engineer. Longitudinal joints shall be overlapped by 20-30 mm or as per the manufacturer's recommendations or as directed by the engineer. The overlay operations shall be completed at the earliest after laying the fabric.

2.41.2.5 Glass Grid Placement

The glass grid shall be placed on the surface provided by the tack coat using mechanical or manual lay down equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. On curves, the Glass grid must be cut and realigned to match the curvature.

Glass grid shall not be installed in areas where the bituminous overlay tapers to a compacted thickness of less than 40 mm. When emulsions are used, the emulsion shall be allowed to cure properly such that no water/moisture remains prior to placing the glass grid. Wrinkles severe enough to cause folds shall be slit and laid flat. Brooming and/or rubber-tire rolling will be required to maximize glass grid contact with the pavement surface. Additional hand-placed tack coat may be required at overlaps and repairs as required by the Engineer. Turning and braking of the paver and other vehicles shall be done gradually and kept to a minimum to avoid movement and damage to the glass grid. Damaged composite shall be removed and replaced with the same type of composite and a tack coat.

All areas where glass grid has been placed shall be paved the same day. No traffic except necessary construction traffic shall be allowed to drive on the glass grid.

Overlaps shall be shingle - lapped in the direction of paving. Additional tack coat shall be placed between the overlap to satisfy saturation requirements of the fabric. Overlap shall be sufficient to ensure full closure of the joint but not exceeding 150 mm.

2.41.2.6 Overlay Placement

Bituminous overlay construction shall closely follow the placement of paving fabric or glass-grid. Excess tack coat that bleeds through the paving fabric or glass grid shall be removed by broadcasting hot mix or sand on the glass grid. Excess sand or hot mix shall be removed before beginning the paving operation. In the event of rainfall prior to the placement of the asphalt overlay, the fabric must be allowed to dry completely before the overlay is placed. Overlay asphalt thickness shall meet the requirements of the contract drawings and documents. The minimum compacted thickness of the first lift of overlay asphalt concrete shall not be less than 40 mm.

2.42 TRAFFIC SIGNS *(cl. 801 of MORT&H)*

2.42.1 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.

2.42.2 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

2.42.2.1 Concrete

Concrete for foundation shall be of M 15 Grade as per Section 1700 of MoRT&H Specifications or the grade shown on the drawings or otherwise as directed by the Engineer.

2.42.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirement of IS: 1786 unless otherwise shown on the drawing.

2.42.2.3 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.

2.42.2.4 Substrate

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

The mechanical proportion of ACM and that of aluminium skin shall conform to the requirements given in Table 800-1, when tested in accordance with the test methods mentioned against each of them.

Table 87 : Specifications for Aluminium Composite Material (ACM) *(Table 800-1 of MORT&H)*

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 Aluminium 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

2.42.2.5 Plate Thickness

Shoulder mounted ground sings with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick with Aluminium and 3 mm thick with Aluminium Composite Material. All other signs be at least 2 mm thick with Aluminium and 4 mm thick with Aluminium Composite Material. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under prevailing wind and other loads.

2.42.3 Traffic Signs having Retro-Reflective Sheeting

2.42.3.1 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.

2.42.3.2 High Intensity Grade Sheeting

2.42.3.2.1 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 of MoRT&H.

Table 88 : Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Grade Sheeting (Type III) (Encapsulated Lens Type) (Candelas Per Lux Per Square Metre) *(Table 800-2 of MORT&H)*

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

A minimum of Coefficient of Retro-reflection (RA) cd/fc/ft^2 (cd-lx-1 m^2).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the Contract or order. When totally wet, the sheeting shall show not less than 90 percent, of the values of retro reflectance indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

2.42.3.3 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 coefficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in Table 800-3 of MoRT&H.

2.42.3.4 Prismatic Grade Sheeting

2.42.3.4.1 Prismatic Grade Sheeting (Type VIM)

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 of MoRT&H.

2.42.3.4.2 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 of MoRT&H.

Table 89 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade Sheeting (Type VIII) (Candelas Per Lux per Square Metre) *(Table 800-4 of MORT&H)*

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

A Minimum Coefficient of Retro reflection (R^A) cd/fc/ft^2 (cd-lx-1m^2).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

Table 90 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade Sheeting (Type IX) (Candelas Per Lux per Square Metre) *(Table 800-5 of MORT &H)*

Obser-vation	Entrance	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow / Green	Fluore-scent Yellow	Fluore-scent Orange
0.1[0B]	-4°	600	500	250	66	130	130	530	400	200
0.1[0B]	+30°	370	280	140	37	74	17	300	220	110
0.2°	-4°	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	-4°	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-4°	80	60	30	8.0	16	3.6	64	48	24
1.0°	+30°	45	34	17	4.5	9.0	2.0	36	27	14

A Minimum Coefficient of Retro reflection (RA) cd/fc/ft^2 (cd-lx-1m^2).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

2.42.3.4.3 Prismatic Grade Sheeting (Type XI)

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 of MoRT&H.

Table 91 : Acceptable Minimum Co-efficient of Retro-Reflection for Prismatic Grade Sheeting Type A (Type XI) (Candelas Per Lux per Square Metre) *(Table 800-6 of MORT&H)*

Obser-vation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluore-scent Yellow/ Green	Fluore-scent Yellow	Fluore-scent Orange
0.1[0B]	-4°	830	620	290	83	125	37	25	660	500	250
0.1[0B]	+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/ft^2 (cd-lx-1m^2).

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

2.42.3.5 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.

2.42.3.6 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.

2.42.3.7 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 coefficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in Tables 800-2 to 800-8 as applicable. Cut-out messages and borders, wherever used, shall be either made out of retro-reflective sheeting or made out of durable transparent overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

2.42.3.8 Colour for Signs

Table 92 : Colour Specified Limits (Daytime) *(Table 800-7 of MORT&H)*

Colour	1		2		3		4		Daytime Luminance Factor (Y%)	
	x	y	x	y	x	y	x	y	Min.	Max.
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	15	-
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	24	45
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	2.5	11
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	2.5	11
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	1	10
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404	12	30
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	1	6
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60	-
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	45	-
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	25	-

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

2.42.3.9 Sizes of Letters

Table 93: Acceptable Limits for Sizes of Letters *(Table 800-8 of MORT&H)*

Design Speed (Km./hr.)	Minimum V 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

Note : 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.

2.43 ROAD MARKINGS *(cl. 803 of MORT&H)*

2.43.1 Scope

The work shall consist of providing road markings of specified width, layout and design using paint of the required specifications as given in the Contract and as per guidelines contained in from IRC:35-1997.

2.43.2 Materials

Road markings shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorised paint or cold applied reflective paint as specified in the item and the material shall meet the requirements as specified in these Specifications.

2.43.3 Ordinary Road Marking Paint

2.43.3.1 Ordinary paint used for road marking shall conform to Grade I as per IS:164.

2.43.3.2 The road marking shall preferably be laid with appropriate road marking machinery.

2.43.4 Hot Applied Thermoplastic Road Marking

2.43.4.1 Thermoplastic Material

2.43.4.1.1 General

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass refiectorizing beads. The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

2.43.4.1.2 Requirements :

Table 94 : Proportions of Constituents of Marking Material (Percentage by Weight) *(Table 800-9 as MORT&H)*

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-30	30-30
Titanium Dioxide	10.0 min.	
Calcium Carbonate and Inert Fillers	42.0 max.	See Note below
Yellow Pigments		See Note below

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

2.43.4.2 Reflectorizing Glass Beads

2.43.4.2.1 General

This Specification covers two types of glass beads to be used for the production of reflectorised pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-9 and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6.4.

2.43.4.2.2 Specific Requirements

a) **Gradation** : The glass beads shall meet the gradation requirements for the two types as given in Table 800-10.

Table 95 : Gradation Requirements for Glass Beads *(Table 800-10 of MORT&H)*

Sieve Size	Percent Retained	
	Type 1	Type 2
1.18 mm	0 t o 3	
850 micron	5 to 20	0 to 5
600 micron		5 to 20
425 micron	65 to 95	
300 micron		30 to 75
180 micron	0-10	10 to 30
Below 180 micron		0 to 15

2.43.4.2.3 Test Methods

The specific requirements shall be tested with the following methods:

i) Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter dessicator which is filled within 25 mm of the top of a dessicator plate with sulphuric acid water solution (specific gravity 1.10). Cover the dessicator and let it stand for 4 hours at 20°C to 29°C. Remove sample from dessicator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.

ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part I).

iii) The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these Specifications. However, if so required, these tests may be carried out as directed by the Engineer.

2.43.4.3 Application Properties of Thermoplastic Material

2.43.4.3.1 The thermoplastic material shall readily get screeded/extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

2.43.4.3.2 The material upon heating to application temperatures shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

2.43.4.4 Preparation

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

ii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

2.43.5 Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirements of Clause 803.4.2.

2.43.6 Application

2.43.6.1 Properties of Finished Road Markings

a) 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.

b) The stripe shall not be slippery when wet.

c) The marking shall not lift from the pavement in freezing weather.

d) After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperatures upto 60°C.

e) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic.

f) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.

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

2.43.7 Cold Applied Reflective Paint

2.43.7.1 Material

2.43.7.1.1 The cold applied paint material shall be homogeneously composed or binder, pigment, extenders and other additives as required for the formulation.

2.43.7.1.2 Composition

The pigments and extenders shall be uniformly dispersed in the binder medium dissolved in organic solvents. The material shall be free from skin, dirt and foreign objects and shall comply with requirements indicated in Table 800-11 of MoRT&H.

Table 96 : Proportions of Constituents or Paints (Percentage by Weight) *(Table 800-11 as MORT&H)*

Component	White	Yellow
Binder	25.0 min.	18.0 min.
Titanium Dioxide	20.0 min.	
Calcium Carbonate and Inert Fillers	16.0 min.	29.0 min.
Yellow Pigments		14.0 min.

2.43.7.1.3 Properties

Non-Volatile Matter content by weight shall be a minimum of 65 percent as determined in accordance with test method ASTM D1644. The liquid paint shall have a density of 1.3 g/cc minimum as determined in accordance with test method ASTM D1475.

2.43.7.1.4 Appearance

Drying Time of the paint as determined by the test method ASTM D711 shall be a maximum of 20 minutes at a wet film thickness of 350 micron. The paint shall set to bear traffic after 40 minutes when the ambient temperature is higher than 24°C. The paint shall not be applied when the surface temperature of the road is higher than 40°C.

2.43.7.1.5 Properties of the Dried Paint Film

When tested using a sand abrasion tester as described in ASTM D968, the quantity of sand required for removal of a 75 micron thick unbeaded dry film shall be greater than 65 litres.

2.43.7.1.6 Minimum Thickness of the Unbeaded Cold Applied Paint Coat

The minimum thickness of the wet unbeaded coat of paint shall not be less than 400 micron, and the minimum thickness of the dry unbeaded coat of paint shall not be less than 200 microns.

2.43.7.1.7 Retro-reflective Properties

The co-efficient of retro-reflection as per British Standards BS EN 1436:1998 shall be as under:

For white paint (Beaded)	-300 mcd/m^2/lux on application
	-100 mcd/m^2/lux after defect liability period of one year
For yellow paint (Beaded)	-200 mcd/m^2/lux on application
	-100 mcd/m^2/lux after defect liability period of one year

The luminous Co-efficient as per British Standards BS EN 1436:1998 shall be as under:

For white paint (Un-beaded)	100 mcd/m^2/lux on application
For yellow paint (Un-beaded)	80 mcd/m^2/lux on application

2.43.7.3 Reflectorising Glass Beads

2.43.7.3.1 Specific Requirements

i) **Gradation:** The glass beads shall meet the gradation requirements as per No. 4 of BS:6088 as given in Table 800-12.

Table 97 : Gradation Requirements for Glass Beads (Table 800-12 of MORT&H)

Sieve Size	Percentage Retained
250 micron	0-10
150 micron	80-100
Below 150 micron	0-20

ii) **Roundness:** The glass beads shall have a minimum of 70 percent true Spheres.

iii) **Refractive Index:** The glass beads shall have a minimum refractive Index of 1.50.

iv) **Free Flowing Properties:** The glass beads shall be free of hard lumps, clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test as given in Clause 803.6.5.4 of MoRT&H.

2.44 ROAD DELINEATORS *(cl. 806 of MORT&H)*

2.44.1 Scope

The work shall cover supplying and fixing roadway indicators, hazard markers and object markers. Roadway indicators shall be properly installed to indicate the horizontal alignment and vertical profile of the roadway so as to outline the vehicle path for safe driving. Hazard markers shall be installed immediately ahead of obstruction of vehicular path such as just before a narrow bridge. Object markers shall be erected where obstruction within the roadway starts such as channelising island in approaches to intersections.

2.44.2 The design, materials to be used and the location of the road delineators (roadway indicators, hazard markers and object markers) shall conform to Recommended Practice for Road Delineators, IRC.79, and to relevant drawings or as otherwise directed by the Engineer. The steel drums such as empty bitumen drums shall not be used as they could pose safety hazards, The delineators shall be retro-reflectorised as shown on the drawings or as directed by the Engineer. The reflectors on the delineators shall be of retro-reflective sheeting with encapsulated lens and with the visibility of 300 m under clear weather conditions, when illuminated by the upper beam of the car headlights.

2.44.3 Installation

The delineators shall be so installed that their posts do not change their orientation and the reflectorised faces are always perpendicular to the direction of travel.

2.45 CRASH BARRIERS *(cl. 811 of MORT&H)*

2.45.1 Concrete Crash Barrier

2.45.1.1 Materials

All materials shall conform to Section 1000 Materials for Structures as applicable, and relevant Clauses in Section 1600 of MoRT&H Specifications shall govern the steel reinforcement.

2.45.1.2 The minimum grade of concrete shall be M25.

2.45.2 Construction Operations

2.45.2.1 The concrete barriers shall be either (i) precast or (ii) constructed by the "cast-in-place with fixed forms" method or the "extrusion or slip form" method or a combination thereof at the Contractor's option with the approval of the Engineer. Where "extrusion or slip form" method is adopted full details of the method and literature shall be furnished.

2.451.2.2 The concrete barrier may be precast in lengths upto 6 m depending upon the feasibility of transport and lifting arrangements. Longitudinal roadside concrete barrier shall be placed on adequate bedding as detailed in the drawing. The top and exposed faces of the barriers shall conform to the specified tolerances, as defined in Clause 810.2.2.3, when tested with 3 m straight edge, laid on the surface.

An expansion joint with pre-moulded asphalt filler board shall be provided at the junctions of crash barrier on structure and crash barrier on the fill. The crash barrier on the fill shall be constructed in pieces of length not exceeding 20 m, with pre-moulded asphalt filler board joints.

Backfilling to the concrete barriers shall be compacted in layers to the compaction of the surrounding earthwork.

2.45.3 Tolerance

The overall horizontal alignment of rails shall not depart from the road alignment by more than ± 30 mm, nor deviate in any two successive lengths from straight by more than 6 mm and the faces shall not vary more than 12 mm from the edge of a 3 m straight edge. Barriers shall be at the specified height as shown in the plans above the edge of the nearest adjacent carriageway or shoulder, within a tolerance of ± 30 mm.

2.45.4 Metal Beam Crash Barrier

2.45.4.1 Materials

2.45.4.1.1 Metal beam rail shall be corrugated sheet steel beams of the class, type, section and thickness indicated on the drawings. Railing posts shall be made of steel of the section, weight and length as shown on the drawings. All complete steel rail elements, terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanized. All elements of the railing shall be free from abrasions, rough or sharp edges and shall not be kinked, twisted or bent.

2.45.4.1.2 The "W" beam type safety barrier shall consist of a steel post and a 3 mm thick "W" beam rail element. The steel post and the blocking out spacer shall both be channel section of 75 mm x150 mm & size 5 mm thick. The rail shall be 70 cm above the ground level and posts shall be spaced 2 m centre-to-centre. Double "W" beam barrier shall be as indicated in IRC:5-1998.

The thrie beam safety barrier shall have posts and spacers similar to the ones mentioned above for "W" beam type. The rail shall be placed at 85 cm above the ground level.

The "W" beam, the thrie beam, the posts, spacers and fasteners for steel barriers shall be galvanized by hot dip process (zinc coated, 0.55 kg per square metre; minimum single spot) unless otherwise specified. The galvanizing on all other steel parts shall conform to the relevant IS Specifications. All fittings (bolts, nuts, washers) shall conform to the IS: 1367 and IS:1364. All galvanizing shall be done after fabrication.

2.45.4.1.3 Concrete for bedding and anchor assembly shall conform to Section 1700 of these Specifications.

2.45.4.2 Construction Operations

2.45.4.2.1 The line and grade of railing shall be true to that shown on the plans. The railing shall be carefully adjusted prior to fixing in place, to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment.

2.45.4.2.2 Unless otherwise specified on the drawing, railing steel posts shall be given one shop coat of paint (primer) and three coats of paint on structural steel after erection, if the sections are not galvanized. Any part of assembly below ground shall be painted with three coats of red lead paint.

2.45.4.2.3 Splices and end connections shall be of the type and designs specified or shown on the plans and shall be of such strength as to develop full design strength of the rail elements.

2.45.4.3 Installation of Posts

2.45.4.3.1 Holes shall be dug or drilled to the depth indicated on the plans or posts may be driven by approved methods and equipment, provided these are erected in proper position and are free from distortion and burring or any other damage.

2.45.4.3.2 All post holes that are dug or drilled shall of such size as will permit proper setting of the posts and allow sufficient room for backfilling and tapping.

2.45.4.3.3 Holes shall be backfilled with selected earth or stable materials in layers not exceeding 100 mm thickness and each layer shall be thoroughly tamped and rammed. When backfilling and tamping are completed, the posts or anchors shall be held securely in place.

2.45.4.3.4 Post holes that are drilled in rock and holes for anchor posts shall be backfilled with concrete.

2.45.4.3.5 Posts for metal beam guardrail on bridges shall be bolted to the structure as detailed on the plans. The anchor bolts shall be set to proper location and elevation with templates and carefully checked.

2.45.4.4 Erection

2.45.4.4.1 Ail guard rail anchors shall be set and attachments made and placed as indicated on the plans or as directed by the Engineer.

2.45.4.4.2 All bolts or clips used for fastening the guardrail or fittings to the posts shall be drawn up tightly. Each bolt shall have sufficient length to extend at least 6 mm through and beyond the full nut, except where such extensions might interfere with or endanger traffic in which case the bolts shall be cut off flush with the nut.

2.45.4.4.3 All railings shall be erected, drawn and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

2.45.4.5 End Treatment for Steel Barrier

2.45.4.5.1 End treatments shall from an integral part of safety barriers which should not spear, vault or roll a vehicle for head-on or angled impacts. The two end treatments recommended for steel barriers are "Turned-down-guardrail" and "Anchored in back slope", as shown on the drawings or as directed by the Engineer.

SPECIFICATION FOR BRIDGE AND CULVERT WORKS

2.46 PILE FOUNDATIONS

2.46.1 Concrete in Piles *(cl. 1104 of MoRT&H)*

For both precast and cast in in-situ piles, the grade of concrete, minimum cement content, water cement ratio and slump at the time of placement shall be as per Table 1100-1 :

Table 98 : Requirements for Concrete in Piles *(Table 1100-1 of MoRT&H)*

	Cast in-situ Concrete by Tremie	Precast Concrete
Grade of concrete	M35	M35
Minimum cement content	400 kg/m³	400 kg/m³
Minimum water cement ratio	0.4	0.40
Slump (mm) as measured at the time of placement	150-200	50-75

The terms 'minimum cement content' and 'minimum water cement' ratio mentioned Table 1100-1, are to be based on total cementitious material (inclusive of all mineral admixtures called additives) mentioned in Clause 1007 of these Specifications. Maximum limits for such additives shall be as specified in Clause 1716.2 of these Specifications.

High alumina cements (i.e. quick setting cement) shall not be used in marine conditions. When both chlorides and sulphates are present, in soil or ground water, sulphate resistant cement shall not be used. For improving resistance against the penetration of chlorides and sulphates from surrounding soils or water, mineral admixtures such as fly ash, silica fumes, GGBS conforming to respective BIS/International Standards and as per IRC: 112, may be used.

2.46.1 TEST PILES *(cl. 1106 of MoRT&H)*

Test piles which are shown on the drawings or specified in the contract or installed by the Contractor on his own to determine the lengths of piles to be furnished, shall conform to the requirements for piling as indicated in these Specifications. Test piles which are used to arrive at the load carrying capacity shall not be incorporated in the structure.

All test piles shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure.

Test piles which are not to be incorporated in the completed structure shall be removed to at least 600 mm below the proposed soffit level of pile cap and the remaining hole so formed shall be backfilled with earth or other suitable material.

The piles shall be load tested in accordance with provisions laid down in this Section.

2.46.2 CAST IN-SITU CONCRETE PILES *(cl. 1107 of MoRT&H)*

2.46.2.1 General

Cast in-situ concrete piles may be either installed by drilling a bore into the ground and removing the material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as "bored piles" and "driven piles" respectively. Cast in-situ concrete piles may be cast in metal shells which may remain permanently in place. However, other types of reinforced concrete cast in-situ piles, cased or uncased, may be used if in the opinion of the Engineer the soil conditions permit their use and if their design and the methods of placing are satisfactory.

Certain specific requirements regarding driving of cast in-situ driven piles shall be as per Clauses 1110 and 1111.

Any liner or borehole which is improperly located or shows partial collapses that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

Boring shall be carried out using rotary equipment. Percussion type of equipment shall be used only if approved by the Engineer.

The diameter of the finished pile shall not be less than that specified. A continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the length of pile that is cast.

Defective piles shall be removed or left in place as judged convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

2.46.2.2 Concreting

Wherever practicable, concrete should be placed in a clean dry hole. Prior to the placing of the reinforcement cage, the pile shaft shall be cleaned of all loose materials. Before concreting of the pile is commenced, it is essential to ensure that no debris remains at the bottom of the shaft, as inadequate cleaning of the base can lead to formation of a soft base or soft toe which may result in reduction of load bearing capacity of the pile.

Reinforcement for the pile as shown on the drawing shall be tied in place to form a cage which is lowered into the pile shaft. Suitable spacers shall be provided to maintain the required cover to reinforcing steel. Reinforcements at the bottom should not be provided with L-bends as these may interfere with cleaning of the pile base.

Where concrete is placed in dry and a casing is present, the top 3 m of the pile shall be compacted using internal vibrators.

Where the casing is withdrawn from cohesive soils for the formation of cast in-situ pile, the concreting should be done with necessary precautions to minimize the softening of the soil by excess water. Where mud flow conditions exist, the casing of cast in-situ piles shall not be allowed to be withdrawn.

Care shall be taken during concreting to prevent the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and while extracting the casing, shall also be avoided.

If the concrete is placed inside precast concrete tubes or consists of precast sections, these shall be free from cracks or other damage before being installed.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils which have the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

The placing of concrete shall be a continuous process from the toe level to the top of the pile. To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6 m (length of pile) per hour.

2.46.2.3 Casing

When concreting is carried out for a pile, a temporary casing should be installed to sufficient depth so as to ensure that fragments of soil from the sides of the hole do not drop into the concrete as it is placed. When the bore hole is stabilized using drilling mud, the temporary casing is not required except near the top.

The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion while driving or when adjacent casings are driven.

Cast in-situ concrete driven piles shall be installed using a properly designed detachable shoe at the bottom of the casing.

Bored cast in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2 m length of top of bore shall invariably be provided with casing to ensure against loose soil falling into the bore. In cases in which the side soil can fall into the hole, it is necessary to stabilize the side of the bore hole with drilling mud, or a suitable steel casing. Permanent steel liner shall be provided at least up to maximum scour level. The minimum thickness of steel liner shall be 6 mm.

Permanent steel liner shall be provided for the full depth of the pile in the following situations where:

i) The surrounding soil is marine clay
ii) Soft soil is present
iii) Surrounding soil has sulphate content equal to or more than 1%
iv) Surrounding water has sulphate content equal to or more than 2500 ppm
v) Leakage of sewage is expected

For bored cast in-situ piles, casing/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the depth shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means.

Where bored cast in-situ piles are used in soils liable to ffow, the bottom of the casing shall be kept sufficiently in advance of the boring tool to prevent the entry of soil into the casing, leading to formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as leak-tight as possible to minimize inflow of water or leakage of slurry during concreting.

The diameter of the boreholes shall not be more than the inside diameter of the liner when the liners are installed before boring. When the liners are installed after boring, the diameter of the boreholes shall not be more than the outside diameter of liner + 2 mm, unless otherwise approved by Engineer.

2.46.2.4 Use of Tremie

The concrete should invariably be poured through a tremie with a funnel, so that the concrete can be properly deposited in the hole without segregation. For concreting done by tremie, the following requirements which are particularly applicable shall be ensured:

a) The hopper and tremie should be a leak proof system.

b) Diameter of tremie shall be not less than 200 mm for use with 20 mm diameter down aggregate.

c) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it or with a steel plate with adequate charge to prevent mixing of concrete and water. However, the plug should not be left in the concrete as a lump.

d) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe. The tremie should be always full of concrete.

e) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent laitance from being entrapped within the pile.

f) All tremie tubes shall be thoroughly cleaned after use.

g) For concrete placed through tremie, there is no need to add 10 percent extra cement.

h) Concreting of piles shall be carried out continuously. In exceptional cases of interruption of concreting the tremie shall not be taken out of the concrete under any circumstances. The tremie pipe shall be raised and lowered slowly from time to time to prevent it from getting stuck in the concrete while ensuring its lower and does not come out of concrete. The concreting shall be resumed before final setting time of concrete, which shall be established before the start of the piling operation. For achieving longer setting time of the concrete, super plasticizers having retarding properties/retarders can be used. If any of these requirements are not met, the pile shall be rejected.

2.46.2.5 Removal of Concrete above Cut-off Level

It is desirable that the concrete above cut-off level, is removed before the concrete is set. This may be done manually or by specially made bailer or other device. Such removal of concrete helps in preventing the damage of the good concrete below the cut-off level, which results from chipping by percussion method.

The removal of concrete shall be within ± 25 mm from the specified cut off level, preferably on the minus side. After removal of such concrete, the concrete shall be compacted with rammer with spikes or vibrated.

In case the concrete is not removed before setting, a groove shall be made on outer perimeter by rotary equipment before chipping by percussion method.

The minimum embedment of cast in-situ concrete piles into pile cap shall not be less than 50 mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from the top of the pile shall be not less than 25 mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully to avoid damaging the rest of the pile.

2.46.3 STEEL PILES *(cl. 1108 of MoRT&H)*

Steel piles shall be of "H" or "I" sections as shown on the drawings and shall be of structural steel conforming to Section 1000 of these Specifications.

Steel piles shall be protected by suitable anti-corrosive painting as specified on the drawing or as directed by the Engineer. Piles shall be stored above the ground having protective packing to minimize damage to surface coating. Each pile shall be supplied preferably in one piece without splices.

At the option of the Contractor, steel piles consisting of structural steel plates welded together may be substituted for the rolled sections specified, provided the depth, width and average thicknesses are at least equal to those of the rolled sections, the steel plates conform to Section 1000 of these Specifications. The flanges shall be welded to the web with continuous fillet welds on either side of the web, and the welding shall conform to Clause 1904.8 of MoRT&H Specifications.

The length of the steel pile may be built up in sections either before or during driving operations. The sections shall be of identical cross-section. Pile splices shall be made with full penetration butt welds over the whole cross-section. Pile splices shall develop at least the yield strength of pile.

The connections shall be made by butt welding the entire cross-section in accordance with the provisions in Clause 1904.8 of these Specifications. Care shall be taken to properly align the sections connected so that the axis of the pile will be straight. The number of welded connections in the length of pile shall be as few as possible.

2.46.4 PILE TESTS *(cl. 1113 of MoRT&H)*

2.46.4.1 Initial Load Test

a) The number of initial tests shall be determined by the Engineer taking into consideration the bore log and soil profile, design length, pile diameter and design pile capacity. However, it shall not be less than two for each category.

b) Initial load test for axial load capacity, including uplift capacity if required, on trial piles of the same diameter as of the design pile, shall be carried out after 28 days design strength is achieved. The testing shall be done as per the procedure laid down in IS:2911, Part-IV. The load test shall be conducted for not less than 21/2 times the design load. The initial load test shall be cyclic load test for piles deriving strength from end bearing and side friction. The maintained load test can be performed for end bearing piles which do not rely on friction and for piles socketed in rock; as initial load test value. The number of initial tests shall be determined by the Engineer taking into consideration the bore log and soil profile.

c) Lateral load tests shall be carried out for estimating the lateral load capacity of the piles. The test procedure shall be carried out as per IS 2911 Part IV. However the permissible deflection shall be as per IRC:78.

d) In particular cases where upper part of pile is likely to be exposed later due to scour, then the capacity contributed by that portion of the pile during load test, shall be accounted for.

e) If the initial load test gives a capacity greater than 25 percent of the capacity calculated by static formula and if it is desired to take benefit of the higher capacity, another two load tests shall be carried out to confirm the earlier value and minimum of the three shall be considered

2.46.4.2 Routine Load Tests

Routine load test shall be carried out at actual locations of foundations of bridges to re-confirm or modify the allowable loads. The lateral load test may be conducted on two adjacent piles. However, results of routine load tests shall not be used for upward revision of design capacity of piles. The minimum number of tests to be conducted for confirming the capacity shall be as per Table 1100-3.

2.46.4.3 Permissible Overload

While conducting routine test on one of the piles belonging to a pile group, if the pile capacity is found to be deficient (based on the settlement criteria of 12 mm for piles of diameter up to and including 600 mm and 2 percent of the pile diameter for piles of diameter more than 600 mm at 1.5 times the design load) an overload up to 10 percent of the capacity may be allowed.

2.46.4.4 For a quick assessment of pile capacity, strain dynamic tests may be conducted after establishing co-relation using the results of load tests. However, results of strain dynamic tests shall not be used for upward revision of design capacity of pile. Detailed guidelines and references are given in IRC:78. These methods can be followed.

To have a fairly good idea about the quality of concrete and construction defects like voids, discontinuities etc., pile integrity tests are extensively conducted. Detailed guidelines in this connection are given in IRC:78.

2.46.5 PILE CAP *(cl. 1114 of MoRT&H)*

Casting of pile cap should be at a level higher than low water level unless functionally required to be below low water level. In such cases dewatering shall be resorted to allow concreting in dry conditions. Pile caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outermost piles in the group. If the pile cap is in contact with earth at the bottom, a leveling course of minimum 80 mm thickness of M 15 nominal mix concrete shall be provided. In marine conditions or areas exposed to the action of harmful chemicals, the pile cap shall be protected with a coating such as bituminous based coal tar epoxy or epoxy based coating or with suitable anti corrosive paint. Concrete with high alumina cement, shall not be used in marine environment.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted three days after casting of pile, while pneumatic tools for chipping shall be permitted only seven days after casting of pile. The top of pile after stripping shall project at least 50 mm into the pile cap.

The top of concrete in a pile shall be brought above cut-off level to permit removal of all laitance and weak concrete before pile cap is laid. This will ensure good concrete at the cutoff level.

2.46.6 IMPORTANT CONSIDERATIONS, INSPECTION / PRECAUTIONS FOR DIFFERENT TYPES OF PILES
(cl. 1115 of MoRT&H)

2.46.6.1 Driven Cast In-Situ Piles

2.46.6.1.1 Specialist literature and the guidelines from the pile construction industry shall be consulted regarding the method of installation, equipment and accessories for pile driving and recording of data.

2.46.6.1.2 During installation of piles, the final "set" of penetration of pile per blow of hammer shall be checked taking an average of last 10 blows.

The pile shoes which may be of either cast iron conical type or mild steel flat type shall have double reams for proper seating of the removable casing tube inside the space between the reams.

2.46.6.1.3 Before commencement of pouring of concrete, it shall be ensured that there is no ingress of water in the casing tube from the bottom. Further, adequate control during withdrawal of the casing tube is essential so as to maintain sufficient head of concrete inside the casing tube at all stages of withdrawal.

2.46.6.1.4 Concrete in piles shall be cast up to a minimum height of 600 mm above the designed top level of pile, which shall be stripped off at the time of construction of pile cap.

2.46.6.2 Bored Cast In-Situ Piles.

2.46.6.2.1 While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete is to be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimize the softening of the soil by excess water. Uncased cast in-situ piles shall not be allowed where mudflow conditions exist.

2.46.6.2.2 The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level throughout the boring process, to ensure the stability of the strata which is being penetrated until the pile has been concreted.

2.46.6.2.3 Where bentonite suspension is used to maintain the stability of the borehole, it is essential that the properties of the material be carefully controlled at stages of mixing, supply to the borehole and immediately before concrete is placed. It is usual to limit:

i) The density of bentonite suspension to 1.05 g/cc
ii) The marsh cone viscosity between 30 and 40
iii) The pH value between 9.5 and 12
iv) The silt content less than 1 percent
v) The liquid limit of bentonite not less than 400 percent

These aspects shall act as controlling factors for preventing contamination of bentonite slurry for clay and silt.

2.46.6.2.4 The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz. after completion of boring and prior to concreting after placing of reinforcement cage. Flushing of bentonite shall be done continuously with fresh bentonite slurry till the consistency of inflowing and outflowing slurry is similar.

2.46.6.2.5 For concreting of piles using tremie, Clause 1107 of MoRT&H Specifications may be referred.

For very long or large diameter piles, use of retarding plasticizer in concrete is desirable.

2.46.6.2.6 For large diameter piles, it may be essential to conduct non-destructive pile integrity tests to evaluate integrity of the pile.

2.46.6.2.7 Where possible, it may be desirable to grout the base of pile with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose, conduit pipes with easily removable plugs at the bottom end, should be placed in the bore along with reinforcement cage before concreting.

2.46.7 TOLERANCES *(cl. 1116 of MoRT&H)*

2.46.7.1 Permissible Tolerances for Piles

(A) Pre-cast Concrete Piles:

o Variation in cross-sectional dimensions	:	± 5 mm
o Variation in length	:	± 25 mm
o Surface irregularities measured with 3 m straight edge	:	5 mm
o Bow for total length in mm	:	1 mm/m length of pile limited to 20 mm

(B) Driven Piles:

o Variation in cross-sectional dimensions	:	+ 50 mm, -10 mm
o Variation from vertical for vertical piles	:	1 in 150
o Variation in the final position of the head in plan	:	75 mm
o Variation of level of lop of piles	:	± 25 mm

(C) Bored Piles:

o Variation in cross-sectional dimensions	:	+ 50 mm, -10 mm
o Variation from vertical for vertical piles	:	1 in 150
o Variation in the final position of the head in plan	:	75 mm
o Variation of level of lop of piles	:	± 25 mm

(D) For raker piles from specified rake	:	1 in 25

2.46.7.2 Permissible Tolerances for Pile Caps

o Variation in dimension	:	+50 mm -10 mm
o Misplacements from specified position in plan	:	15 mm
o Surface irregularities measured with 3 m straight edge	:	5 mm with 3 m straight edge
o Variation of levels at the top of piles	:	± 25 mm

2.47 WELL FOUNDATIONS

2.47.1 GENERAL

2.47.1.1 Wells may have a circular, rectangular or D-shape in plan and may consist of one, two or more compartments in plan.

2.47.1.2 In case of well foundations of size larger than 12 m diameter, supplemental construction specifications will be necessary.

2.47.1.3 The subsurface geotechnical investigations to be carried out before commencement of work of well foundations shall be in accordance with relevant clauses of Section 1900 of MoRT&H Specifications.

2.47.1.4 In case blasting is anticipated for facilitating sinking through difficult strata such as boulders and rock, special protective/strengthening measures for the curb and steining of the well will be required.

2.47.1.5 Pneumatic sinking may have to be resorted to in cases where the well has to be sunk through rock/hard strata or where there are obstacles such as tree trunks, large sized boulders etc., which cannot be removed by open dredging. In such cases, the decision regarding adoption of pneumatic sinking shall be taken on the basis of results of confirmatory bores and as directed by the Engineer.

2.47.2 SETTING OUT AND PREPARATIONS FOR SINKING *(cl. 1203 of MoRT&H)*

2.47.2.1 Necessary reference points shall be accurately fixed to mark x-x axis along the direction of traffic and y-y axis normal to direction of traffic. Such reference points shall be away from the zone of blow-ups or possible settlements which may result from well sinking operations and shall be connected to the permanent stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations. The distances between the wells shall be checked with the help of precision instruments.

2.47.2.2 A temporary benchmark shall be established near the well foundation, away from the zone of blow-ups or possible settlement. The bench mark shall be checked regularly with respect to the permanent bench mark established at the bridge site.

2.47.2.3 For wells located on the banks of the river or in dry area, the bed may be prepared by excavating the soil up to 1.5 m, followed by levelling and dressing before placing the cutting edge.

2.47.2.4 For wells which are to be located in water, a sand island shall be constructed for laying the cutting edge and well curb. Sand islands are practicable for water depths of up to 5 m under stable bed soil conditions. Where the depth of water is greater than 5 m or in fast flowing rivers or for locations where soil is too weak to sustain sand island, floating caissons may have to be adopted.

The plan dimensions of sand islands shall be such as to have a working space of at least 2 m all around the steining of the well. Sand islands shall be maintained to perform their functions, until the well is sunk to a depth below the original bed level at least equal to the depth of water at that location.

The sand island shall be held in position and protected against scour by means of wooden bailies properly braced or sheet piles. The top level of the sand island to be decided by the Engineer, shall be sufficiently above the prevailing water level so that it is not affected by wave action.

2.47.2.5 Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer. Generally, the following equipment may be required for the work:

a) crane with grab buckets - capacity 0.5 cum to 2.0 cum
b) submersible pumps
c) air compressors, air locks and other accessories where pneumatic sinking of well is anticipated
d) chisels of appropriate sizes
e) aqua-header for cutting rocky strata
f) diving helmets and accessories
g) batching plants for concrete production
h) equipment for transportation, placing and compaction of concrete

2.47.3 CUTTING EDGE *(cl. 1204 of MoRT&H)*

2.47.3.1 The cutting edge shall be made from structural steel sections conforming to

2.47.3.2 Section 1900 of these Specifications and shall be strong enough to facilitate sinking of the well through the type of strata expected to be encountered. The weight of the cutting edge shall not be less than 40 kg per metre length. It shall be properly anchored into the well curb as shown on the drawing.

2.47.3.3 When there are two or more compartments in a well, the bottom of the cutting edge of the inner walls shall be kept at about 300 mm above that of outer walls.

2.47.3.4 In V shaped cutting edge, the inclined plate should meet the vertical plate in such a way that full strength connection by welding is feasible.

2.47.3.5 The parts of cutting edge shall be erected on level firm ground about 300 mm above prevalent water level. Temporary supports shall be provided to facilitate fabrication and for maintaining the assembly in true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, "V" cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending, such "V" cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified, shall be fillet welded using single cover plate to ensure the requisite strength of the original section.

2.47.4 WELL CURB *(cl. 1205 of MoRT&H)*

2.47.4.1 The well curb shall be such that it will offer minimum resistance while sinking but will be strong enough to be able to transmit superimposed loads from the steining to the bottom plug. The shape and outline dimensions of the curb shall be as shown in IRC:78. The internal angle of the curb shall be about 30° to 37° depending upon geotechnical data of the strata through which the well is to be sunk.

2.47.4.2 The well curb shall be in reinforced concrete having concrete mix in accordance with Table 1700-2 and Table 1700-3 and with minimum reinforcement of 72 kg/cum excluding bond rods. The steel shall be suitably detailed to prevent spreading and splitting of curb during sinking. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds. Concreting of the well curb shall be done in one continuous operation.

2.47.4.3 Steel formwork for well curb shall be fabricated strictly in conformity with the drawing. The formwork on outer face of curb may be removed within 24 hours after concreting while that on inner face shall be removed only after 72 hours.

In case blasting is anticipated, the inner face of the well curb shall be protected with steel plates of thickness not less than 10 mm up to the top of the well curb. If considered necessary, the inner face of steining may also be protected with steel plates of 6 mm thickness up to a height of 3 m above the top of the well curb or as specified by the Engineer. The curb as well as 3 m height of steining above the curb, shall be provided with additional hoop reinforcement of 10 mm diameter bars at 150 mm spacing. Additional hoop reinforcement shall be provided in the steining for a further height of up to two times the thickness of steining above the plates, so as to avoid cracking which may arise on account of sudden change in the effective section due to curtailment of plate.

2.47.5 FLOATING CAISSONS *(cl. 1206 of MoRT&H)*

2.47.5.1 Floating caissons are generally fabricated at or near the banks on dry land or in dry docks and then towed into position. For floating caissons, a detailed method statement covering fabrication, floating and sinking operations, shall be prepared and furnished to the Engineer. Such statement shall include the total tonnage of steel involved, fabrication and welding specifications, list of materials and plant and a description of operations and manpower required for the work.

2.47.5.2 Floating caissons shall be of structural steel conforming to Section 1900 of these Specifications. The joints of the fabricated structure shall be absolutely leak-tight and shall be checked against leakage before floating and being towed to site. The reinforcement of the curb and steining of the well shall be fixed inside the shell by welding before the caisson is floated. Stability of floating caissons shall be ensured against overturning and capsizing under the action of water current, wave pressure and wind while being towed and kept in position. To maintain the stability of the shell while being floated, it may be provided with ballast in the form of water filling up to required level or filling with small amount of concrete. It shall be ensured that the draught of the floating caisson is always less than the depth of water available, so as to facilitate its smooth hindrance-free movement while being towed.

2.47.5.3 Height of caisson shall be planned to ensure that at any given time, at least one metre of the shell shall be above water level. In case the location is affected by the action of waves, the height shall be suitably increased to avoid water spilling into the caisson. In case the bed has soft soil, the caisson shall be provided with 3 to 5 metres of additional height, as it may sink by itself after grounding in bed. Simultaneous sinking and concreting is required to prevent caisson from tilting. In sandy stratum especially with strong water current, appropriate additional height of caisson is necessary for accommodating local scour.

2.47.5.4 The floating caisson shall be held in position against untoward movement by wire ropes/chains, using winches mounted on stationary suitable platforms/buoys or similar anchoring systems. Anchoring in minimum three directions, shall be provided to prevent unacceptable longitudinal and lateral movement. The anchoring system shall permit small movements in order to facilitate correct positioning of the caisson at the exact location of the well and until the stage when it is just getting grounded. Special care is necessary where variation in water level is frequent, e.g. in tidal zones.

2.47.5.5 After being held in correct position, concreting of the floating caisson shall be commenced. The concrete mixed in batching plants, shall be carried to the floating caisson on barges and placed in position through concrete pumps or tremie. When large volumes of concreting are involved, the batching plant concrete pump, crane etc, may all be mounted on a barge kept in the vicinity of the caisson. As no vibration is possible inside the shell, it shall be ensured that the concrete has a slump of 150 to 200; alternatively, self-compacting concrete can be used. The concrete shall be carefully placed uniformly all around the caisson so that it settles vertically without any tendency to tilt.

2.47.6 WELL STEINING *(cl. 1207 of MoRT&H)*

2.47.6.1 The dimensions, shape, concrete strength and reinforcements of the well steining shall strictly conform to those shown on the drawings. The formwork shall preferably be of M.S. sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

2.47.6.2 The height of the first lift of steining to be cast above the well curb shall not be more than 2 m and subsequent lifts shall not exceed the diameter of the well or the depth of well to be sunk below the bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially. Concreting of steining may be carried out in subsequent lifts of about 2 to 2.5 m. Attempts should be made to minimize the number of construction joints. The concreting layers shall be limited to 450 mm restricting the free fall of concrete to not more than 1.5 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

2.47.6.3 The steining of the well shall be built in one straight line from bottom to top such that if the well is titled, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for alignment. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

2.47.6.4 For measuring the height of steining, it shall be marked with at least 4 gauges, two in traffic direction and two normal to traffic direction, distributed equally on the outer face of the well. The marking shall be in the form of a 100 mm wide strip painted on the steining, with every metre marked in black paint. Marking of the gauges shall be done carefully and accurately with a steel tape, starting with zero at the bottom of the cutting edge. The marking shall be continued upwards as each lift of steining is added.

2.47.6.5 After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Engineer will direct and the Contractor shall execute the remedial measures, if required, before acceptance of the well steining. In case the well is found to be unacceptable even after remedial measures are carried out, then it shall stand rejected.

2.47.7 WELL SINKING *(cl. 1208 of MoRT&H)*

2.47.7.1 General

The well shall be sunk true and vertical through all types of strata. No well shall be permitted to be placed in a pre-dredged hole.

Sinking or loading of the well with kentledge shall be commenced only after the steining has been cured for at least 48 hours or as specified in the drawings.

The well shall be sunk by excavating the material uniformly from inside the dredge hole using cranes with grab buckets of appropriate capacity. Use of water jetting, explosives and divers may be adopted for sinking of wells through difficult strata, with prior approval of the Engineer. Well sinking can also be carried out by jack down method.

Normally dewatering of well should not be permitted as a means for sinking the well. It shall never be resorted to if there is any danger of sand blowing under the well. Dewatering shall however be done when well is to be founded in rock. Pneumatic sinking may have to be resorted to where obstacles such as tree trunks, large sized boulders etc. are met or when there is hard strata which cannot be removed by open dredging. The necessity for adopting pneumatic sinking shall be decided by the Engineer.

Complete history of sinking of each well giving details of concreting, sinking and problems met, if any, shall be maintained in the format given in Appendix VII.

2.47.7.2 Sand Blows in Wells

Dewatering of the well shall not be carried out if sand blows are expected. Any equipment or men working inside the well, shall be brought outside the well as soon as there are any indications of sand blow occurring. Sand blow can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

2.47.7.3 Use of Kentledge for Sinking of Well

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well.

Where tilt has occurred or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

2.47.7.4 Use of Water Jetting

Water jetting can be used to facilitate sinking of wells through clay/hard strata. The decision regarding use of water jetting shall be taken at the design stage itself, based on geotechnical investigations which may be indicating presence of hard, clayey strata. For carrying out water jetting, the required number of steel pipes of 40 to 50 mm diameter shall be embedded in the steining of the well, spaced evenly around its periphery. The bottom of the steel pipe shall taper down to a nozzle exiting in the sloping face of the well curb. The diameter of the nozzle shall be 6 mm. The steel pipe shall be kept about 1 m above the top of each lift of steining, so that it can be extended by means of suitable couplers before the next lift of steining is cast. When the well reaches the hard strata and the need for water jetting arises, the tops of the embedded pipes shall be connected to pumps of required capacity for pumping in water at high pressure. The water jet issuing from the nozzle of the pipe under high pressure, cuts through the hard material and loosens it, permitting the well to sink at a faster rate than would otherwise have been possible. When water jetting is to be adopted, the Contractor shall furnish a method statement for approval of the Engineer covering all aspects of the work including the number, capacity and location of the high pressure pumps and other ancillaries required for executing the work.

2.47.7.5 Use of Jack Down Method

The jack down method of sinking shall be adopted as per requirement or as directed by the Engineer. The first step shall be to install ground anchors outside the periphery of the well. The number, location and depth of ground anchors are decided based on the properties of the surrounding soil to develop the necessary resisting force through skin friction. The drill holes of about 150 mm diameter along with casings shall be taken down to a depth of about 20 m or more below the founding level of the well, depending on requirements of design. After the holes have been drilled to the required depth, prestressing strands of adequate diameter and capacity are cut to the desired length and lowered into the holes. The holes shall then be grouted with cement slurry with non-shrink additive. Once the grouting is completed till the ground level, the casing is removed. The removal of the casing shall be done before the grout sets. In case rock is met with, the anchors shall be socketed into rock.

Heavy duty pressurization girders fabricated of steel, shall be placed over stools resting on the steining of the well, against which the hydraulic jacks connected to the ground anchors, can exert pressure to push the well down. The hydraulic jacks shall be of capacity 500 T or more as per requirement. Before applying pressure from the jacks, 1 m deep sump is created inside the well by dredging. Pressure on different jacks is exerted in such a manner as to neutralize any tendency of the well to tilt. With the use of the jacks and controlled dredging, high rates of sinking can be achieved and the chances of sand blowing can also be reduced.

For use of jack down method of sinking, the Contractor shall furnish a method statement for approval of the Engineer, giving full details of construction of ground anchors, fabrication of pressurizing girder, type, number and capacity of jacks to be used, method of dredging and application of jack down force and all other relevant aspects for proper execution of the work.

2.47.7.6 Use of Explosives

Mild explosive charges may be used as an aid for sinking of the well. All prevalent laws concerning handling, storing and using of explosives shall be strictly followed. All safety precautions shall be taken as per IS:4081 "Safety Code for Blasting and related Drilling Operations", to the extent applicable, whenever blasting is resorted to.

When the likelihood of resorting to blasting is predicted in advance, protection of the bottom portion of the well shall be done as per Clause 1205.4.

Blasting of any sort shall be done only with prior permission and in the presence of the Engineer. Blasting shall not be done before the concrete in the steining has hardened sufficiently and is more than 7 days old.

After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken if required.

If blasting has been done after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 m depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed, except under expert direction and with the permission of the Engineer. The pattern of charges may be suitably arranged with delay detonators so as to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 m and the spacing of holes may normally be kept as 0.5 m to 0.6 m.

There should be no equipment inside the well nor shall there be any worker in the close vicinity of the well at the time of exploding the charges.

If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimised by covering blasting holes with rubber mats before detonating the charge.

2.47.7.7 Use of Divers

Divers may be used for removal of obstructions during sinking, carrying out rock blasting and for inspection. All safety precautions shall be taken as per any acceptable safety code or any statutory regulations in force, when divers carry out work under water in the well.

Only persons trained in diving operations shall be employed after being certified fit for diving by an approved doctor. They shall work under expert supervision. The raising of the diver from the bottom of wells shall be controlled so that decompression rate conforms to the rate as laid down in relevant regulations.

The diving and other equipment shall be of acceptable standard and certified to this effect by an approved independent agency. They shall be well maintained as per requirements for safe use.

Arrangement for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Standby compressor shall be provided to cover the contingency of breakdown of the compressor.

Separate high pressure connection shall be made for use of pneumatic tools. Electric lights where provided shall be at 50 volts (maximum).

2.47.7.8 Use of Pneumatic Sinking

2.47.7.8.1 General

The Engineer shall familiarize himself with particular reference to 'caisson diseases' and working of the medical air-lock. A doctor competent to deal with cases of 'caisson diseases' or other complications arising as a result of working under high pressure, shall be stationed at the construction site when pneumatic sinking is under progress.

The Contractor shall provide complete facilities and ensure strict enforcement of the requirements outlined in these specifications.

Safely provisions as contained in IS:4138 and in these specifications shall be strictly followed.

Pneumatic sinking shall be limited to a depth of 30 m below ground level.

2.47.7.8.2 Man Locks and Shafts

Locks, reducers, and shaft used in connection with caissons shall be of riveted construction throughout. The material used in their manufacture shall be steel plate with thickness not less than 6 mm.

Shafts shall be subjected to hydrostatic or air pressure test so as to ensure leak-tightness at a pressure of at least 0.5 MPa. The pressure at which testing has been done shall be clearly and visibly displayed.

The shaft shall be provided with safe, proper and suitable staircase for its entire length including landing platforms which shall be not more than 6 m apart. Where this is impracticable due to space constraints, suitable ladders along with landing platforms shall be installed. These shall be kept clear and in good condition at all times and shall be constructed, inspected and maintained to the entire satisfaction of the Engineer.

A 1 m wide platform with 1 m high railing shall be provided all round the caisson air locks.

Where 15 or more men are employed, caissons shall have two locks, one of which shall be used as a man-lock.

Locks shall be located so that the lowest part of the bottom door shall not be less than 1 m above the highest water level in the well.

The supply of fresh air to the working chamber shall at all times be sufficient to permit work to be done without any danger or excessive discomfort. All air supply lines shall be fitted with check valves.

A man lock shall be used solely for the compression or decompression of workers and not for the passage of plant and material and shall be maintained in a reasonably clean and sufficiently warm state. However, any hand tool or hand instruments used for the purpose of the work may be carried into the man lock,

Where it is not reasonably practicable to provide a separate man lock for use by workers only, the lock when it is in actual use for compression or decompression of a person, shall be in a reasonably clean and sufficiently warm state and shall not be put simultaneously to any other use.

2.47.7.8.3 Valves

Exhaust valves shall be provided, having risers extending to the upper part of the chamber. These shall be operated, whenever necessary specially after a blast. Precautions shall be taken that men are not allowed to resume work after a blast, until the gas and smoke have cleared.

2.47.7.8.4 Medical Supervision and Certification

Every employee absent from work for 10 or more consecutive days due to illness or any other disability, shall be required to pass the regular physical examination by the doctor before being permitted to return to work.

After a person has been employed continuously in compressed air for a period of 2 months, he shall be re-examined by the doctor and shall not be permitted to work until such re-examination has been made and the report is satisfactory.

No person known to be addicted to the excessive use of intoxicants shall be permitted to work in compressed air.

The doctor shall, at all times, keep a complete and full record of examination made by him, which shall contain dates of examinations, a clear and full description of the persons examined, his age and physical condition at the time of examination and a statement as to the period for which he has been engaged in such work. Records shall be kept at the place where the work is in progress and shall be subject to inspection by authorized officers.

Every man lock shall always have a doctor or a responsible person in attendance. In case the person in charge is not a doctor, he must have positive means of promptly communicating with and securing the services of a competent doctor in case of emergency. Such arrangements shall invariably be subject to the approval of the Engineer.

All cases of compressed-air illness shall be reported and copies of all such reports shall be kept in file at the place of work.

2.47.7.8.5 Lighting

All lighting in compressed air chambers shall be operated only by electricity. Two independent electric lighting systems with independent sources of supply shall be used. These shall be so arranged that the emergency source shall become automatically operative in case of failure of the regularly used source.

The minimum intensity of light on any walkway ladder, stairway, or lower working level shall be one-quarter (1/4) candlepower. In all work places, the lighting shall always be such as to enable workmen to see their way about clearly. All external parts of lighting fixtures and electrical equipment lying within 2.5 m above the floor shall be constructed of non-combustible, non-absorbing insulating materials. If metal is used, it must be effectively earthed. Portable lamp shall have non-combustible, non-absorbing insulating sockets, approved handles, basket guards and approved cables. The use of worn out or defective portable and pendant conductors is prohibited.

2.47.7.8.6 Safety Against Fire Hazard

No oil, gasoline, or other combustible material shall be stored within 30 m of any shaft, caisson or tunnel opening. It shall be positively ensured that leaking flammable liquids do not flow into such areas. Oil may be stored in suitable tanks in isolated fireproof buildings, which are not less than 15m away from any shaft, caisson, or tunnel opening or any building directly connected thereto.

Where feasible, a fire hose connected to a suitable source of water shall be provided at the top of every caisson. Where fire mains are not accessible, water shall be stored in tanks near the top of every caisson, provided fire pails or suitable pumps are kept available. Approved fire extinguishers shall also be provided.

2.47.7.8.7 Sanitation

Properly heated, lighted and ventilated dressing rooms shall be provided for all employees engaged in compressed air work. Such rooms shall contain lockers and benches and be open and accessible to person during intermissions between shifts. Adequate toilet accommodation of one for every twenty five employees shall be provided.
Care shall be taken to keep all parts of the caissons and other working compartments, including locker rooms, dry rooms, rest rooms and other equipment in good sanitary condition and free from refuse, decaying or other objectionable matter.

Smoking shall be strictly prohibited and matches and smoking materials shall not be allowed to be brought into the locker rooms.

A separate dry room shall be provided where working clothes may be dried in a reasonable time.

2.47.7.8.8 Protection Against Gases

In all cases where release of gas is expected as in the case of sinking through alluvium impregnated with decayed vegetable matter, the use of Davy Safety Lamp shall be compulsory.

2.47.7.8.9 Additional Safety Provisions

a) The weight of the pneumatic platform and that of steining and kentlege, if any, shall be sufficient to resist the uplift from air inside, skin friction being neglected in this case. If at any section, the total weight acting downwards is less than the uplift pressure of air inside, additional kentledge shall be placed on the well.

   If it is not possible to make the well heavy enough during excavation, "blowing down" may be used. The men should be withdrawn and air pressure reduced. The well should then begin to move with small reduction in air pressure. "Blowing down" should only be used when the ground is such that it will not heave up inside the chamber when the pressure is reduced. When the well does not move with the reduction in air pressure, kentledge should be added. "Blowing down" should be in short stages and the drop should not exceed, 0.5 m at any stage. To control sinking during blowing down, use of packing is recommended.

b) The pneumatic sinking plant and other allied machinery shall not only be of proper design and make, but also shall be operated by competent and well trained personnel. Every part of the machinery and its fixtures shall be minutely examined before installation and use. Availability of appropriate spares, standbys, safety of personnel as recommended in IS:4138 for working in compressed air must be ensured at site. Codes for safety and for working in compressed air and other labour laws and practices prevalent in the country, as specified to provide safe, efficient and expeditious sinking shall be followed.

c) Inflammable materials shall not be taken into air locks and smoking shall be prohibited. Wherever gases are suspected to be issuing out of dredge hole, the same shall be analysed by trained personnel and necessary precautions adopted to avoid hazard to life and equipment.

d) Where blasting is resorted to, it shall be carefully controlled and all required precautions shall be observed. Workers shall be allowed inside after blasting only when a competent and qualified person has examined the chamber and steining thoroughly and found the same to be safe.

2.47.7.9 Precautions During Sinking

a) When wells have to be sunk close to each other and clear distance between them is less than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately so that the sinking proceeds uniformly. Simultaneous and even dredging shall be carried out in the wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Plugging of all the wells shall be done together.

b) During sinking of double D-shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally.

c) Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

d) Before seasonal floods, all wells on which sinking is in progress shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods.

e) All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

f) The dredged material shall not be allowed to accumulate around the well. It shall be dumped and spread, as far away as possible, and then continuously and simultaneously removed, as directed by the Engineer. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

g) Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter/least lateral dimension of the well in plan. Normally the depth of sump shall not exceed 3.0 m below the level of the cutting edge unless otherwise specially permitted by the Engineer.

h) In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

i) In pneumatic sinking, the well shall not, at any time, be dropped to a depth greater than 500 mm by the method of "blowing down".

j) Dewatering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand-blow.

k) Sand blowing in wells can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

l) In soft strata prone to settlement/creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment, has been completed.

2.47.7.10 Tilts and Shifts

Unless otherwise specified, the tilt of any well i.e. its inclination from the vertical, shall not exceed 1 (horizontal) in 80 (vertical). The shift of the well i.e. the horizontal displacement of the centre of the well at the founding level from its theoretical position, shall not be more than 150 mm in any resultant direction.

Tilts and shifts shall be carefully checked and recorded regularly during sinking operations in the format given in Appendix - VIII. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points.

Whenever any tilt is noticed, adequate corrective measures like placing eccentric kentledge, pulling, strutting, anchoring or depositing more dredged material outside the tilted face, water/air jetting, shall be adopted before any further sinking. After correction, the dredged material shall be removed and disposed of sufficiently away from the affected well. In case of sinking by jack down method tilt can be controlled by suitably adjusting jack down pressure on one side.

A pair of wells close to each other have a tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent such movement.

Tilts occurring in a well during sinking in dipping rocky strata can be controlled by suitably supporting the curb.

In the event of a well developing tilt or shift beyond the specified permissible values, the Contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Engineer, to bring the tilt and shift within permissible values.

If the resultant tilt and shift of any well exceeds 1 in 80 or 150 mm respectively the well so sunk shall be regarded as not conforming to specification and classified as substandard work. The Engineer in his sole discretion, may consider accepting such a well, provided:

i) Calculations for foundation pressures and steining stresses, accounting for the actual tilt and shift furnished by the Contractor show that the well is safe, remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap etc.), shall be carried out by the Contractor at his own cost.

ii) The Contractor shall be subjected to reduction in rates as a penalty in accordance with Clause 1215(g).

In case the Engineer, in his discretion, rejects the well, the Contractor shall dismantle the rejected well to the extent directed by the Engineer and remove the debris. Further, the Contractor shall at his own risk and cost, complete the bridge with modified span arrangement acceptable to the Engineer.

2.47.7.11 Seating of Wells

The well shall be uniformly seated on the founding strata. It shall be ensured by test borings that the properties of the soil encountered at the founding level and up to a depth of one and a half times the well diameter, is identical to that adopted in the design. The procedure for test boring shall be in accordance with the provisions of these Specifications. In case the soil encountered is inferior to that adopted in design, the well shall be re-designed by the Engineer adopting the soil properties actually encountered and the founding level intimated to the Contractor, who shall carry out the work accordingly.

In case of seating of wells in hard rocky strata, where the rock profile is steeply sloping, pneumatic methods of sinking may be adopted to seat the well evenly as directed by the Engineer. The decision of adopting pneumatic sinking shall be taken by the Engineer. The cutting edge may also be embedded for a suitable depth in the rocky strata, as decided by the Engineer keeping in view the quality of rock. A sump of depth 300 mm in hard rock or 600 mm in ordinary rock shall be made inside the well by chiselling or blasting as approved by Engineer. Diameter of sump shall be 1.5 m to 2 m less than that of the dredge hole. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid.

2.47.8 BOTTOM PLUG *(cl. 1209 of MoRT&H)*

A bottom plug of concrete shall be provided in all wells, the top level of which shall be kept a minimum of 300 mm above the top of the curb, as shown in IRC78. A suitable sump shall be made below the level of the cutting edge. Before concreting the bottom plug, it shall be ensured that the inside faces of curb and steining have been cleaned thoroughly.

The concrete mix used in bottom plug shall have a minimum cement content of 330 kg per cu.m with a slump about 150 mm, to permit easy flow of concrete through tremie to fill up all cavities. Concrete shall be laid in one continuous operation till the dredge hole is filled to the required height. For under water concreting, the concrete shall be placed by tremie under still water condition and the minimum cement content shall not be less than 330 kg/m3 inclusive of all mineral admixtures, if added.

In case of grouted concrete, the grout mix shall not be leaner than 1:2. It shall be ensured that the grout fills up all interstices upto the top of the bottom plug by suitable means such as, controlling the rate of pumping etc.

Any dewatering required, shall only be done 7 days after casting of bottom plug.

The concrete production and placement equipment should be sufficient to enable under water concreting within stipulated time. Necessary standby equipment should be available for emergency situation.

Before commencing plugging, all loose material from the bottom of the well shall be removed. Concreting shall be done in one continuous operation till the dredge hole is filled up to the required height and thereafter soundings shall be taken to ensure that the concrete has been laid to the required height. Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug. The concrete after placing, shall not be disturbed in any way for at least 7 days.

In order to check whether there is any rise in the level of the bottom plug, soundings should be taken at the close of concreting and once every day for the next 3 days.

The soundness of the bottom plug may be tested by dewatering the well to a level 5 m below the surrounding water level and checking the rise of water. For foundation subjected to artesian pressure, the depth of dewatering by 5 m shall be measured form the still water level created inside the well by the construction of false steining. The rate of rise shall preferably be less than 10 cm per hour. In case the rate is higher, suitable remedial measures as directed by the Engineer, shall be taken by the Contractor at his own cost.

2.47.9 SAND FILLING *(cl. 1210 of MoRT&H)*

Sand filling shall commence 7 days after laying of bottom plug. The level of the top of the bottom plug shall be verified before starting sand filling.

The sand shall be clean and free from earth, clay clods, roots, boulders, shingles, etc. and shall be compacted as directed. Sand filling shall be carried out up to the level shown on the drawing or as directed by the Engineer.

2.47.10 TOP PLUG *(cl. 1211 of MoRT&H)*

After filling sand up to the required level, a top plug of 300 mm thick concrete of grade M 15, shall be provided over it as shown on the drawing or as directed by the Engineer.

2.47.11 WELL CAP *(cl. 1212 of MoRT&H)*

A reinforced cement concrete well cap will be provided over the top of the steining in accordance with the drawing. Formwork will be prepared conforming to the shape of well cap. In case sand filling has been carried out up to the top of the well, the concrete of the well cap may be laid directly on it after it has been suitably levelled. Otherwise, suitable shuttering supported on the inside of the steining, shall be provided for carrying the weight of the green concrete of the well cap.

Concreting shall be carried out in dry condition. A properly designed false steining may be provided where required, to ensure that the well cap is laid in dry condition.

The bottom of the well cap shall be laid preferably as low as possible but above the LWL in the active channel. Where the bed level is higher than the LWL, the top of the well cap may be suitably raised and kept 1m below existing ground level.

Bond rods of steining shall be anchored into the well cap.

2.47.12 TOLERANCES *(cl. 1213 of MoRT&H)*

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150 mm in any resultant direction.

For the well steining and well cap, the permissible tolerances shall be as follows:

a)	Variation in dimension	:	+50 mm, -10 mm
b)	Misplacement from specified	:	15 mm position in plan
c)	Surface unevenness measured with	:	5 mm 3 m straight edge
d)	Variation of level at the top	:	± 25 mm

2.48 FORMWORK

2.48.1 MATERIALS *(cl. 1502 of MoRT&H)*

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

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

2.48.2 DESIGN OF FORMWORK *(cl. 1503 of MoRT&H)*

a) The design, erection and removal of formwork shall conform to IRC:87 "Guidelines for Formwork, False work and Temporary Structures" and these specifications. The forms shall be such as to ensure that they can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of formwork for inspection.

b) The Contractor shall furnish the design and drawing of complete formwork (i.e. the forms as well as their supports) for approval of the Engineer before any erection is taken up. If proprietary system of formwork is used, the Contractor shall furnish detailed information as per Appendix 1500/1, to the Engineer for approval.

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

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

2.48.3 WORKMANSHIP *(cl. 1504 of MoRT&H)*

2.48.3.1 The formwork shall be robust and strong and the joints shall be leak-proof. Ballies shall not be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Staging shall be provided with an appropriately designed base plate resting on firm strata.

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

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

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

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

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

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

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

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

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

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

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

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

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

2.48.4 LINING OF FORMWORK *(cl. 1505of MoRT&H)*

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

2.48.5 PRECAUTIONS *(cl. 1506 of MoRT&H)*

The following precautions shall be observed:

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

ii) Provision for safe access to the formwork shall be made at all levels as required.

iii) Close watch shall be maintained to check for settlement of formwork during concreting and any settlement shall be promptly rectified.

iv) Natural ground shall be checked for bearing capacity and likely settlement before erection of the staging.

v) It shall be ensured that water used for curing or rain water does not stagnate near the base plate of the staging.

vi) For shutters used for deep and narrow member, temporary openings in the sides shall be provided to facilitate pouring and compaction of concrete.

2.48.6 PREPARATION OF FORMWORK BEFORE CONCRETING *(cl. 1507 of MoRT&H)*

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

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

a) The contact surfaces of the forms shall be cleaned carefully and dried before applying a release agent.

b) It should be ensured that the release agent is appropriate to the surface to be coated. The same type and make of release agent shall be used throughout on similar formwork materials and different types should not be mixed.

c) The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess wiped out.

d) It shall be ensured that the reinforcement or the surface of the hardened concrete shall not come in contact with the release agent.

All forms shall be thoroughly cleaned immediately before concreting.

The Contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and

approve the formwork. However, such inspection shall not relieve the contractor of his responsibility for safety of formwork, men, machinery, materials and finish or tolerances of concrete.

2.48.7 REMOVAL OF FORMWORK *(cl. 1508of MoRT&H)*

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

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

Form work shall not be released unless the concrete has achieved strength of at least twice the stress the concrete may be subjected at the time of the removal of formwork. When no test is conducted for determination of strength of concrete and where the time of removal of formwork is not specified, the same shall be as under:

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

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

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

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

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

2.48.8 RE-USE OF FORMWORK *(cl. 1509 of MoRT&H)*

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

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

2.48.9 SPECIALISED FORMWORK *(cl. 1510 of MoRT&H)*

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

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

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

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

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

2.49 STEEL REINFORCEMENT

2.49.1 GENERAL

Steel for reinforcement shall meet the requirements of Section 1000 of MoRT&H Specifications.

Reinforcements may be either mild steel or high strength deformed bars. They may be uncoated or coated with epoxy.

2.49.2 PROTECTION OF REINFORCEMENT *(cl. 1603 of MoRT&H)*

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or by thoroughly cleaning it using any suitable method such as sand blasting, mechanical wire brushing etc., as directed by the Engineer. Reinforcements shall be stored above the ground in a clean and dry condition, on blocks, racks or platforms and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete, shall be protected within one week after initial placing of concrete, with a brush coat of neat cement mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

In case of fusion bonded epoxy coated reinforcement or hot dipped galvanized bars used, reference shall be made Clause 1010.3.2 of Section 1000 of these specifications.

2.49.3 BENDING OF REINFORCEMENT *(cl. 1604 of MoRT&H)*

Bar bending schedule shall be furnished by the Contractor and got approved by the Engineer before start of work.

Reinforcing steel shall conform to the dimensions and shapes given in the approved Bar Bending Schedules.

Bars shall be bent cold to the specified shape and dimensions or as directed by the Engineer using a proper bar bender, operated by hand or power to obtain the correct shape and radii of bends.

Bars shall not be bent or straightened in a manner that will damage the parent material or the coating.

Bars bent during transport or handling shall be straightened before being used on work. They shall not be heated to facilitate straightening.

2.49.4 PLACING OF REINFORCEMENT *(cl. 1605 of MoRT&H)*

a) The reinforcement cage should generally be fabricated in the yard at ground level and then shifted and placed in position. The reinforcement shall be placed strictly in accordance with the drawings and shall be assembled in position only when the structure is otherwise ready for placing of concrete. Prolonged time gap between assembling of reinforcement and casting of concrete, which may result in rust formation on the surface of the bars, shall not be permitted.

b) Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS:280 to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1 mm.

c) Bars shall be kept in position usually by the following methods:

   i) In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover, shall be placed between the bars and formwork, subject to satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided they have the same strength and specification as those of the member.

   ii) In case of dowels for columns and walls, the vertical reinforcement shall be kept in position by means of timber templates with slots cut in them accurately, or with cover blocks tied to the reinforcement. Timber templates shall be removed after the concreting has progressed upto a level just below their location.

iii) Layers of reinforcements shall be separated by spacer bars at approximately one metre intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be allowed to sag between supports.

iv) Necessary stays, blocks, metal chairs, spacers, metal hangers, supporting wires etc. or other subsidiary reinforcement shall be provided to fix the reinforcement firmly in its correct position.

v) Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc., as devices for positioning reinforcement shall not be permitted.

d) Bars coated with epoxy shall be placed on supports that do not damage the coating. Supports shall be installed in a manner such that planes of weakness are not created in hardened concrete. The coated reinforcing steel shall be held in place by use of plastic or plastic coated binding wires especially manufactured for the purpose. Refer Section 1000 of these Specifications for other requirements.

e) Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concreting is commenced.

2.49.5 BAR SPLICES *(cl. 1606 of MoRT&H)*

2.49.5.1 Lapping

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing, shall be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other, and shall be kept apart by 25 mm or 1.25 times the maximum size of coarse aggregate, whichever is greater. If this is not feasible, overlapping bars shall be bound with annealed steel binding wire not less than 1 mm diameter and twisted tight in such a manner as to maintain minimum clear cover to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points along the span where stresses are low.

2.49.5.2 Welding

2.49.5.2.1 Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or greater than that of the bars connected.

2.49.5.2.2 While welding may be permitted for mild steel reinforcing bars conforming to IS:432, welding of deformed bars conforming to IS: 1786 shall in general be prohibited. Welding may be permitted in case of bars of other than Fe 240 grade including special welding grade of Fe 415 grade bars conforming to IS: 1786, for which necessary chemical analysis has been secured and the carbon equivalent (CE) calculated from "the chemical composition using the formula :

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mg+V}{5} + \frac{Ni+Cu}{15}$$

is 0.4 or less.

2.49.5.2.3 The method of welding shall conform to IS:2751 and IS:9417, any supplemental specifications and Clause 1904.8 of these Specifications to the satisfaction of the Engineer.

Welding may be carried out by metal arc welding process. Oxy-acetelene welding shall not be permissible. Any other process may be used subject to the approval of the Engineer and necessary additional requirements to ensure satisfactory joint performance. Precautions on overheating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.

All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm) which may be lap welded. Single-V or Double-V butt joints may generally be used. For vertical bars single bevel or double bevel joints may be used.

Welded joints shall be located well away from bends and shall be not less than twice the bar diameter away from a bend.

Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, process, consumables, operators and welding procedure, are adequate to produce and maintain uniform quality at par with that attainable in shop welding, to the satisfaction of the Engineer.

Joint welding procedures which are to be employed shall invariably be established by a procedure specification. All welders and welding operators to be employed shall be qualified by tests prescribed in IS:2751. Inspection of welds shall conform to IS:822 and destructive or non-destructive testing may be undertaken when deemed necessary. Joints with weld defects detected by visual inspection or dimensional check inspection, shall not be accepted.

Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in two or three stages, the surface shall be cleaned properly after each stage. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Only competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars.

M.S. electrodes used for welding shall conform to IS:814.

2.49.5.2.4 Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum permissible stresses and welds so staggered that at any one section, not more than 20 percent of the bars are welded.

2.49.5.2.5 Specimens of welded pieces of reinforcement taken from the site, shall be tested. The number and frequency of tests shall be as directed by the Engineer.

2.49.5.3 Mechanical Couplers and Anchorages

2.49.5.3.1 Mechanical Couplers

Bars may be joined with approved patented mechanical devices as indicated on the drawing or as approved by the Engineer e.g. by special grade steel sleeves swaged on to bars in end to end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 percent of the characteristic strength of the reinforcement bar.

2.49.5.3.2 Anchorages

Bars may be anchored with approved patented mechanical anchorages as indicated on the drawing or as approved by the Engineer. The anchorages shall be connected to the reinforcing bar by the use of taper thread system. The anchorage shall be capable of developing the characteristic strength of reinforcement without damage to concrete and shall have sufficient diameter and width to develop adequate shear cone strength. The connection shall develop 125% of the characteristic strength of reinforcement bar.

2.50 STRUCTURAL CONCRETE

2.50.1 GRADES OF CONCRETE *(cl. 1703 of MoRT&H)*

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

Table 99 : Grades of Concrete *(Table 1700-1 of MoRT&H)*

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

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

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

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

Table 100 : Requirement of Concrete for Different Exposure Condition using 20 mm Aggregate *(Table 1700-2 of MoRT&H)*

Exposure Condition	Maximum Water Cement Ratio	Minimum Cement Content, kg/m³	Minimum Grade of Concrete
Moderate	0.45	340	M25
Severe	0.45	360	M30
Very Severe	0.40	380	M40

Note :

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

Cement content shown in the above table shall be increased by 40 kg/m3 for use of 12.50 mm nominal size aggregates and decreased by 30 kg/m3 for use of 40 mm nominal size aggregates.

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

2.50.2 Requirements of Consistency

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

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

Table 101 : Requirements of Consistency *(Table 1700-4 of MoRT&H)*

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

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

2.50.3 Requirements for Design Mixes

2.50.3.1 Target Mean Strength

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

i) The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.

ii) Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Table 1700-5 of MoRT&H

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

2.50.3.2 Trial Mixes

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

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

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

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

2.50.3.3 Control of Strength of Design Mixes

a) Adjustment to Mix Proportions

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

b) Change of Current Margin

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

c) Additional Trial Mixes

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

2.50.4 Requirements of Nominal Mix Concrete

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

Table 102 : Requirements for Nominal Mix Concrete *(Table 1700-6 of MoRT&H)*

Concrete Grade	Total Quantity of Dry Aggregate by Mass per 50 kg of Cement to be taken as the Sum of Individual Masses of Fine and Coarse Aggregates (kg)	Proportion of Fine to Coarse Aggregate (by Mass)	Maximum Quantity of Water for 50 kg of Cement (Litres)	
			PCC	RCC
M 15	350	Generally 1:2, subject to upper limit 1:1.5 and lower limit of 1:2.5	25	
M20	250		25	22

2.50.5 Grading of Aggregates for Pumped Concrete

Materials for pumped concrete shall be batched consistently and uniformly. Maximum size of aggregate shall not exceed one-third of the internal diameter of the pipe.

The grading of aggregates shall be continuous and shall have sufficient ultra-fine materials (material finer than 0.25 mm). Proportion of fine aggregates passing through 0.25 mm shall be between 15 and 30 percent and that passing through 0.125 mm sieve shall not be less than 5 percent of the total volume of aggregate. Admixtures to increase workability can be added. When pumping long distances and in hot weather, set-retarding admixtures can be used. Fluid mixes can be pumped satisfactorily after adding plasticisers and super plaslicisers. Suitability of concrete shall be verified by trial mixes and by performing pumping test.

2.50.6 ADMIXTURES *(cl. 1705 of MoRT&H)*

2.50.6.1 Chemical Admixtures

Chemical admixtures such as superplasticisers, or air entraining, water reducing, accelerating and retarding agents for concrete, may be used with the approval of the Engineer.

As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of their products only after obtaining complete information of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the work. Admixtures/additives conforming to IS:9103 may be used subject to approval of the Engineer. However, admixtures/additives generating hydrogen or nitrogen and containing chlorides, nitrates, sulphides, sulphates or any other material likely to adversely affect the steel or concrete, shall not be permitted.

The general requirements for admixtures are given in Clause 1007 of these Specifications.

Compatibility of the admixtures with the cement and any other pozzolona or hydraulic addition shall be ensured by for avoiding the following problems

i) Requirement of large dosage of superplasticiser for achieving the desired workability,
ii) Excessive retardation of setting,
iii) Excessive entrainment of large air bubbles,
iv) Unusually rapid stiffening of concrete,
v) Rapid loss of slump
vi) Excessive segregation and bleeding.

2.50.6.2 Mineral Admixtures

For use of mineral admixtures, refer Clauses 1714.1 and 1715.2.

2.50.7 SIZE OF COARSE AGGREGATES *(cl. 1706 of MoRT&H)*

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be as given in Table 1700-7.

Table 103 : Maximum Nominal Size of Coarse Aggregates *(Table 1700-7 of MoRT&H)*

Components	Maximum Nominal Size of Coarse Aggregate (mm)
I) RCC well curb	20
ii) RCC/PCC well steining	40
iii) Well cap or Pile Cap Solid type piers and abutments	40
iv) RCC work in girder, slabs wearing coat, kerb, approach slab, hollow piers and abutments, pier/abutment caps, piles	20
v) PSC Work	20
vi) Any other item	As specified by the Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values :

a) 10 mm less than the minimum lateral clear distance between individual reinforcements

b) 10 mm less than the minimum clear cover to the reinforcement

c) One quarter of minimum thickness of member

The proportions of the various individual sizes of aggregates shall be so adjusted that the grading produces the densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

2.50.8 EQUIPMENT *(cl. 1707 of MoRT&H)*

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under:

a) Production of Concrete :

i) For overall bridge length of less than 200 m - batch type concrete mixer, diesel or electric operated, with a minimum size of 200 litres automatic water measuring system and integral weigher (hydraulic/pneumatic type).

ii) For overall bridge length of 200 m or more - concrete batching and mixing plant fully automatic, with minimum capacity of 15 cum per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be checked over the range in use, when set up at each site and thereafter, periodically as directed by the Engineer.

The accuracy of the measuring devices shall fail within the following limits :

Measurement of Cement	± 3 percent of the quantity of cement in each batch
Measurement of Water	± 3 percent of the quantity of water in each batch
Measurement of Aggregate	±3 percent of the quantity of aggregate in each batch
Measurement of Admixture	± 3 percent of the quantity of admixture in each batch

b) Transportation of Concrete:

i)	Concrete dumpers	minimum 2 tonnes capacity
ii)	Powered hoists	minimum 0.5 tonne capacity
iii)	Chutes	
iv)	Buckets handled by cranes	
v)	Transit truck mixer	
vi)	Concrete pump	
vii)	Concrete distributor booms	
viii)	Belt conveyor	
ix)	Cranes with skips	
x)	Tremies	

c) For Compaction of Concrete :

i)	Internal vibrators	size 25 mm to 70 mm
ii)	Form vibrators	minimum 500 watts
iii)	Screed vibrators	full width of carriageway (upto two lanes)

2.50.9 BATCHING, MIXING, TRANSPORTING, PLACING AND COMPACTION *(cl. 1708 of MoRT&H)*

2.50.9.1 General

Prior to start of concreting, the Contractor shall submit for approval of the Engineer, his programme along with list of equipment proposed to be used by him for batching, mixing, transporting and placing concrete.

2.50.9.2 Batching of Concrete

In batching concrete:

- The quantity of cement, aggregate and mineral admixtures, if used, shall be determined by mass.
- Chemical admixtures, if solid, shall be determined by mass.
- Liquid admixtures may be measured in volume or mass, and
- Water shall be weighed or measured by volume in a calibrated tank.

The concrete shall be sourced from on-site or off-site batching and mixing plants, or from approved Ready Mixed Concrete plants, preferably having quality certification.

Except where supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock piles. The materials should be stock piled several hours, preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible to ensure that the specified grading is maintained.

The water/cement ratio shall always be maintained constant at its correct value. To this end, determination of moisture content in both fine and coarse aggregates shall be made as frequently as possible, depending on weather conditions. The amount of added water shall be adjusted to compensate for any observed variations in the moisture content. To allow for the variation in mass of aggregate due to variation in moisture content, suitable adjustment in the mass of aggregate, shall also be made. Accurate control shall be kept on the quantity of mixing water, which when specified, shall not be changed without approval.

2.50.9.3 Mixing Concrete

2.50.9.3.1 Mixing at Site

All concrete shall be machine mixed. In order to ensure uniformity and good quality of concrete the ingredients shall be mixed in a power driven batch mixer with hopper and suitable weigh batching arrangement or in a central mix plant. Hand mixing shall not be permitted. The mixer or the plant shall be at an approved location considering the properties of the mixes and the transportation arrangements available with the Contractor. The mixer or the plant shall be approved by the Engineer.

Mixing shall be continued till materials are uniformly distributed, a uniform colour of the entire mass is obtained and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement. In no case shall mixing be done for less than 2 minutes. It shall be ensured that the mixers are not loaded above their rated capacities and are operated at a speed recommended by the manufacturer. When mineral admixtures are added at the mixing stage, their thorough and uniform blending with cement shall be ensured, if necessary by longer mixing time. The addition of water after the completion of the initial mixing operation, shall not be permitted.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch and also before changing from one type of cement to another.

2.50.9.3.2 Ready Mix Concrete

Use of ready mix concrete proportioned and mixed off the project site and delivered to site in a freshly mixed and unhardened state conforming to IS:4926, shall be allowed with the approval of the Engineer.

2.50.9.4 Transporting Concrete

Mixed concrete shall be transported from the place of mixing to the place of final deposit as rapidly as possible by methods which will prevent the segregation or loss of the ingredients. The method of transporting or placing of concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position so that no contamination, segregation or loss of its constituents materials take place.

Concrete may be transported by transit mixers or properly designed buckets or by pumping. Transit mixers or other hauling equipment when used should be equipped with the means of discharge of concrete without segregation. During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to be reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

In case concrete is to be transported by pumping, the fresh concrete should have adequate fluidity and cohesiveness to be pumpable. Proper concrete mix proportioning and initial trials should ensure this. The conduit shall be primed by pumping a batch of mortar through the line to lubricate it. Once the pumping is started, it shall not be interrupted, as concrete standing idle in the line is liable to cause plug. The operator shall ensure that some concrete is always there in the pump's receiving hopper during operation. The lines shall always be maintained clean and free of dents.

Pipelines from the pump to the placing area shall be laid with minimum bends. For large quantity placements, standby pumps shall be available. Suitable air release valves, shutoff valves etc. shall be provided as per site requirements. The pumping of priming mix i.e. rich mix of creamy consistency, to lubricate the concrete pump and pipelines, shall precede the pumping of concrete. Continuous pumping shall be done to the extent possible. After concreting, the pipelines and accessories shall be cleaned immediately. The pipes for pumping shall not be made of material which has adverse effect on concrete. Aluminium alloy pipelines shall not be used.

2.50.9.5 Placing of Concrete

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained. If concreting is not started within 24 hours of the approval being given, the approval shall have to be obtained again from the Engineer. Concreting shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes, unless a proper construction joint is formed.

The concrete shall be deposited as nearly as practicable in its original position to avoid re-handling. Methods of placing should be such as to preclude segregation. Care should be taken to avoid displacement of reinforcement or movement of formwork. To achieve this, concrete should be lowered vertically in the form and horizontal movement of concrete inside the forms should, as far as practicable, be minimised.

The concrete shall be placed and compacted before its initial setting so that it is amenable to compaction by vibration. The workability of concrete at the time of placement shall be adequate for the compaction equipment to be used. If there is considerable time gap between mixing and placing of concrete, as in the case of ready mixed concrete plants or off-site batching and mixing plants, concrete mix shall be designed to have appropriately higher workability at the time of discharge from the mixer, in order to compensate the loss of workability during transit. This is generally achieved by suitable chemical admixtures. Keeping these considerations in view, the general requirement for ready mixed concrete plants or off-site batching and mixing plants, is that concrete shall be discharged from the truck mixer within two hours of the time of loading. A longer period may be permitted if suitable retarding admixtures are used.

In wall forms, drop chutes attached to hoppers at the top should preferably be used to lower concrete to the bottom of the form. As a general guidance, the permissible free fall of concrete may not exceed 1.5 metres and under no circumstances shall it be more than 2 metres. When free fall of larger height is involved, self-compacting concrete having adequate fluidity, cohesiveness and viscosity and which uniformly and completely fills every corner of the formwork by its own weight without segregation, shall be used.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not more than 300 mm in all other cases.

Concrete when deposited shall have temperature of not less than 5°C and preferably not more than 30°C and in no case more than 40°C. In case of site mixing, fresh concrete shall be placed and compacted in its final position within 30 minutes of its discharge from the mixer. When the concrete is carried in properly designed agitator operating continuously, the concrete shall be placed and compacted within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. It may be necessary to add retarding admixtures to concrete, if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

2.50.9.6 Compaction of Concrete

Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over-vibration shall be avoided to minimize the risk of forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrations shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided.

When internal vibrators are used, they shall be inserted vertically to the full depth of the layer being placed and ordinarily shall penetrate the layer below for a few centimetres. The vibrator should be kept in place until air bubbles cease escaping from the surface and then withdrawn slowly to ensure that no hole is left in the concrete, care being taken to see that it

remains in continued operation while being withdrawn. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdown. Mechanical vibrators used shall comply with IS:2502, !S:2506, IS:2514 and IS:4656.

2.50.10 CONSTRUCTION JOINTS *(cl. 1709 of MoRT&H)*

Construction joints shall be avoided as far as possible. In no case shall the locations of such joints be changed or increased from those shown on the drawings except with the express approval of the Engineer.

Joints should be positioned where they are readily accessible for preparation and concreting. Construction joints should be positioned to minimize the effects of the discontinuity of the durability, structural integrity and appearance of the structure. As far as possible, joints should be provided in non-aggressive zones, but if joints in aggressive zones cannot be avoided, they should be sealed. Joints should be located away from the regions of maximum stress caused by loading; particularly where shear and bond stresses are high.

In beams and slabs joints should not be near the supports. Construction joints between slabs and ribs in composite beams, shall be avoided. For box girders, there shall be no construction joint between the soffit and webs.

Joints should be either vertical or horizontal. For a vertical construction joint, the lifts of concrete shall finish level or at right angles to the axis of the member. Concreting shall be continued right up to the joint.

Before resuming work at a construction joint when concrete has not yet fully hardened, all laitance shall be removed thoroughly. The surface shall be roughened, taking care to avoid dislodgement of coarse aggregates. Concrete shall be brushed with a stiff brush soon after casting, while the concrete has only slightly stiffened. If the concrete has partially hardened, it may be treated by wire brushing or with a high pressure water jet, followed by drying with an air jet, immediately before the new concrete is placed. Fully hardened concrete shall be treated with mechanical hand tools or grit blasting, taking care not to split or crack aggregate particles. The practice of first placing a layer of mortar or grout when concreting joints, shall be avoided. The old surface shall be soaked with water, without leaving puddles, immediately before starting concreting. The new concrete shall be thoroughly compacted against it.

Where there is likely to be a delay before placing the next concrete lift, protruding reinforcement shall be protected. In all cases, where construction joints are made, the joint surface shall not be contaminated with release agents, dust, or sprayed curing membrane and reinforcement shall be firmly fixed in position at the correct cover.

The sequence of concreting, striking of forms and positioning of construction joints for every individual structure, shall be decided well in advance of the commencement of work.

2.50.11 CONCRETING UNDER WATER *(cl. 1710 of MoRT&H)*

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used, shall be got approved from the Engineer before any work is started.

Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall not be less than 16°C, nor more than 30°C.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 m per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter. To minimise the formation of laitance, care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only. The number and spacing of the tremies should be worked out to ensure proper concreting. However, it is necessary to have a minimum number of 2 tremies for any concreting operation, so that even if one of the tremies goes out of commission during concreting, the other one can be used to complete the work. The tremie concreting when started, should continue without interruption for the full height of the member being concreted. The capacity of the concrete production and placement equipment should be sufficient to enable the underwater concreting to be completed uninterrupted within the stipulated time.

The top section of the tremie shall have a hopper large enough to hold one full batch of the mix or the entire contents of the transporting bucket, as the case may be. The tremie pipe shall not be less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength shall be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding

of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise the tremie slowly in order to allow a uniform flow of concrete. At all times after placing of concrete is started and until all the required quantity has been placed, the lower end of the tremie pipe shall be kept below the surface of the plastic concrete and shall not be taken out of concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. It is advisable to use retarders or suitable superplasticizers to retard the setting time of concrete, which shall be established before the commencement of work.

2.50.12 Concreting in Cold Weather

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5°C and that the temperature shall be maintained above 4°C until the concrete has hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stockpiled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65°C. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. Concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement. To counter slower setting of concrete, accelerators can be used with the approval of the Engineer. However, accelerators containing chloride shall not be used.

2.50.13 Concreting in Hot Weather

When depositing concrete in hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 30°C while placing. This shall be achieved by using chilled mixing water, using crushed ice as a part of mixing water, shading stock piles of aggregates from direct rays of the sun, sprinkling the stock piles of coarse aggregate with water to keep them moist, limiting temperature of cement below 30°C at the time of use, starting curing before concrete dries out and restricting time of concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered as part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted. The Contractor will be required to state his methodology for the Engineer's approval when temperatures of concrete are likely to exceed 30°C during the work.

2.50.14 PROTECTION AND CURING *(cl. 1712 of MoRT&H)*

2.50.14.1 General

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately after compaction of the concrete.

The concrete shall be protected from:

a) Premature drying out particularly by solar radiation and wind
b) High internal thermal gradients
c) Leaching out by rain and flowing water
d) Rapid cooling during the first few days after placing
e) Low temperature or frost
f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.
g) Vibration caused by traffic including construction traffic.

Concrete shall be protected, without allowing ingress of external water, by means of wet (not dripping) gunny bags, hessian etc. Once the concrete has attained some degree of hardening (approximate 12 hrs after mixing), moist curing shall commence and be continued through the requisite period. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

2.50.14.2 Water Curing

Water for curing shall be as specified in Section 1000 of these specifications.

Sea water shall not be used for curing. Sea water shall not come into contact with concrete members before they have attained adequate strength.

The concrete should be kept constantly wet by ponding or covering or use of sprinklers/ perforated pipes for a minimum period of 14 days after concreting, except in the case of concrete with rapid hardening cement, where it can be reduced to

5 days. Water should be applied on surfaces after the final set. Curing through watering shall not be done on green concrete. On formed surfaces, curing shall start immediately after the forms are stripped. The concrete shall be kept constantly wet with a layer of sacking, canvas, hessian or similar absorbent material.

2.50.14.3 Steam Curing

Where steam curing is adopted, it shall be ensured that it is done in suitable enclosure to contain the live steam in order to minimize moisture and heat losses. The initial application of the steam shall be after about four hours of placement of concrete to allow the initial set of the concrete to take place.

Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete. Steam curing is applied in enclosures or tunnels through which concrete members are transported on a conveying system. Alternatively, portable enclosures or plastic covers are placed over precast members and steam is supplied to the enclosures. The rate of increase or decrease of temperature should not be more than 10°C to 20°C per hour and the maximum temperature shall be about 70°C. The maximum temperature shall be maintained until the concrete has attained the desired strength required at the end of steam curing period and shall be decided by prior trials. When steam curing is discontinued, the air temperature shall not drop at a rate exceeding 10°C per hour, until a temperature of about 10°C above the ambient temperature outside has been reached. Steam curing of concrete shall be followed by water curing for at least 7 days. The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

2.50.14.4 Curing Compound

Membrane forming curing compounds consisting of waxes, resins, chlorinated rubbers etc. may be permitted by the Engineer in special circumstances. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist cured and no curing compound shall be permitted in locations where concrete surfaces are required to be bonded together.

Liquid membrane forming compounds shall conform to ASTMC 309 and the curing efficiency shall be as per ASTMC 156.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking. The membrane formed shall be stripped off after 14 days, when curing is complete.

Impermeable membranes, such as sheet materials for curing concrete conforming to ASTM C 171 or polyethylene sheeting covering closely the concrete surface, may also be used to provide effective barrier against evaporation.

2.50.15 FINISHING *(cl. 1713 of MoRT&H)*

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and ail other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water and carefully pointed and rendered true with mortar. The mortar shall be of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as possible. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of twenty four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing.

All construction and expansion joints in the completed work shad be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good. The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance of the member, shall be rejected. Surface defects of a minor nature may be accepted. On acceptance of such work, the same shall be rectified as directed by the Engineer.

2.50.16 CONCRETE WITH BLENDED CEMENTS OR MINERAL ADMIXTURES *(cl. 1714 of MoRT&H)*

2.50.16.1 Production of Concrete

In order to improve the durability of the concrete, use of blended cement or blending of mineral admixtures, is permitted.

The maximum limit of flyash and ground granulated blast furnace slag in concrete, shall be as specified in Clause 1715.2. Blending at site shall be permitted only through a specific facility with complete automated process control to achieve the specified design quality or through RMC plants with similar facility.

2.50.16.2 Modified Properties

For concrete made with Portland Pozzolona Cement, Portland Blast furnace slag cement or mineral admixtures, the setting time and rate of gain of strength are different from those of concrete made with OPC alone. Cognizance of such modified properties shall be taken in deciding de-shuttering time, initial time of prestressing, curing period and for early age loading.

2.50.16.3 Compatibility of Chemical Admixtures

Compatibility of chemical admixtures and superplasticizers with Portland Pozzolona cement, Portland blast furnace slag cement and mineral admixtures shall be ensured by trials outlined in Clause 1705 of MoRT&H.

2.50.17 HIGH PERFORMANCE CONCRETE *(cl. 1715 of MoRT&H)*

2.50.17.1 General

High Performance Concrete shall be used where special performance requirements of high strength, high early strength, high workability, low permeability and high durability for severe service environments, are required. Production and use of such concrete in the field shall be carried out with high degree of uniformity between batches and very stringent quality control.

2.50.17.2 Materials

Cement, mineral admixtures, chemical admixtures, aggregates and water shall conform to Section 1000 of MoRT&H Specifications and this Section, Flyash when used, shall neither be less than 20 percent nor shall be greater than 35 percent of the total by mass of ordinary Portland cement and flyash and shall conform to grade-1 of IS:3812.

Ground granulated blast furnace (GGBS) slag when used, shall neither be less than 50 percent nor greater than 70 percent of the total mass of ordinary Portland cement and GGBS and shall conform to IS:12089.

Silica fume conforming to IS:15388 shall be used.

The cement content of concrete inclusive of any mineral admixtures shall not be less than 380 kg/m3. The cement content excluding any mineral admixtures (Portland cement content alone) shall not exceed 450 kg/m3. The water/cement (cement plus all cementitious materials) ratio should generally not exceed 0.33 but in no case shall be more than 0.40.

2.50.17.3 Compatibility of Admixtures

Compatibility of the superplasticiser and admixtures with the cement and any other Pozzoianic or hydraulic dilutes shall be ensured by trials as outlined under Clause 1705 of MoRT&H.

2.50.17.4 Characteristic Strength and Target Mean Strength

Characteristic strength and the initial target mean strength of concrete, shall be as given in Table 1700-8 of MoRT&H.
The target mean strength shall be calculated as per Clause 1704.2 after obtaining data on standard deviation from sufficient samples.

2.50.18 TESTS AND STANDARDS OF ACCEPTANCE *(cl. 1717 of MoRT&H)*

2.50.18.1 Concrete shall conform to the surface finish and tolerance as prescribed in these Specifications for respective components.

2.50.18.2 Random sampling and lot by lot acceptance inspection, shall be made for the 28 days cube strength of concrete.

2.50.18.3 Concrete under acceptance, shall be notionally divided into lots for the purpose of sampling before commencement of work. The basis of delimitation of lots shall be as follows:

i) No individual lot shall be more than 30 cu.m in volume
ii) Different grades of mixes of concrete shall be divided into separate lots.
iii) Concrete of a lot shall be used in the same identifiable component of the bridge.

2.50.18.4 Sampling and Testing

Concrete for preparing 3 test cubes shall be taken from a batch of concrete at point of delivery for construction, according to procedure laid down in IS:1199.

A random sampling procedure shall be adopted which ensures that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes.

150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28 day test strength result for each cube shall form an item of the sample. Tests at other age shall also be performed, if specified.

Where automated batching plant/Ready Mixed Concrete Plant is located away from the place of use and the time gap between production and placement is more than the initial setting time or where any ingredients are added subsequent to mixing, separate sets of samples shall be collected and tested at batching plant and at location of placement. The results shall be compared and used to make suitable adjustment at batching plants so that properties of concrete at placement are as per the requirements.

2.50.18.5 Test Specimen and Sample Strength

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than ±15 percent of the average. If variation is more, the test results of the sample are invalid.

2.50.18.6 Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 1700-9 of MoRT&H.

2.50.18.7 Acceptance criteria

2.50.18.7.1 Compressive Strength

1) Cubes

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

a) The mean strength determined from any group of four consecutive non-overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
b) Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

2) Cores

When the concrete does not satisfy both the conditions given in (1) above, representative cores shall be extracted from the hardened concrete for compression test in accordance with the method described in IS:1199 and tested to establish whether the concrete satisfies the requirement of compressive strength.

Evaluation of compressive strength by taking cores may also be done in case of doubt regarding the grade of concrete used either due to poor workmanship or based on results of cube strength tests.

The locations from which core samples are to be taken and their number shall be decided so as to be representative of the whole of the concrete under consideration. However, in no case shall fewer than three cores be tested. Cores shall be prepared and tested as described in IS: 516. Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has strength less than 75 percent of the specified strength.

2.50.18.7.2 Chloride and Sulphate Content

The total chloride and sulphuric anhydride (S03) content of all the constituents of concrete as a percentage of mass of cement in the mix, shall not exceed the values given in this Section.

2.50.18.7.3 Density of Fresh Concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

2.50.18.7.4 Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

2.50.18.7.5 Permeability Test

Water permeability test as per DIN: 1048 Part 5-1991 shall be carried out as described below:

i) A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared.

ii) After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that specimen can be subjected to a water pressure of up to 7 bars. Atypical machine is shown in Appendix-1700/1.

iii) The concrete specimen shall be subjected to a water pressure of 0.5 N/mm2 from the top for a period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and the specimen rejected as failed.

iv) After 3 days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.

v) When the split faces show signs of drying (after 5 to 10 minutes), the maximum depth of penetration in the direction of height shall be measured with the scale and extent of water penetration established.

vi) The mean of maximum depth of penetration obtained from three specimens thus tested, shall be taken as the test result and it shall not exceed 25 mm.

2.50.18.7.6 If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance, shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable even after investigation, the Contractor shall remove the rejected concrete forthwith.

2.50.18.7.7 When durability of concrete is desired the rapid chloride ion permeability test as stated under Clause 1714.3.1 shall also be performed in addition to above tests.

2.49 PRE STRESSING

2.51.1 GENERAL *(cl. 1802 of MoRT&H)*

The work shall be carried out in accordance with the drawings and these Specifications or as approved by the Engineer.

Structural concrete and untensioned steel for the production of prestressed concrete members shall conform to the requirements of Section 1700 and Section 1600 respectively, of these Specifications, unless specifically modified by requirements set forth in this Section.

2.51.2 MATERIALS *(cl. 1803 of MoRT&H)*

2.51.2.1 All materials shall conform to Section 1000 of MoRT&H Specifications.

2.51.3 Sheathing

2.51.3.1 General

The sheathing ducts shall be of the spiral corrugated type either in mild steel or HDPE or in PP for internal tendons. They shall be in as long lengths as practicable from considerations of handling and transportation without getting damaged.

External tendons shall be housed in either High Density Poly-Ethylene (HDPE) sheaths or metallic steel sheaths (plain or with protective coatings), which have smooth internal surfaces.

2.51.3.2 M.S. Sheathing Ducts

The material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS: 513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

The material shall be clean and free from rust and normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used.

The sheathing shall conform to the requirements specified in Table 94 and Appendix IX. All the joints of sheathing shall be water tight and conform to provisions contained in Clause 1804.6 of MoRT&H.

Table 104 : Details of Ducts *(Table 1800-1 of MoRT&H)*

No. of Strands/ Dia in mm	Diameter of Duct in mm		Thickness of MS Sheathing in mm	Thickness of HDPE Duct in mm
	Metallic	HDPE		
6/13	50	50	0.3	2.0
12/13	75	75	0.4	2.5
19/13	85	85	0.4	2.5
27/13	100	100	0.5	3.0
12/15	85	85	0.4	2.5
19/15	100	100	0.5	3.0
27/15	125	130	0.5	4.0

2.51.3.3 Corrugated HDPE Sheathing Ducts

The material for the ducts shall be high density polyethylene or polypropylene with more than 2 percent carbon black to provide resistance to ultraviolet degradation. The ducts shall be corrugated on both sides. All tests on raw materials and tests to be conducted on the finished product, shall be in accordance with fib Technical Report Bulletin 7 "Corrugated plastic ducts for internal bonded post tensioning".

Each batch of the HDPE ducts supplied to the site shall be accompanied by the supplier's certificate for properties of the raw materials which shall comply with the Technical report Bulletin 7. In addition the shore hardness for D-3 sec value shall be 60±5. For the approval of the finished product, the tests mentioned in the Appendix A1 to A9 of fib Technical Report Bulletin 7, shall be conducted at the reputed institutions or at the manufacturer's laboratories. Results shall comply with the provisions of the fib Technical report Bulletin 7, except for the wear resistance, minimum bending radius and bond length test which are modified as follows:

a) Wear resistance test: The wear resistance of the duct i.e. the minimum residual wall thickness after loss, shall not be less than 1.5 mm for ducts up to 85 mm in diameter and not less than 2 mm for ducts greater than 85 mm in diameter.

b) Minimum bending resistance: The test apparatus shall be identical to the wear test apparatus with the same clamping force. However sample shall not be moved but shall be as held in position for a period of 7 days. The residual wall thickness shall be as mentioned in (a) above.

c) Bond length test: The ducts shall transmit full tendon strength from the tendon to the surrounding concrete over a length of not grater then 40 times duct diameter.

Each supply of the ducts shall be accompanied by test report of the finished product also. The test certificates issued by the institutes will be valid for a period of two years.

2.51.3.4 Diameter and Thickness of Sheathing Ducts

The internal diameter and thickness of sheathing shall be as shown in the drawing or as indicated in Table 1800-1, whichever is greater:

Where prestressing tendons are required to be threaded after concreting, the internal diameter of sheathing shall be about 5 mm larger than required above for spans more than 30 m. In severe environment, cables shall be threaded after concreting. In such cases a temporary tendon shall be inserted in the sheathing or the sheathing shall be stiffened by other suitable method during concreting.

2.51.4 Anchorages

2.51.4.1 Prestressing accessories like jacks, anchorages, wedges, block plates, etc. shall be procured from authorized manufacturers only. Anchorages shall conform to "Recommendations for acceptance and application of prestressing systems" published by FIB. The prestressing accessories shall be subjected to an acceptance test prior to their actual use on the work. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

2.51.4.2 Swages of prestressing strand and button-heads of prestressing wire, where provided shall develop a strength of at least 95 percent of the specified breaking load of the strand or wire as the case may be. Where swaging/button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to taking up the work.

2.51.4.3 Untensioned steel reinforcements, around anchorages shall conform to the details of prestressing system and as shown on the drawing.

2.51.4.5 Couplers

Couplers or other similar fixtures used in conjunction with the prestressing strands or bars, shall have an ultimate tensile strength of not less than the strengths of the individual strands or bars being joined and shall also meet the requirements of individual anchorages.

2.51.5 TESTING OF PRESTRESSING STEEL AND ANCHORAGES *(cl. 1804 of MoRT&H)*

All materials specified for testing shall be furnished free of cost by the Contractor and shall be delivered in time for tests to be made, well in advance of anticipated time of use.

All wires, strands or bars to be shipped to the site, shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall also be similarly identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5 m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or type to be used, shall be furnished along with short lengths of strands as required.

2.51.5.1 Post Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The location of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High capacity tendons shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distance between any two cable ducts shall in no case be less than 50 mm or diameter of duct, whichever is greater, when grouping of cable is not involved. Where precast segments are used, the clear distance between cables shall be at least 150 mm.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars, so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to the approval of the Engineer. The temporary tendon shall be pulled out by a special threading machine or other contrivance, before threading the permanent tendon.

Where possible, tendons shall be placed prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendons which are damaged or contaminated shall be cleaned or replaced.

2.51.5.2 Pre-tensioning

Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

2.51.5.3 Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer, prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces, shall be removed immediately.

2.51.5.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The flame cutting of wire or strand shall be carried out at least 75 mm beyond the point where the tendon will be gripped by the anchorage or jacks.

In post tensioned members, the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

2.51.5.5 Coupling of MS Sheathing Ducts

For major projects, the sheathing duct should preferably be manufactured at the project site utilizing appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers.

Where sheathing duct joints are unavoidable, they shall be made cement slurry tight by the use of corrugated threaded sleeve couplers, which can be tightly screwed on to the outer side of the sheathing ducts.

The length of the coupler should not be less than 150 mm but should be increased upto 200 mm wherever practicable. The joints between the end of coupler and duct shall be sealed with tape to prevent penetration of slurry during concreting. The couplers of adjacent ducts shall be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers can be conveniently manufactured using the sheath making machine with the next higher size of die set.

For typical details of coupling refer Appendix 1800/1 of MoRT&H Specifications.

2.51.5.6 Coupling of HDPE Sheathing Ducts

The HDPE sheathing can be joined by any one of the following three methods.

a) Use of threaded sleeve couplers in the same manner as given for metallic sheathing.

b) Welding of two ends of HDPE sheathing using appropriate machine such as Roaster Machine or Mirror Machine.

c) Use of heat shrink couplers made of HDPE sleeves. The sleeves are integrated with the parent sheathing by hot process by using heating torch.

For typical details of coupling, refer Appendix 1800/1 of MoRT&H Specifications.

2.51.5.7 Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. For cables longer than 50 m grout vents or drains may be provided at or near the lowest points. Additional vents shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20 m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without leakage of water, air pressure or grout.

2.51.5.8 Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning.

Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface by a minimum of 100 mm.

After the prestressing operations are completed and prestressing wires/strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 micron per coat and entire recess shall be filled with concrete or non-shirk/ pre-packaged mortar of epoxy concrete.

2.51.6 TENSIONING EQUIPMENT *(cl. 1807 of MoRT&H)*

All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements :

i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.

ii) Where two or more wires/strands constitute a tendon, a single multi-pull stressing jack shall be used, which is capable of tensioning simultaneously all the wires/strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.

iii) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete.

iv) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the liner measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

All dynamometers and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two percent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 percent of its breaking load, the gauge is reading between 50 percent and 80 percent of its full capacity. Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check, whenever requested for by the Engineer.

Jack and pump shall be calibrated from an approved laboratory prior to use and then at intervals not exceeding three months.

2.51.7 POST TENSIONING *(cl. 1808 of MoRT&H)*

Tensioning force shall be applied in gradual and steady steps, in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows :

a) If the calculated elongation is reached before the specified gauge pressure, continue tensioning till the specified gauge pressure is attained, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq. cm until the calculated elongation is reached, provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this discrepancy:

   i) Check the correct functioning of the jack, pump and leads.

   ii) De-tension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re-tension the cable, if free.

   iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

   iv) If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

d) When stressing from one end only, the slip at the end remote from the jack, shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/11.

The number of stages of prestressing and grouting shall be kept to a minimum, preferably two in the case of simply supported girders.

2.51.8 GROUTING OF PRESTRESSED TENDONS *(cl. 1809 of MoRT&H)*

Grouting of prestressed tendons shall be carried out in accordance with provisions given in Appendix 1800/III of MoRT&H Specification. A record of grouting operations shall be maintained in the format given in Appendix VI.

2.51.9 TRANSPORTATION STORAGE AND HANDLING OF PRECAST GIRDERS *(cl. 1814 of MoRT&H)*

Precast girders shall be transported in an upright position. Points of support and the direction of the reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

Method of transportation should be planned in such a way that the vehicle employed to transport the long girders can successfully negotiate the available road geometry. Adequate care shall be taken to ensure that the girder being transported does not topple due to unstable arrangement. For this purpose, height of the vehicle shall be kept as low as possible. This will also help in accommodating greater height of the system during transportation below existing bridges or through any other constraints. Girders should be transported only after 28 day concrete strength is achieved.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of precast units to prevent them from being cracked or damaged. Units cracked or damaged by improper storing or handling, shall be replaced by the Contractor at his cost.

Handling of precast girders from precasting location to the bridge site requires careful operation. Lifting location shall be strictly as indicated on the construction drawings.

Lifting devices generally consist of loops of prestressing strand or mild steel bars or any other suitable arrangement. If it is anticipated that embedded material for lifting devices will be cast into the face of the member that will be exposed to view or to corrosive materials in the completed structure, the depth of removal of the embedded material and the method of filling the resulting cavities, shall be as shown on the construction drawings. The depth of removal shall not be less than the clear cover required to the reinforcing steel. The cavity so formed shall be suitably grouted for protecting the embedded metal. Also, the projecting reinforcement shall be suitably protected against corrosion.

2.52 STRUCTURAL STEEL

2.52.1 GENERAL *(cl. 1902 of MoRT&H)*

General requirements relating to the supply of material shall conform to the Specifications of IS: 1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Unless otherwise specified, high tensile steel rivets conforming to IS: 1149 shall be used only for members of high tensile steel conforming to IS:961 and shall not be used for members of mild steel.

Unless otherwise specified, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS:4000.

2.52.2 MATERIALS *(cl. 1903 of MoRT&H)*

2.52.2.1 All materials shall conform to Section 1000 of these Specifications. Special requirements are given below:

Mild steel for bolts and nuts shall conform to IS:226 but have a minimum tensile strength of 44 kg/sq.mm and minimum percentage elongation of 14.

High tensile steel for bolts and nuts shall conform to IS:961 but with a minimum tensile strength of 58 kg/sq.mm.

Use of high strength friction grip bolts shall be permitted only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Engineer or as laid down in special provisions.

2.52.2.2 Castings and Forgings

Steel castings and forgings shall comply with the requirements of the following Indian Standards, as appropriate:

IS: 1030, IS: 1875, IS: 2004, IS: 2644, IS: 2708, IS: 4367

2.52.2.3 Fasteners

Bolts, nuts washers and rivets shall comply with the following or relevant Indian Standards as appropriate:

IS: 1148, IS: 1149, IS: 1363, IS: 1364, IS: 3640 , IS: 3757, IS: 4000, IS: 5369, IS: 5370, IS: 5372, IS: 5374, IS: 5624, IS: 6610, IS: 6623, IS: 6639, IS: 6649, IS: 7002

2.52.2.4 Welding Consumables

Welding consumables shall comply with the following Indian Standards as appropriate :

IS: 814, IS: 1395, IS: 3613, IS: 6419, IS: 6560

2.52.2.5 Welding

IS: 816, IS: 822, IS: 1024, IS: 1182, IS: 4853, IS: 5334, IS: 7307, IS: 7310, IS: 7318, IS: 9595

2.52.2.6 Paints

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer.

The type of paints which can be used shall be as follows :

a) Ordinary i.e. paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy
b) Chemical Resistant - one pack type (ready for use) or two pack type (mixed before use).
c) Vinyl
d) Chlorinated rubber
e) Bituminous - (IS:9862)
f) Epoxy -(IS:14925)
g) Polyurethane - (IS:13759)
h) Zinc rich -(IS:14589

Unless otherwise specified, paints shall conform to the relevant Indian Standards. Paints shall be tested for the following qualities as per Specifications given in the relevant IS codes:

Weight (for 10 litres of paint, thoroughly mixed)
Drying time
Consistency
Dry thickness and rate of consumption

2.52.3 FABRICATION *(cl. 1904 of MoRT&H)*

2.52.3.1 General

All work shall be in accordance with the drawings and as per these Specifications. Fabrication work shall be taken up only after receipt of approved fabrication/working drawings. It shall be ensured that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number. Method of marking shall be commensurate with the process of manufacture and such as to ensure retention of identity at all stages.

Unless specifically required under the contract, corresponding parts need not be interchangeable, but the parts shall be match marked as required under Clause 1904.9 of MoRT&H.

Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Engineer before they are used in the finished structure.

All structural steel members and parts shall have straight edges and plane surfaces. They shall also be free from twist. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

The Contractor shall submit his programme of work to the Engineer for his approval at least 15 days before the commencement of fabrication, which shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures. He shall also submit for approval of Engineer, a Quality Assurance Plan according to the nature of fabrication work (whether welded or riveted) which should clearly define the points of checking and inspection during the stages of fabrication as well as supply of materials.

The Contractor shall prepare shop drawings for fabrication of any member and obtain approval of the Engineer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop drawings. These drawings shall distinguish between shop and field welds.

2.52.3.2 Preparation of Holes

2.52.3.2.1 Drilling and Punching

Holes for rivets, black bolts, high strength bolts and countersunk bolts/rivets (excluding close tolerance and turn fitted bolts) shall be either punched or drilled. For bolts/rivets less than 25 mm dia, the diameter of holes shall be 1.5 mm larger while for those of 25 mm dia or more, the diameter of holes shall be 2 mm larger than the diameter of the bolt/rivet.

All holes shall be drilled except those for secondary members such as floor plates, hand rails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for material conforming to IS:2062 up to Grade E250 (Fe 410w).

Holes through material of more than one thickness or through main material thickness exceeding 20 mm for steel conforming to IS:2062 up to Grade E250 (Fe 410w) or 16 mm for steel conforming to IS:2062 up to Grade E300 (Fe 440w) and above, shall either be sub-drilled or sub-punched to a diameter of 3 mm less than the required size and then reamed to the required size. The reaming of material more than one thickness shall be done after assembly.

Where several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tacking bolts and the holes shall be drilled through the group in one operation. Alternatively, and in the case of repetition work, the plates and sections may be drilled separately from jigs and templates. Jigs and templates shall be checked at least once after every 25 operations. All burrs shall be removed.

In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted to ensure strict interchange ability. In such cases, one span in ten or any number less than ten of each type shall be erected from pieces selected at random by the Engineer and should there be any failure of the pieces to fit, all similar spans shall be erected complete. In the event of spans being proved completely interchangeable, all corresponding parts shall carry the same mark so that sorting of the materials at site is facilitated.

2.52.3.3 Size of Holes

The diameters of rivet holes in millimetres are given in Table 1900-1 of MoRT&H.

2.52.3.4 Close Tolerance Bolts and Barrel Bolts

For close tolerance or turn fitted bolts, the diameter of the holes shall be equal to the nominal diameter of the bolt shank + 0.15 mm to - 0.0 mm.

2.52.3.5 Holes for High Strength Friction Grip Bolts

All holes shall be drilled after removal of burrs. Where the number of plies in the grip does not exceed three, the diameters of holes shall be 1.5 mm larger than those of bolts. Where the number of plies in the grip exceeds three, the diameters of holes shall be as follows, unless otherwise specified by the Engineer:

In outer plies	1.5 mm larger than diameter of bolts
In inner plies	not less than 1.5 mm and not more than 3.0 mm larger than diameter of bolts

2.52.3.6 Rivets and Riveting

2.52.3.6.1 The riveting shall be done by hydraulic or pneumatic machine unless otherwise specified by Engineer. The driving pressure shall be maintained on the rivets for a short time after the upsetting is completed.

2.52.3.6.2 The diameter of rivets shown on the drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimensions as given in IS handbook on Steel Sections, Part-I. The underside of the head shall be free from burrs.

2.52.3.6.3 The tolerance on the diameter of rivets shall be in accordance with IS: 1148 for mild steel rivets and IS: 1149 for high tensile steel rivets. Unless otherwise specified, the tolerance shall be minus.

2.52.3.6.4 When countersunk head is required, the head shall fill the countersunk hole and projection after countersinking shall be ground off wherever necessary. The included angle of the head shall be as follows:

a) For plates over 14 mm thickness 90 degree
b) For plates upto and including 14 mm thickness 120 degree

2.52.3.6.5 Mild steel rivets shall be heated uniformly to a light cherry red colour between 650°C to 700°C for hydraulic riveting and orange colour for pneumatic riveting. High tensile steel rivets shall be heated up to 1100°C. The rivets shall be red hot from head to the point when inserted and shall be upset in its entire length so as to fill the hole as completely as possible when hot. After being heated and before being inserted in the hole, the rivet shall be made free from scale by striking it on a hard surface. Any rivet whose point is heated more than the prescribed limit, shall not be driven.

Where flush surface is required, any projecting metal shall be chipped or ground off.

2.52.3.6.6 Before riveting is commenced, the parts/members to be riveted shall be firmly drawn together with bolts, clamps or tack welds so that the various sections and plates are in close contact throughout. Every third hole of the joint shall have assembly bolts till riveted. Drifts shall only be used for drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a larger size than the nominal diameter of the hole shall not be used.

2.52.3.6.7 Driven rivets, when struck sharply on the head by a quarter pound rivet testing hammer, shall be free from movement and vibrations. Assembled riveted joint surfaces, including those adjacent to the rivet heads, shall be free from, dirt, loose scale, burrs, other foreign materials and defects that would prevent solid seating of parts.

2.52.3.6.8 All loose or burnt rivets, rivets with cracked or badly formed defective heads or rivets with heads which are unduly eccentric with the shanks, shall be removed and replaced. In removing rivets, the head shall be sheared off and the rivet punched out so as not to damage the adjacent metal. If necessary, the rivets shall be drilled out. Re-cupping or re-caulking shall not be permitted. The parts not completely riveted in the shop shall be secured by bolts to prevent damage during transport and handling.

2.52.3.7 High Strength Friction Bolts and Bolted Connections

The general requirement shall be as per relevant IS Specifications mentioned in Clause 1903.2.2. Unless otherwise specified by the Engineer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS:4000.

2.52.4 Welding

2.52.4.1 All welding shall be done with the prior approval of the Engineer and the workmanship shall conform to the specifications of the relevant Indian Standards as appropriate.

When material thickness is 20 mm or more, special precautions like pre-heating shall be taken as laid down in IS:9595. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.

The general welding procedures including particulars of the preparation of fusion faces for metal arc welding, shall be carried out in accordance with IS:9595.

The welding procedures for shop and site welds including edge preparation of fusion faces shall be as per details shown on the drawings and shall be submitted in writing for the approval of the Engineer, in accordance with Clause 22 of IS:9595, before commencing fabrication.

Any deviation from this procedure has to be approved by the Engineer. Preparation of edges shall, wherever practicable, be done by machine methods.

Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planing and shall be left free of slag. Manual flame cutting shall be permitted by the Engineer only where machine cutting is not practicable.

Electrodes to be used for metal arc welding shall comply with relevant Indian Standards mentioned in Clause 1903.2.3. Procedure test shall be carried out as per IS:3613 to find out suitable wire-flux combination for welded joint.

Assembly of parts for welding shall be in accordance with provisions of Clauses 14 to 16 of IS:9595.

Welded temporary attachment should be avoided as far as possible. If unavoidable, the method of making any temporary attachment shall be as approved by the Engineer. Any scars from temporary attachment shall be removed by cutting and chipping and surface shall be finished smooth by grinding to the satisfaction of the Engineer.

Welding shall not be carried out when the air temperature is less than 10°C, when the surfaces are wet, during periods of strong winds and in snowy weather, unless the work and the welding operators are adequately protected.

2.52.4.2 For welding of any particular type of joint, welders shall undergo the appropriate welders qualification test as prescribed in any of the relevant Indian Standards IS:817, IS:1966, IS:1393, IS:7307 (Part I), IS:7310 (Part I) and IS:7318 (Part I) to the satisfaction of the Engineer.

2.52.4.3 In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimize shrinkage stress.

All requirements regarding pre-heating of parent material and interpass temperature shall be in accordance with provisions of IS:9595.

2.52.4.4 Peening of weld shall be carried out wherever specified by the Engineer:

a) If specified, peening may be employed to be effective on each weld layer except the first filling layer.

b) After weld has cooled, the peening should be carried out by light blows from a power hammer using a round nosed tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.

2.52.5 Tolerances

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 1900-2 of MoRT&H.

2.52.6 Non-Destructive Testing of Welds

One or more of the following methods may be applied for inspection or testing of weld :

a) Visual Inspection
b) Magnetic Particle and Radiographic Inspection
c) Ultrasonic inspection
d) Liquid Penetration Inspection

2.52.7 PAINTING *(cl. 1906 of MoRT&H)*

2.52.7.1 General

Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include preparation of metal surfaces, application of protective covering and drying of the paint coatings along with all tools, scaffolding, labour and materials necessary.

Coatings shall be applied only to dry surfaces and the coated surfaces shall not be exposed to rain or frost before they are dry. The coatings shall be applied to all surfaces excluding shear connectors and inner surfaces of fully sealed hollow sections. While coating adjacent surfaces, care shall be taken to ensure that primer is not applied on the shear connectors.

2.52.7.2 Types of Paints

i) Ordinary Paints

These include paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy, etc.

Ordinary painting can generally be sub-divided into two types:

a) Primary Coats :
This shall be applied immediately after the surface preparation and should have the properties of adhesion, corrosion inhibition and imperviousness to water and air.

b) Finishing Coats :

This shall be applied over the primary coat and should have the properties of durability, abrasion resistance, aesthetic appearance and smooth finish.

ii) Chemical Resistant Paints

The more highly corrosion resistant paints can be divided into two main groups :

a) One pack paints (ready for use)
b) Two pack paints (mixed before use)

The two pack paints shall be mixed together just before use since they remain workable thereafter only for a restricted period of time.

iii) Other types of paints as mentioned in Clause 1903.4 of MoRT&H Specifications may also be used, subject to approval by the Engineer.

All paints shall conform to relevant IS Standards as appropriate.

2.52.7.3 Surfaces which are inaccessible for cleaning and painting after fabrication shall be painted as specified before being assembled for riveting.

All rivets, bolts, nuts, washers etc., are to be thoroughly cleaned and dipped into boiling linseed oil conforming to IS:77.

All machined surfaces are to be well coated with a mixture of white lead conforming to IS: 34 and mutton tallow conforming to IS: 887.

In site painting, the whole of the steel work shall be given the second cover coat after final passing and after touching up the primer and cover coats, if damaged in transit.

2.52.7.4 Quality of Paint

Only paints which have been tested for the following qualities as per the specifications given in the relevant IS codes, should be used :

- Weight test (weight per 10 litre of paint thoroughly mixed)
- Drying time
- Flexibility and adhesion
- Consistency
- Dry thickness and rate of consumption

2.52.7.5 Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS:1477 (Part I).

2.52.7.6 Surface Preparation

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer:

a) Dry or wet grit/sand blasting
b) Pickling which should be restricted to single plates, bars and sections
c) Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

2.52.7.7 Coatings

Prime coat to be used shall conform to the specification of primers approved by the Engineer. Metal coatings shall be considered as prime coats. Primer shall be applied to the blast cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

a) Epoxy Based Painting

   i) Surface preparation : Remove oil/grease by use of petroleum hydrocarbon solution (IS:1745) and grit blasting to near white metal surface.
   ii) Paint system : 2 coats of epoxy zinc phosphate primer = 60 micron: Total 5 coats = 200 micron

b) Conventional Painting System for areas where corrosion is not severe Priming Coat:

   One coat of ready mixed, red lead primer conforming to IS: 102
   or
   One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074
   or
   Two coats of red oxide zinc chrome primer conforming to IS:2074. Finishing Coats:

Two cover coats of red oxide paint conforming to IS: 123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats, if damaged in transit.

c) Conventional Painting System for areas where corrosion is severe Priming Coat:

Two coats of ready mixed red lead primer conforming to IS: 102

or

One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed zinc chrome primer conforming to IS:2074.

Finishing Coats :

Two coats of aluminium paint conforming to IS:2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats, if damaged in transit.

2.52.7.8 Painting in the Shop

All fabricated steel shall be painted in the shop after inspection and acceptance with at least one priming coat, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

Field contact surfaces and surfaces to be in contact with cement, shall be painted with primer only. No paint shall be applied within 50 mm of design location of field welds. Paint shall be completely dry before loading and transporting of the fabricated steel work to site.

Surfaces not in contact but inaccessible after shop assembly shall receive the full specified protective treatment before assembly.

Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded, if the specified paint or metal coating would be harmful to welders or is likely to impair the quality of site welds.

Exposed machined surfaces shall be adequately protected.

2.52.7.9 Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

Specified protective treatment shall be completed after erection.

2.52.7.10 Methods of Application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and shall be as approved by the Engineer. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas inaccessible for painting and areas shaded for spray application shall be coated first by brushing.

2.52.7.11 Protective Coatings in Different Environments

Table 1900-3 gives guidelines for various types of coatings to be used in various environmental conditions. Approximate life to first maintenance is also indicated.

Table 105 : Guidelines for Selection of Types of Protective Coatings *(Table 1900-3 of MoRT&H)*

	Type of Coating	Exposure Condition
i)	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer, and 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry thickness = 150 urn	Moderate
ii)	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 µm (life up to 5 years)	Polluted inland environment
iii)	Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness : 130-150 urn	Moderate
iv)	Blast clean the surface; 2 coats of drying type oil primer; 1 under coat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness : 165-190 urn	Polluted inland environments
v)	Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber primer, 1 under coat of high build chlorinated rubber; 1 finishing coat of chlorinated rubber. Total dry film thickness : 200 um	Severe coastal and non-coastal interior situations
vi)	Blast clean the surface; 350 - 450 um thickness coal tar epoxy.	Severe
vii)	Pickle; hot dip galvanised (Zinc). Total thickness : 85 um (life up to 15-20 years)	Moderate
viii)	Grit blast, hot dip galvanised. (Zinc). Total thickness = 140 um (life more than 20 years)	Moderate
ix)	Grit blast; 1 coat of sprayed zinc/aluminum followed by suitable sealer Total thickness = 150 um (life up to 15-20 years)	Severe

2.53 BEARINGS

2.53.1 GENERAL *(cl. 2002 of MoRT&H)*

a) Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be in accordance with the details shown on the drawings.
b) The bearings may either be supplied directly to the Engineer by the manufacturer to be installed by the Contractor or supplied and installed by the Contractor as part of the contract. In the former case, the manufacturer shall be associated with the installation of the bearings to the full satisfaction of the Engineer, whereas in the latter case, the Contractor shall be solely responsible for the satisfactory supply and installation of the bearing. In the detailed description of the specification, a general reference shall be made to the Contractor or manufacturer and the interpretation shall be as per terms of contract.
c) The Contractor shall exercise the utmost care in setting and fixing all bearings in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.
d) Bearings shall be handled with care and stored under cover.
e) When bearing assemblies or plates are shown on the drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12 mm) and shall be finished by grinding.
f) It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm thickness) may be provided for this purpose.
g) It shall be ensured that the bottoms of girders to be seated on the bearings are plane at the locations of the bearings and that the bearings are not displaced while placing the girders.
h) M.S bearings sliding on M.S. plates shall not be permitted. For sliding plate bearings, stainless steel surface sliding on stainless steel plate with mild steel matrix shall be used. The other option shall be to provide PTFE surface sliding on stainless steel.
i) Segmental rollers are not permitted; only full cylindrical rollers shall be used. Adequate width of base plate shall be provided to cater for anticipated movements of the supporting structure.
j) For seismic Zones IV and V, roller and rocker bearing components shall have guides to prevent them from being displaced during earthquakes.
k) For bridges with skew angle less than 20°, the bearings shall be placed at right angles to the longitudinal axis of the bridge. For bridges with skew angle greater than 20°, very wide bridges and curved bridges, the location of bearings shall be ensured as shown on the drawings.

l) Easy access to the bearing shall be made available for purposes of inspection and maintenance. Provision shall also be made for jacking up of the superstructure so as to allow repair/replacement of bearings.

m) For types of bearings not covered in this Section, required specifications shall be as laid down in the contract.

2.53.2 STEEL BEARINGS *(cl. 2003 of MoRT&H)*

2.53.2.1 Mild Steel

Mild steel to be used for components of bearings shall comply with IS: 2062, Steel for General Structural Purposes.

2.53.2.2 Forged Steel

Forged steel to be used in components of bearings shall be in accordance with Clause 1009.5 of MoRT&H Specifications.

2.53.2.3 High Tensile Steel

High tensile steel shall comply with IS: 961.

2.53.2.4 Cast Steel

Cast steel shall be in accordance with Clause 1009.1 of MoRT&H Specifications.

For the purpose of checking the soundness, castings shall be ultrasonically examined following procedures as per IS:7666, with acceptance standard as per IS:9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS:1030.

2.53.2.5 Stainless Steel

Stainless steel shall be in accordance with Clause 1009.7 of MoRT&H Specifications.

2.53.3 ELASTOMERIC BEARINGS *(cl. 2005 of MoRT&H)*

Elastomeric bearings shall cater for translation and/or rotation of the superstructure by elastic deformation.

2.53.3.1 Materials

i) Chloroprene Rubber (CR) only shall be used.

ii) Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life viz. Neoprene WRT, Neoprene W, Bayprene 110, Bayprene 210, Skyprene B-5, Skyprene B-30, Denka S-40V and Denka M-40, shall be used.

iii) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

iv) The polychloropene content of the compound shall not be lower than 60 per cent. The ash content shall not exceed 5 per cent of its weight. Polychloropene content shall be determined in accordance with ASTM-D297 and ash content as per IS:3400-Part XXII.

v) Use of synthetic rubber-like materials such as Ethyl Propylene Dimonomer (EPDM), Isobutane Isoprene Copolymer (IIR) and Chloro-Isoprene Copolymer (CIIR) shall not be permitted.

2.53.3.2 Properties of Elastomer

The elastomer shall conform to the properties specified in Table 2000-1.

Laminates of mild steel conforming to IS:2062/IS:1079 or equivalent international grade, shall only be permitted. The yield stress of the material shall not be less than 250 MPa. Use of any other material like fibre glass or similar fabric as laminates, shall not be permitted.

The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for carrying out the following tests on elastomer in accordance with the relevant provisions of ASTM D-297.

2.53.3.3 Manufacturing Tolerances

The bearings shall be fabricated/manufactured with the tolerances specified in Table 2000-3. Tolerances of thickness of individual layer of elastomer, dimension of laminates, and flatness of laminates are primarily meant for quality control during production. In order to measure thickness of individual layer of elastomer, dimension of laminates and flatness of laminates of a finished bearing, it is essential to cut the bearing, which may be done if agreed upon between the manufacturer and the buyer.

2.53.3.4 Acceptance Specifications

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and Engineer.

A testing programme shall be submitted by the manufacturer to the Engineer and his approval obtained before commencement of acceptance testing.

Any acceptance testing delayed 180 days beyond the date of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the Inspector with the aid of the manufacturer's personnel having adequate expertise and experience in rubber testing, working under the supervision of the Inspector and to his complete satisfaction.

Inspection and acceptance shall be carried out lot by lot.

2.53.4 POT BEARINGS *(cl. 2006 of MoRT&H)*

2.53.4.1 General

Pot bearings shall consist of a metal piston supported by a disc of unreinforced elastomer confined within a metal cylinder to take care of rotation. Horizontal movement, if required, shall be provided by sliding surfaces of PTFE pads sliding against stainless steel mating surfaces, with a system of sealing rings. Pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

2.53.4.2 Materials

2.53.4.2.1 Structural steel, mild steel, high tensile steel and steel for forging shall conform to the requirements of Section 1009 of MoRT&H Specifications.

2.53.4.2.2 Cast steel shall comply with Grade 280-520W or 340-570W of IS:1030.

2.53.4.2.3 Stainless steel shall conform to AISI 316 L or 02Cr17Ni12M02 of IS:6911.

2.53.4.2.4 PTFE

The raw material for PTFE used in bearings shall be pure polytetrafluoroethylene, free sintered without regenerated materials or fillers. The mechanical and physical properties of unfilled PTFE shall comply with Grade A of BS:3784 or equivalent. PTFE shall be either in the form of solid rectangular modules or large sheets with dimples formed by hot pressing or moulding. Sheet with dimples formed by machining or drilling from a solid PTFE sheet, shall not be permitted. The surface of PTFE sheets/modules which are to be in contact with metal backing plates shall be provided with suitable chemical treatment for proper bonding. Adhesives used for bonding PTFE to backing plates, shall produce a bond with minimum peel strength of 4 N/mm width when tested in accordance with BS:5350 (Part C9).

2.53.4.2.5 Elastomer

The elastomer to be used for the components of bearings shall comply with provisions of Table 2000-1 of MoRT&H.

The confined elastomer inside the pot shall have the properties as given in Table 2000-4 of MoRT&H.

2.53.4.2.4 Certification and Marking

i) Bearings should be transported to bridge site after final acceptance by the Inspector/inspection agency appointed by the concerned authority, along with an authenticated copy of the certificate of acceptance. An information card listing the required bearing characteristics, duly certified by the manufacturer should also be appended with the certificate.

ii) All bearings shall have suitable index markings in indelible ink or flexible paint, which if practicable, shall be visible even after installation, giving the following information:

Name of manufacturer
Month and year of manufacture
Bearing designation
Type of bearing
Load and movement capacity
Centre line markings to facilitate installation
Direction of major and minor movement, if any
Preset, if any

2.53.4.3 Installation

2.53.4.3.1 General

a) Bearings shall be so located as to avoid the accumulation of dirt and debris on or around them. Detailing of the structure shall be such that water is prevented from reaching the bearings.

b) In order to avoid contamination of moving surfaces, bearings should not normally be dismantled after leaving the manufacturer's workshop. However, if for any reason, a bearing is required to be dismantled, it shall be done only under expert supervision for which the manufacturer's help may be sought.

c) Transfer of load from the superstructure to the bearings should not be allowed until the bedding material has developed sufficient strength. Temporary clamping devices should be removed at the appropriate time before the bearings are required to accommodate movement. The holes exposed on removal of temporary transit clamps should be filled with selected material. Where re-use of these fixing holes may be required, the material used for filling the holes should be capable of being easily removed without damaging the threads.

d) Suitable temporary supporting arrangements under bearing base plates should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. Such temporary supports, if provided, should be removed once the bedding material has reached its required strength. Any voids left as a consequence of their removal should be made good using the same bedding material. Steel folding wedges and rubber pads are suitable for use as temporary supports under bearing plates.

2.53.4.3.2 Bedding

i) The bedding material shall be selected keeping in view a number of factors such as the type and size of bearing, construction sequence, load on the bearing, required setting time, friction requirements, access around bearings, design and condition of surface in the bearing area and thickness, strength and shrinkage of bedding material.

ii) Commonly used bedding materials are cementitious or chemical resin mortar and grout. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.

iii) The bedding material, whether above or below the bearing, should extend over the whole area of the bearing in order to ensure even loading. After installation, there shall be no voids or hard spots. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

iv) The bedding material shall be capable of transmitting the applied load to the structure without being damaged. Surfaces to receive bedding mortar shall be suitably prepared so as to be compatible with the mortar chosen.

2.53.4.3.3 Fixing of Bearings

i) Bearings should be anchored in order to counter vibration and accidental impact. Anchorage should be accurately set into recesses cast into the structure using templates. The remaining space in the recesses should be filled with material capable of withstanding the loads.

ii) Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Voids beneath the bearings should be completely filled with bedding material using the appropriate method.

iii) Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location.

iv) If the structure is of steel, the bearings may be bolted directly onto it. Care shall be taken to ensure that there is no mismatch between the bolt holes of the structure and those of the bearing.

v) Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.

2.53.4.3.4 Bearings Supporting In-situ Concrete Deck

i) Where bearings are installed prior to casting of an in-situ concrete deck, formwork around bearings should be properly sealed to prevent grout leakage. It is essential that the bearings and particularly the working surfaces are protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of green concrete. Any mortar contaminating the bearings should be completely removed before it sets.

ii) For bearings supporting precast concrete or steel beams, a thin layer of synthetic resin mortar should be used between bearings and the beams. Bearings shall be bolted to anchor plates or sleeves embedded in precast concrete elements or to machined sole plates on steel elements.

2.53.4.3.5 Installation Tolerances

Bearings shall be located so that their centre lines are within ± 3 mm of their correct position. The level of a bearing or the mean levels of more than 1 bearing at any support, shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder, but not exceeding ± 5 mm. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction, even under superstructure in gradient.

2.54 SURFACE AND SUBSURFACE GEOTECHNICAL INVESTIGATION

2.54.1 The field work shall consist of excavation, drilling of boreholes for the purpose of collection of undisturbed and disturbed samples, standard penetration tests, in-situ vane tests, static and dynamic cone penetration tests, other field tests, as specified by the Engineer and preparation of bore logs. It will also include collection, preservation and testing of disturbed and undisturbed samples from boreholes, borrow pits, etc. as specified by the Engineer. All in-situ tests shall be supplemented by laboratory investigations. Relevant Indian Standards such as IS:1498, IS:1888, IS:1892, IS:2131, IS:2132, IS:2720, IS:4434 and IS:4968 and Annex 2 of IRC:78 shall be followed for guidance.

2.54.2 The soundings by dynamic method, where required shall be carried out in bore holes using a standard sampler as specified in IS: 2131.

2.54.3 EXTENT AND NUMBER OF BORES *(cl. 2402 of MoRT&H)*

2.54.3.1 Investigations shall cover the entire length of the bridge and also extend on either side for a distance about twice the depth below bed of the last main foundation. Bores shall be taken at the location of each pier and abutment of the bridge. A minimum of two bores shall be taken in the approaches on either side, along the centre line of the alignment, at a distance of 50 m and 120 m behind the abutment positions. In case of viaducts in the approaches on either side of the bridge, bores shall be taken at the location of each foundation of the viaduct spans.

2.54.3.2 Where detailed investigation indicates appreciable variation or where variations in a particular foundation are likely to appreciably affect the construction (specially in case of bridge foundations resting on rock), it will be necessary to take additional bores in the transverse direction also, to establish complete profile of the underlying strata. The number of additional bores shall be decided depending upon the extent of variation in local geology at a particular foundation location and should cover the entire area of that foundation.

2.54.4 DEPTH OF BORES *(cl. 2403 of MoRT&H)*

2.54.4.1 The bores shall be taken below the proposed founding level to a depth of at least VA times the width of foundation. In case the soil at that level is found to be unsuitable or of doubtful bearing capacity, the depth of investigation below the proposed founding level, shall be extended to 4 times the width of foundation or til! firm and stable soil or rock is met with. If rock is met with, the depth of drilling into rock having RQD more than 75, may be limited to 3 metres.

2.54.4.2 For embankments and guide bunds, the depth of bore should cover all strata likely to cause undesirable settlement affecting their stability. The depth of bore holes below the ground level may ordinarily be 2.5 times the maximum height of the embankment/ guide bund, subject to a minimum of 20 m. However, borings can be terminated at shallower depths when firm strata or bed rock is encountered. Where highly compressible strata are encountered, the boring may have to be taken deeper. In order to ensure that firm strata is sufficiently thick, the boring should extend 3 metres into the firm strata.

2.54.5 DETAILED INVESTIGATION *(cl. 2404 of MoRT&H)*

2.54.5.1 The subsurface investigation for bridges shall be carried out in the following three zones:

i) between bed level and up to anticipated maximum scour depth (below H.F.L.)
ii) from the maximum scour depth to the founding level
iii) from founding level to a depth of about VA times the width of the foundation

The data required to be obtained from each zone will cover soil classification, particle size distribution, shearing strength characteristics, compressibility and permeability as detailed in Table 1 of Annex 2 of IRC:78.In all cases, samples of soils shall be collected at every 1 m to 1.5 m depth or at change of strata.

2.54.5.2 For bridge works, the investigations shall be comprehensive enough to give the following information to the designer:

i) the engineering properties of the soil/rock,
ii) the location and extent of soft layers, cavities and gas pockets, if any under the hard founding strata,
iii) the geological condition like type of rock, faults, fissures or subsidence due to mining, cavities, hollows, porosity etc.,
iv) ground water level,
v) artesian conditions, if any,
vi) quality of water in contact with the foundation,
vii) the depth and extent of scour,
viii) suitable depth of foundation,
ix) bearing capacity of the stratum
x) probable settlement and differential settlement of the foundations,
xi) likely sinking or driving effort, and
xii) likely construction difficulties.

2.54.6 DETAILED INVESTIGATION FOR BRIDGE FOUNDATIONS RESTING ON ROCK *(cl. 2405of MoRT&H)*

2.54.6.1 Identification and classification of rock types for engineering purposes may in general be limited to broad, basic geological classes in accordance with accepted practice. Strength of parent rock alone is of limited value because overall characteristics depend to a large extent on character, spacing and distribution of discontinuities such as joints, bedding planes, faults and weathered seams in the rock mass. An important factor affecting the behaviour of the rock is the weathered zone at top.

2.54.6.2 Basic Information Required from Investigations

i) Geological system
ii) Depth of rock strata and its variation over the length of the bridge
iii) Whether bed consists of isolated boulders or continuous rock formation
iv) Extent and character of weathered zone
v) Structure of rock - including bedding planes, faults, fissures, solution cavities etc.
vi) Properties of rock material - strength, geological formation, etc.
vii) Colour, quality and quantity of water coming out of drill holes
viii) Erodability of rock to the extent possible, where relevant

2.54.6.3 Core Recovery and Rock Quality Designation

The quality of rock cores shall be classified according to Rock Quality Designation as given in Table 2400-1 of MoRT&H.

Table 106 : Classification According To RQD *(Table 2400-1 of MoRT&H)*

RQD Percent	Core Quality
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
25	Very Poor

2.54.7 BORING *(cl. 2406 of MoRT&H)*

Boring shall be done by any of the following methods depending on the soil type and types of samples required for the investigation.

i) Auger Boring
ii) Shell and Auger Boring
iii) Percussion Boring
iv) Wash Boring
v) Rotary Boring

For detailed subsurface investigation, only rotary drills shall be used. Casing shall also be invariably provided with diameters not less than 150 mm up to the level of rock, if any. Use of percussion or wash boring equipment shall be permitted only to penetrate through bouldery or gravelly strata for progressing the boring but not for the collection of samples. While conducting detailed borings, the resistance to the speed of drilling i.e. rate of penetration, core loss, etc., as specified in Annex-2 of IRC:78 shall be carefully recorded to evaluate the different types of strata and specially to distinguish sand from sandstone, clay from shale, etc.

2.54.8 METHODS OF SAMPLING *(cl. 2408 of MoRT&H)*

There are two types of samples viz. (a) Disturbed sample (b) Undisturbed sample. The usual methods for sampling conforming to IS:1892 and IS:2132 are given below ;

Nature of Ground	Type of Sample	Method of Sampling
Soil	Disturbed	Hand Samples
		Auger Samples
		Shell Samples
	Undisturbed	Hand Samples
		Tube Samples
Rock	Disturbed	Wash samples from Percussion or rotary drilling
	Undisturbed	Cores

2.54.9 PROCEDURE FOR TAKING SAMPLES *(cl. 2409 of MoRT&H)*

2.54.9.1 For proper identification of subsurface material, sample should be recovered containing all the constituents of the materials in their proper proportion. In clayey deposits, such samples could be collected by split spoon samplers. In sandy deposits, sampling spoons shall be fitted with suitable devices for retaining samples. All data required for soil identification (Appendix-2.1 of IRC:75) should be collected from the samples so extracted when undisturbed samples, are not available. Penetration test should be carried out with the standard split spoon sampler or penetrometers if the soil is coarse grained. If the soil profile is known to be fairly regular, preliminary and detailed investigation may be combined. Tube samplers can be used in place of split spoon samplers for collecting samples in clayey strata.

2.54.9.2 Disturbed Soil Samples

2.54.4.2.1 Disturbed samples of soil shall be obtained in the course of excavation and boring. For procuring samples from below the ground water level, where possible, special type of sampler shall be used. Where Standard Penetration Test is conducted, representative samples shall be obtained from the split spoon. While collecting disturbed samples from borrow areas it shall be ensured that the samples collected represent all types of borrow materials to be used in the construction of embankment and subgrade.

2.54.9.2.2 The size of sample generally required shall be as given in Table 2400-2 of MoRT&H.

Table 107 : Size of Soil Sample Required *(Table 2400-2 of MoRT&H)*

S.No.	Purpose of Sample	Soil Type	Weight of Sample Required Kg
1)	Soil identification, natural moisture content tests, mechanical analysis and index properties, chemical tests	cohesive soils sands & gravels	1 3
2)	Compression tests	cohesive soils and sand	12.5
3)	Comprehensive examination of construction material and borrow area soil including soil stabilization	cohesive soils sands gravelly soil	25-50 50-100

2.54.9.2.3 While taking out disturbed soil samples, Standard Penetration Test may also be conducted to find out the bearing capacity of the subsoils at specified levels.

2.54.9.3 Undisturbed Soil Samples

2.54.9.3.1 The location of the bore-hole shall be as indicated on the drawing or given by the Engineer. The depth of the bore-hole shall be as indicated on the drawing or shall be governed by the criteria given therein or as directed by the Engineer.

2.54.9.3.2 Samples shall be obtained in such a manner that their moisture content and structure do not get altered. This may be ensured by use of correctly designed sampler and by careful preservation and packing.

2.54.9.3.3 Standard Penetration Test may have to be conducted in each case to obtain additional data as directed by the Engineer, in soft clay, in-situ vane shear test as per IS:4434 may have to be conducted. Where all the three operations have to be carried out in one layer, the sequence shall be as follows: undisturbed soil sampling, in-situ vane shear test, Standard Penetration Test.

2.54.9.3.4 For compression test samples, a core of 40 mm diameter and about 150 to 200 mm length may be sufficient, but for other laboratory tests, a core of 100 mm diameter and 300 mm length shall be taken unless otherwise specified by the Engineer.

2.54.9.3.5 The upper few millimeters of both types of sample shall be removed as the soil at the bottom of the bore hole usually gets disturbed by the boring tools.

2.54.9.4 Rock Samples

2.54.9.4.1 Disturbed Samples

The sludge from percussion borings or from rotary borings which have failed to yield a core, shall be collected to serve as a disturbed sample. It may be recovered by settlement of circulating water in a trough.

2.54.9.4.2 Undisturbed Samples

Block samples taken from the rock formation shall be dressed to a size of about 90 mm x 75 mm x 50 mm.

Cores of rock shall be taken by means of rotary drills fitted with a coring bit with core retainer, if warranted.

2.54.9.4.3 In case rock is met with at shallow depths, test pits or trenches may be dug. These are most dependable since they permit a direct examination of the surface, the weathered zone and discontinuities, if any. It is also possible to take representative samples for tests. For guidance, IS:4453 may be referred.

2.54.10 TESTS FOR INVESTIGATION OF SHALLOW FOUNDATIONS OF BRIDGES *(cl. 2411 of MoRT&H)*

2.54.10.1 Digging of test pits or trenches is the most dependable method of investigation, since it permits direct and reliable visual examination of the type of soil and its stratification. In-situ tests like plate bearing tests, shear tests and uni-axial jacking tests can also be conveniently carried out in the test pits.

2.54.10.2 Tests shall be conducted on undisturbed samples, which may be obtained from open pits. The use of Plate Load Test (as per IS: 1888) is considered desirable to ascertain the safe bearing capacity and settlement characteristics. A few exploratory bore holes or soundings extending to a depth of about V/2 times the proposed width of foundation shall also be made to ascertain whether there is any weak strata underlying the foundation.

The results of laboratory tests shall be correlated with those of in-situ tests like Plate Load Tests and Penetration Test.

2.54.11 TESTS FOR INVESTIGATION FOR DEEP FOUNDATIONS OF BRIDGES *(cl. 2412 of MoRT&H)*

2.54.11.1 The tests to be conducted for obtaining the properties of soil are different for cohesive soils and for cohensionless soils. These are enumerated below and shall be carried out, wherever practicable, according to soil type. While selecting the tests and interpreting the results, limitation of applicability of particular tests shall be taken into account. A most suitable and appropriate combination of tests shall be chosen, depending on the properties needed for design and constructional aspects.

2.54.11.2 Cohesionless Soil

a) **Laboratory Tests**

n) Classification tests, index tests, density determination, etc.
ii) Shear strengths by triaxial/direct shear, etc.

b) **Field Tests**

i) Plate Load Test (as per IS: 1888)
ii) Standard Penetration Tests (as per IS:2131)
iii) Dynamic Cone Penetration Test (as per IS:4968 Part I or Part II)
iv) Static Cone Penetration Test (as per IS:4968 Part III).

2.54.11.3 Cohesive Soil

a) **Laboratory Tests**

i) Classification tests, index tests, density determination, etc.
ii) Shear strengths by triaxial/direct shear, etc.
iii) Unconfined Compression Test (as per IS:2720 Part X)
iv) Consolidation Test (as per IS:2720 Part V)

b) **Field Tests**

i) Plate Load test (as per IS:1888)
ii) Vane Shear Test (as per IS:4434).
iv) Static Cone Penetration Test (as per IS:4968 Part III)
v) Standard Penetration Tests (as per IS:2131),
vi) Dynamic Cone Penetration Test (as per IS:4968 (Part I or Part II)

2.54.11.4 For both cohesionless and cohesive soils where dewatering is expected, permeability tests may be conducted as per IS: 2720 Part XVII.

2.54.11.5 The subsoil water shall be tested for chemical properties to ascertain whether there is any hazard which may cause deterioration of concrete in foundations. Where dewatering is expected to be required, permeability characteristics shall also be determined.

2.55 EXPANSION JOINTS

2.55.1 GENERAL *(cl. 2602 of MoRT&H)*

2.55.1.1 The type of expansion joint proposed to be used shall conform to the design and got approved by the Engineer.

2.55.1.2 Expansion joints shall be robust, durable, water-tight and easy for inspection, maintenance and replacement. Site fabricated expansion joints shall be prohibited. Expansion joints shall be procured from approved manufacturers and shall be of proven type.

2.55.1.3 Alternative proprietary type deck joints proposed by the Contractor in lieu of the type specified shall comply in all respects with the manufacturer's specifications and meet the required range of movements and rotations and be fit for the purpose of ensuring satisfactory long term performance. For such proprietary type deck joints the following information shall be provided.

i) Name and location of the proposed manufacturer.
ii) Dimensions and general details of the joint including material specifications, holding down bolt or anchorage details and installation procedures.

iii) Evidence of satisfactory performance under similar environmental conditions of similar joints being produced by the manufacturer.

Acceptance of any alternative type of expansion joint shall be at the sole discretion of the Engineer. Such deck joints shall be installed in accordance with the manufacturer's recommendations and to the requirements of these Specifications.

Vehicular traffic shall not be allowed over expansion joints after their installation for such period as may be determined by the Engineer.

2.55.1.4 The expansion joint shall be provided to cover the entire carriageway, kerb and footpath, wherever provided. It shall follow the profile of the deck including the kerb, footway and facia. The expansion joint for kerb, footway and facia may be of different type and specification from that used for the carriageway and it shall cater to all movements and rotations for which the carriageway expansion joint is designed and shall be water tight.

2.55.2 FILLER JOINTS *(cl. 2604 of MoRT&H)*

2.55.2.1 Components

The components of this type of joint shall be corrugated copper plate at least 2 mm thick placed slightly below the wearing coat, 20 mm thick compressible fiber board to protect the edges, 20 mm thick pre-moulded joint filler filling the gap up to the top level of the wearing coat and sealant of suitable joint sealing compound.

2.55.2.2 Material

i) The material used for filling expansion joint shall be bitumen impregnated felt, elastomer or any other suitable material, as specified on the drawings, impregnated felt shall conform to the requirements of IS:1838, and shall be got approved from the Engineer. The joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall be avoided.

ii) Expansion joint materials shall be handled with care and stored under cover by the Contractor to prevent damage.

iii) Any damage occurring after delivery shall be made good to the satisfaction of the Engineer and at the expense of the Contractor.

2.55.2.3 Fabrication and Installation

i) Joint gaps shall be constructed as shown on the drawings. Surfaces of joint grooves shall be thoroughly cleaned with a wire brush to remove all loose materials, dirt and debris, then washed or jetted out.

ii) Pre-moulded expansion joint filler shall not be placed in position until immediately prior to the placing of the abutting material. If the two adjacent faces of the joint are to be installed at different times, the joint filler shall be placed only when the second face is ready to be kept in position

iii) Sealants shall be installed in accordance with the manufacturer's recommendations.

iv) Sealants shall be finished approximately 3 mm below the upper surfaces of the joint.

v) Joint materials spilt or splashed onto finished surfaces of the bridge during joint filling operations shall be removed and the surfaces made good to the Engineer's approval.

vi) No joint shall be sealed until inspected by the Engineer and approval is given to proceed with the work.

2.55.3 REINFORCED ELASTOMERIC JOINT *(cl. 2605 of MoRT&H)*

2.55.3.1 Components

Reinforced elastomeric expansion joint shall comprise of following components:

i) Steel Inserts : The elastomeric slab units shall be fixed to the steel inserts properly anchored in the deck concrete. Fixing of elastomeric slab units with anchoring bolts directly embedded in deck concrete shall not be permitted. Steel inserts along with anchorage shall be fabricated at manufacturer's workshop and not at site.

ii) Anchorage : The anchorage shall either be loop anchors connected to the inserts by anchor plate or sinusoidal anchor bars welded with the horizontal leg of the steel inserts. For loop anchors with anchor ptate, the thickness of the anchor plate shall not be less than 12 mm. Diameter of anchor loops shall not be less than 16 mm and the spacing of anchors shall not be more than 250 mm. For sinusoidal anchors, diameter of bar shall not be less than 12 mm.

iii) Fixing Bolts : Fixing bolts and nuts shall be made of stainless steel. Tightened nuts shall be locked by using lock washers.

iv) Elastomeric Plugs : The plug holes provided in elastomeric slab units to house fixing bolts shall be plugged with elastomeric plugs pressed in position after applying adhesive on the surfaces.

v) Adhesives and Sealants : Special sealant to be poured into the plug holes before plugging and special adhesive to be used for installation, shall be as per the recommendation of manufacturer.

vi) Necessary spacer bars to ensure proper positioning of bolts and leveling and aligning steel inserts during fixing with deck as well as special jigs to be used to preset the elastomeric slab units, shall be provided by the manufacturer.

2.55.3.2 Material

i) Mild steel to be used for manufacture of steel reinforcing plates, inserts and anchorage shall comply with Grade B of IS:2062.

ii) Cast steel to be used for manufacture of steel reinforcing plates shall comply with IS:1030.

iii) The elastomer to be used for manufacture of elastomeric slab units shall comply with Clause 915.1 of IRC:83 (Part II), compounded to give hardness IRHD 60 ± 5.

2.55.3.3 Fabrication

j) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be sand/shot blasted to SA 2½ and provided with a coat of epoxy primer enriched with metallic zinc. Surfaces not to be in contact with or embedded in concrete shall be provided with an additional coat of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per manufacturer's specification with minimum total dry film thickness of 150 micron.

ii) Elastomeric slab units shall be fully moulded to the required size in one single vulcanizing operation including the reinforcing plates and encasing layers as one integral and homogeneous unit. Edges of reinforcing steel sections shall be rounded. The elastomeric slab units shall be manufactured generally as per the stipulations laid down in Clause 917 of IRC: 83 (Part II). Adjoining portions of elastomeric slab units shall be provided with suitable male-female groove to ensure water tightness.

iii) Permissible tolerances of fabrication shall be as follows:

Plan dimension	± 5 mm
Total height	± 3 mm

2.55.3.4 Supply and Handling

i) The Contractor shall supply all steel-reinforced elastomeric expansion joints including bolts, nuts, sealant, plugs and all other accessories for the effective installation of the joints including angled jointing sections for kerbs.

ii) Expansion joint material shall be handled with care and stored under cover by the Contractor to prevent damage. Any damage occurring after delivery shall be made good at the expense of the Contractor to the satisfaction of the Engineer.

2.55.4 SINGLE STRIP/BOX SEAL JOINT *(cl. 2606 of MoRT&H)*

2.55.4.1 Components

Strip seal expansion joint shall comprise the following:

i) **Edge Beam :** This shall be either extruded or hot rolled steel section including continuously shop welded section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further, the configuration shall be such that the section has a minimum thickness of 10 mm all along its cross section (flange and web). Thickness of lips holding the seal shall not be less than 6 mm. The minimum height of the edge beam section shall be 80 mm. The minimum cross sectional area of the edge beam shall be 1500 mm2.

ii) **Anchorage :** The edge beams of single strip/box seal joints shall be anchored in the concrete with rigid loop anchorage. The anchor loops shall be connected to the edge beam by means of anchor plate welded to the edge beam. Total cross sectional area of anchor loop on each side of the joint shall not be less than 1600 mm2 per metre length of the joint and the centre to centre spacing shall not exceed 250 mm. The thickness of anchor plate shall not be less than 0.7 times the diameter of anchor loop or 12 mm whichever is higher. The anchor loop at the edge profiles should be at right angles to the joint. Planned deviations of this direction are allowable only for the range of 90° ± 20°. The anchoring reinforcement of the construction must lie parallel to the anchor loops.

iii) **Sealing Element :** This shall be a preformed/extruded single strip of such a shape as to promote self-removal of foreign material during normal joint operation. The seal shall possess high tear strength and be insensitive to oil, gasoline and ozone. It shall have high resistance to ageing. The specially designed proprietary type of locking system of seal in the housing of edge beam shall be such as to ensure 100% water tightness as well as ease of installation and replacement. Mechanical fastening of sealing element with edge beam shall not be permitted. Sealing element shall be continuous over the entire joint

The working movement range of the sealing element shall be at least 80 mm with a maximum of 100 mm at right angles to the joint and ± 40 mm parallel to the joint.

Minimum gap for inserting the Chloroprene seals in the expansion joint shall be 25 mm.

2.55.4.2 Material

i) The steel for edge beams shall conform to any of the steel grade equivalent to RST 37-2 or 37-3 (DIN), S235JRG2 or S355K2G3 of EN 10025 (DIN 17100), ASTM A 36 or A 588, CAN/CSA Standard G40.21 Grade 300 W and Grade B of IS:2062. For subzero condition, material for steel shall conform to IS:2062 Grade C.
ii) The sealing element shall be made of Choloroprene Rubber (CR). The properties of CR shall be as specified in Table 2600-1 of MoRT&H.
iii) Anchorage steel shall conform to Grade B of IS: 2062 or equivalent standard.

2.55.4.3 Fabrication (Pre-installation)

i) Rolled steel profiles for edge beams shall be long enough to cater for the full carriageway width. These shall be cut to size as per actual requirements. Alignment of the steel profiles shall then be made on work tables in accordance with the actual bridge cross-section. For this purpose, the contour of bridge cross-section shall be sketched on the tables. After the steel profiles are aligned, these will be fixed to the tables by means of screw clamps and tacked by arc welding.
ii) Anchor plates shall be cut to the required size by gas cutting. These shall be welded to the edge beams.
iii) Anchor loops shall be bent to the required shape and welded to anchor plates.
iv) All steel sections shall be protected against corrosion by either hot dip galvanizing with a minimum thickness of 150 micron or by epoxy coating.
v) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be given treatment as mentioned in Clause 2605.3 (i) of MoRT&H.
vi) The finally assembled joints shall then be clamped and transported to the work site.

2.55.4.4 Handling and Storage

i) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
ii) The manufacturer shall supply either directly to the Engineer or to the Contractor ail the materials of strip seal joints including sealants and all other accessories for the effective installation of the joint.
iii) Expansion joint material shall be handled with care. It shall be stored under cover on suitable wooden padding to prevent damage. Any damage occurring after delivery shall be made good at the cost of Contractor to the satisfaction of the Engineer

2.55.5 MODULAR STRIP/BOX SEAL EXPANSION JOINTS *(cl. 2607 of MoRT&H)*

2.55.5.1 Components

A modular expansion joint shall consist of two or more modules/cells of individual capacity 80 mm to cater to a horizontal movement in excess of 80 mm. It shall allow movements in all three directions and rotation about all three axes as per the design requirements. The structural system shall consist of two edge beams, one or more central/separation beams or

lamellas and cross support bars supporting individuals or multiple central beams to transfer the loads to the bridge deck through the anchorage system.

i) Edge Beams and Central Beams/Lamella : These shall be as per Clause 2606.1(i) of MoRT&H.

ii) Anchorage : Anchorage of edge beam shall be as per Clause 2606.1 (ii). Studs and/or loop anchors with anchor plate may be used as anchorage of other components like joist box and covers of controlling system.

iii) Sealing Element : This shall be as per Clause 2606.1 (iii). Minimum gap for inserting the neoprene seals in the expansion joint shall be 25 mm.

iv) Support and Control System : The control system should allow closing and opening of the joint and also ensure that all modules open and close equally during all movement cycles of the joint. The overall support and control system shall be either single/multiple support bar control system or swivel joint system comprising of resilient/shock absorption components and elastic/sliding control system conforming to the specifications recommended by the manufacturer. The gap between the consecutive centre beams at the joint surface shall be limited to 80 mm when the joint opens fully due to maximum contraction of deck.

2.55.5.2 Material

i) The steel for edge beams, centre beam/lamella, transverse support bar and other steel components shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 or 52-3 (DIN), S235JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A588, CAN/CSA standard G40.21 Grade 300 W.

ii) The sealing element shall be of Chloroprene Rubber (CR). The properties of CR shall be as specified in Table 2600-1 of MoRT&H.

iii) The specification for all other materials shall be as per manufacturer's recommendation.

2.55.5.3 Fabrication (Pre-installation)

i) Profile of edge beam, centre beam/lamella shall be long enough to cater for full carriageway width.

ii) The fabrication of all components of the joints including anchorage system and transportation of assembled joints shall be as per manufacturer's specification.

iii) All steel sections shall be suitably protected against corrosion as stated in Clause 2606.3 (iv).

iv) All surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete shall be given treatment as mentioned in Clause 2605.3 (i) of MoRT&H.

2.55.5.4 Handling and Storage

i) Arrangement for transportation and storage shall be as per manufacturer's specification.

ii) The manufacturer shall supply either directly to the Engineer or to the Contractor all the materials of strip seal joints including all sealants and other accessories for the effective installation of the joint.

2.55.6 ASPHALTIC PLUG JOINT *(cl. 2608 of MoRT&H)*

2.55.6.1 General

i) This joint shall consist of a polymer modified bitumen binder, carefully selected single size aggregate, closure/bridging metallic plate and heat resistant foam caulking/backer rod.

ii) The joint shall be capable of performing satisfactorily, within the temperature (ambient) range of-5°C to +50°C.

2.55.6.2 Material

i) Binder: The polymer modified bitumen binder shall have the capacity to fill the gaps and voids between single size aggregates and to impart flexibility to accommodate various design movements. It shall be a patented blend of bitumen, synthetic polymer, filler and surface active agent and shall be so formulated as to combine necessary fluidity for the installation process, low temperature flexibility and flow resistance at high ambient temperature. The binder shall satisfy following requirement:

- Softening point : 100°C minimum
- Cone penetration at 25°C, 0.1 mm (BS:2499) : 100 mm max

- Flow resistance at 70°C, 5 hours (BS:2499) : 3 mm max
- Extension Test 5 cycle of extension to 50% (blocks prepared to ASTM D1190atarate of 3.2 mm/hour at and tested to limits BS:2499) : 25°C
- Safe heating temperature. : 210°C

ii) Aggregates : The aggregate shall be of single size chosen from basalt granite, grit stone or gabro group. The nominal size of aggregate shall be 12.5 mm for joints up to 75 mm depth and 20 mm for joints of larger depth. The flakiness index shall not be more than 25 percent. The aggregate shall satisfy grading requirements stipulated in Table 2600-2 of MoRT&H.

Table 108 : Grading Requirements of Aggregate *(Table 2600-2 of MoRT&H)*

IS Sieve Designation	Nominal Size of Aggregate	
	20 mm	25 mm
	Percentage by Weight Passing the Sieve	
26.5 mm	100	-
19.9 mm	85- 100	100
13.0 mm	0-35	85-100
9.5 mm	0-7	0-35
6.3 mm	-	0-7
2.3 mm	0-2	0-2
75 micron	0- 1	0-1

The Polished Stone Value (PSV), Aggregate Abrasion Value (AAV), Aggregate Impact Value (AIV) and Aggregate Crush Value (ACV) shall be as below:

PSV > 60
AAV > 05
AIV < 18
ACV = 10-25

The surface characteristics should promote proper adhesion,

iii) Closure Plate : The closure plate shall be weld able structural steel conforming to IS:2062. The minimum thickness of steel plate shall be 6 mm and the width shall not be less than 200 mm. Closure plate shall preferably be of single length but it shall not have more than 2 pieces per traffic lane width which shall be welded together to form the required length. It shall be provided with equidistant holes at a maximum spacing of 300 mm centers for anchorage to the caulking/ backer rod along the longitudinal centre line of the plate. The plate shall be protected against corrosion by galvanizing or by any other approved anti-corrosive coating paint with a minimum thickness of 100 micron.

iv) Foam Caulking/Backer Rod: The foam caulking shall be closed cell polyolefin or open cell polyurethane foam cylindrical type. The backer rod shall be of diameter equal to 150 percent of the joint opening. It shall be heat resistant and possess good flexibility and recovery characteristics with density of 25 kg/m3 to 30 kg/m3.

2.56 WEARING COAT AND APPURTENANCES

2.56.1 WEARING COAT *(cl. 2702 of MoRT&H)*

2.56.1.1 Bituminous Wearing Coat

Bituminous wearing coat shall comprise of following types:

Type 1: Bituminous Concrete 50 mm thick laid in single layer
Type 2: Bituminous Concrete 40 mm thick overlaid with 25 mm thick mastic asphalt
Type 3: Stone Matrix Asphalt 50 mm thick laid in single layer
Type 4: Mastic Asphalt 50 mm thick laid in single layer

Before laying wearing coat the deck surface shall be thoroughly cleaned and tack coat shall be applied. The construction operations and bituminous mixes and tack coat shall conform to Section 500 of MoRT&H Specifications.

2.56.1.2 Cement Concrete Wearing Coat

Cement concrete wearing coat shall be laid separately over the bridge deck. The thickness of wearing coat shall be 75 mm. The concrete shall be of minimum M30 grade. Steel reinforcement of 8 mm diameter at 150 mm spacing in both directions shall be provided at the mid depth of the wearing coat. In a length of 1 m near the expansion joint additional reinforcement of 8 mm diameter bars shall be provided in both directions to make the spacing as 75 mm.

Cement concrete and steel reinforcement shall conform to Section 1700 and Section 1600 respectively of MoRT&H Specifications.

Curing of wearing coat shall start as early as possible.

All carriageway and footpath surfaces shall have non-skid characteristics.

2.56.1.2.1 The cross slope in the deck shall be kept as 2.5 percent.

2.56.1.2.2 For the structures with flat deck surface, camber/super elevation in the wearing coat shall be achieved as below:

i) In bituminous wearing coat provide profile making course before laying wearing coat. The profile making course shall be of the same material as of wearing coat. The thickness of wearing coat at any point shall not be less than that given in Clause 2702.1 of these Specifications.

ii) In case of cement concrete wearing coat provide profile corrective course along with wearing coat in single layer.

2.56.1.2.3 Overlay on the existing wearing coat on bridge decks shall not be permitted.

In case the wearing coat is damaged, it shall be repaired or replaced. The dismantling of wearing coat shall be as per Section 2800 of these Specifications.

2.56.2 RAILING AND CRASH BARRIER *(cl. 2703 of MoRT&H)*

2.56.2.1 General

a) Bridge railing/crash barrier includes the portion of the structure erected on and above the kerb.

b) Railing/crash barrier shall not be constructed until the centering false work for the span has been released and the span is self-supporting.

c) For concrete with steel reinforcement, specifications for the items of controlled concrete and reinforcement mentioned under relevant Sections of these Specifications shall be applicable.

d) The railing/crash barrier shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled with non-shrink mortar.

e) The type of railing/crash barrier to be constructed shall be as shown on the drawings and shall conform to IRC:5 and IRC:6.

f) Care shall be exercised in assembling expansion joints in the railing/ crash barrier to ensure that they function properly.

g) The railing/crash barrier shall be of such design as to be amenable to quick repairs.

h) The material of metal railing/crash barrier shall be handled and stored with care, so that it remains clean and free from damage. Railing/crash barrier materials shall be stored above the ground on platforms, skids, or other supports and kept free from grease, dirt and other contaminants.

Any material which is lost, stolen or damaged after delivery shall be replaced or repaired by the Contractor. Methods of repairs shall be such that they do not damage the material or protective coating.

2.56.2.2 Metal Railing/Crash Barrier

Materials, fabrication, transportation, erection and painting for bridge railing/crash barrier shall conform to the requirements of Section 1900 of these Specifications.

All steel railing elements, pipe terminal Sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint.

If galvanised, all elements of the railing/crash barrier shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done as per method approved by the Engineer.

Damaged galvanised surfaces, edges of holes and ends of steel railing/crash barrier cut after galvanising shall be cleaned and re-galvanised.

The railing/crash barrier shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout its length. Holes for field connections shall be drilled with the railing/crash barrier in place in the structure at proper grade and alignment.

Unless otherwise specified on the drawings, metal railing/crash barrier shall be given one shop coat of paint and three coats of paint after erection, if sections are not galvanised.
Railing/crash barrier shall follow the alignment of the deck. Where required as per the drawings, the rail elements shall be before erection.

2.56.2.3 Cast In-Situ Concrete Railing/Crash Barrier

The portion of the railing/crash barrier or parapet which is to be cast in-situ shall be constructed in accordance with the requirements for Structural Concrete Section and reinforcement conforming to Sections 1600 and 1700 of these Specifications.

Forms shall be fabricated conforming to the shape of railing/crash barrier shown on the drawings. It shall be ensured that no form joint appears on plane surfaces. For bridges/ viaducts of length more than 500 m horizontal slip forms shall be used for casting of crash barriers.

All mouldings, panel work and bevel strips shall be constructed according to the details shown on the drawings. All corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects. Castings of posts shall be done in single pour.

2.56.3 APPROACH SLAB *(cl. 2704 of MoRT&H)*

Reinforced concrete approach slab with 12 mm dia bars at 150 mm c/c in each direction both at top and bottom in M30 grade of concrete covering the entire width of the roadway, shall be provided as per details given on the drawings or as approved by the Engineer. Minimum length of approach slab shall be 3.5 m and minimum thickness 300 mm.

The cement concrete and reinforcement shall conform to Sections 1700 and 1600 respectively of these Specifications.

The approach slab shall rest on a base of 150 mm thick M15 grade concrete or as shown on the drawings or as directed by the Engineer.

2.56.4 DRAINAGE SPOUTS *(cl. 2705 of MoRT&H)*

Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be of corrosive resistant material such as galvanised steel with suitable cleanout fixtures. The spacing of drainage spouts shall not exceed 10 m. The discharge from drainage spout shall be kept away from the deck structure by means of suitable down pipes upto 500 mm above High Flood Level. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located runners and down pipes to discharge the surface run-off into drains provided at ground level.

2.56.5 WEEP HOLES *(cl. 2706 of MoRT&H)*

Weep holes shall be provided on all plain concrete, reinforced concrete, brick masonry and stone masonry structures such as, abutment, wing wall and return walls as shown on the drawings or as directed by the Engineer to permit water to flow out without building up pressure in the backfill. Weep holes shall be provided with 100 mm diameter AC/PVC/HDPE pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be of rectangular shape 80 mm wide, 150 mm high or circular with 150 mm diameter. Weep holes shall extend through the full width of concrete/masonry with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes shall be 1 m in either direction or as shown in the drawings with the lowest at 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.

2.57 REINFORCED SOIL

2.57.1 REINFORCING ELEMENT *(cl. 3103 of MoRT&H)*

2.57.1.1 The reinforcing element shall be metallic in the form of strips (aluminum alloy strip, copper strip, carbon steel strip, galvanised steel strip, stainless steel strip, ladder) or mats of metal (steel grids, woven and welded steel wire meshes) or synthetic (PET, HDPE, PVA, PP) reinforcement in the form of grid or strip or strap or combination of metallic or synthetic or any other proprietary material which may be approved by the Engineer and shown on the drawings

2.57.1.2 Aluminum alloy strip shall comply with BS:1470 quality 5454 in the H 24 condition.

2.57.1.3 Copper strip shall comply with BS:2870 quality C 101 or C 102 in the 1/2 H condition and shall have 0.2 percent proof stress of not less than 180 N/mm2.

2.57.1.4 Carbon steel strip shall comply with BS EN 10025 or IS:2062 and have a silicon content of not more than 0.55 percent. The fabricated element shall be galvanized in accordance with IS:4759 and IS:2629 and the minimum zinc coating weight shall not be less than 1000gm/sq.m

The steel strips with minimum bearing and shear strength of 490N/mm2 shall comply with the requirements of BS EN 10025, Grade S 355 JR, or IS:2062 grade Fe 490, except the elongation (on base metal) for which minimum 22 percent is acceptable.

Tests shall be carried out to provide values of

i) Pull-out coefficient as per ASTM D 6706 "Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil" and

ii) Coefficient of interaction between reinforced fill soil and geogrids as per ASTM D 5321-"Standard Test method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear method" or as per IS: 13326: Part 1 -1992 "Method of test for the evaluation of interface friction between geosynthetics and soil: Part 1 Modified direct shear technique" for all types of geogrids.

One set of project specific tests shall be conducted at third party accredited laboratory or at a reputed institute.

Each roll shall have at least one identification label with roll number and product type.

The fill material in the reinforced soil zone shall have drained or effective angle of friction not less than 30°, measured in accordance with IS: 2720 (Part 13), by conducting a drained direct shear test. In case the fill material has 25 percent or more particles of 4.75 mm or larger, drained shear test using large shear box may be conducted (IS: 2720 Part 39: Section 1). The gradation of fill soil shall be as per following limits.

Sieve Size	Percentage Passing
75 mm	100%
425 micron	0-60%
75 micron	less than 15
PI<6	

Materials with more than 15 percent passing 75 micron sieve, but less than 10 percent of particles smaller than 15 microns are acceptable provided PI is less than 6 and angle of friction is not less than 30°.

Fly ash may be used as fill material in reinforced soil walls provided its angle of internal friction is not less than 300 and PI is less than 6. Gradation requirements need not be completely satisfied. Reference may be made to IRC Guide lines on Use of Flyash in Road Embankments (IRC:SP-58). Fly ash shall also satisfy requirements concerning pH and environmental conditions of the fill vis-a-vis the reinforcement type as specified in Clause 3014.1.

The fill material used in the reinforced soil zone shall be free from organic or other deleterious materials and shall not react adversely (chemically, electrically or biologically) with the reinforcement material and/or facia material.

Properties of fill soil in the reinforced zone, unreinforced zone (or retained/back fill) soil and the foundation soil shall be determined accurately during the construction phase, as per quality assurance plans and directions of Engineer so as to ensure that these are the same as those considered in the design phase.

The fill soil in the unreinforced zone shall conform to the requirements specified in the design.

2.57.2 Steel Reinforcement

Where galvanized steel reinforcement is used, the fill material shall be free draining granular material and shall meet the following requirements as per Table 3100.1.

Table 109: Recommended Limits of Electrochemical Properties for Reinforced Fills with Steel Reinforcement *(Table 3100-1 of MoRT&H)*

Property	Criteria	Test Method
Resistivity	> 3000 ohm-cm	AASHTO T-288
pH	> 5 and < 10	AASHTO T-289
Chlorides	< 100 PPM	ASTM D 4327
Sulphates	< 200 PPM	ASTM D 4327

2.57.3 Geosynthetic Reinforcement

Where geosynthetic reinforcement is used for reinforcing elements manufactured from polyester yarn, pH value of the fill material shall be between 3 and 9, and for reinforcing elements manufactured from PVA, PP and HDPE, the pH value shall be greater than 3.

2.57.4 FACIA MATERIAL *(cl. 3105 of MoRT&H)*

2.57.4.1 The facing system shall be one of the following

a) Precast reinforced concrete panels
b) Precast concrete blocks and precast concrete hollow blocks.
c) Gabion facing
d) Wrap around facing using geosynthetics
e) Metallic facing, prefabricated in different shapes including welded wire grid and woven steel wire mesh
f) Other proprietary and proven systems Facing shall be sufficiently flexible to withstand any deformation of the fill and foundations.

The facia units to be adopted in the project shall be shown in the drawings and shall be approved by the Engineer.

2.57.4.1.1 Precast Reinforced Concrete Panels

The minimum thickness of precast concrete panels shall be 180 mm including facing textures, logos and embellishments. The grade of concrete shall be minimum M35. The concrete shall conform to the requirements of Section 1700 of these Specifications.

Facia panel systems shall have provision of both horizontal and vertical gaps to prevent concrete to concrete contact. The horizontal gap between the facing elements shall be maintained by provision of Ethylene Propylene Diene Monomer (EPDM) pad. Bedding material shall consist of either cement mortar or a durable gasket seating such as resin bonded cork, bitumen bonded cork or EPDM.

The joints between the panels shall be covered from inside with non-woven geotextile strips glued to the facing element ensuring full coverage of joints. Synthetic glue shall be used for this purpose. The width of the geotextile strip shall not be less than 100 mm.

2.57.4.1.2 Precast Concrete Blocks/Segmental Blocks/Modular Blocks

Precast concrete blocks are dry cast and shall be manufactured from fully automatic block making machines. The minimum grade of concrete shall be M 35 for all kinds of modular blocks. In case of hollow blocks, the hollow area shall not exceed 40 percent of the cross sectional area of the block. The outer side of the block shall have minimum thickness of 100 mm.

2.57.4.1.3 Gabion Facia

Where gabion facia is used, it shall conform to the provisions of BS 8006-1:2010 and EN 14475 and made of mechanically fabricated and selvedged double twisted hexagonal mesh. Wire used for the double twisted mesh shall be hot dip galvanized as per IS:4826 -heavily coated and soft type, with wire and mesh properties in accordance with EN-10223 with minimum Zn or Zn + alloy coating as per EN-10244 and 0.5 mm thick PVC coating as per EN-10245 and ISO-527.

2.57.4.1.4 Wrap Around Facing using Geosynthetics

Where geosynthetics, including geogrids are used as wrap around facia, these shall form a part of the reinforcing element. The wrap around shall have adequate length to resist pull out and the wrap around length shall be calculated on the basis of safety in pull out. Wrap around facia shall be protected by suitable means, against adverse effects of natural forces.

2.57.4.1.5 Metallic Facing, Prefabricated in Different Shapes Including Welded Wire Grid, Steel Sheet and Woven Steel Wire Mesh

Where steel sheet and steel grids facings are used for facing, steel for steel sheet shall be as per BS:1449-Part 1 and steel grids shall conform to BS:4482, BS:4483 and BS:4489.

Where mechanically woven steel wire mesh in wrap around form is used for facing, the steel wire mesh (IS:4826, IS:280, IS:13360, EN:10218, EN:10223, EN:14475) shall be with mechanical selvedging and bottom panel shall continue as an integrated tail mesh.

Where welded steel wire mesh units in wrap around form (EN:10079, EN:10080, and EN:ISO 1461, EN:14475) are used as facing, the bottom panel shall continue as an integrated tail mesh.

2.57.4.1.6 Facia type adopted shall be given in the design and shown with complete details in the drawings. The system supplier shall provide any test data to satisfy the Engineer regarding the properties and suitability of the facia system adopted, if so required.

Where facia such as wrap around or gabion or welded wire and woven steel wire mesh facings have been used and where climate conditions are appropriate, a green finish shall be provided where specified.

2.57.5 Connection between the Facia and Reinforcement

Connection between the facia panels and the reinforcing element shall be by using either nut or bolt, HDPE inserts with bodkin joint, hollow embedded devices, polymeric/steel strips/ rods/pipes, fibre glass dowels or any other material shown in the drawings. The connection between the panel and the reinforcement shall provide for 100 percent of the long term design strength of the reinforcing element in continuity.

In case of modular block facia and other type of facia such as gabion facia, where the reinforcement is held by friction between the facia block and the reinforcement, the connection strength shall be determined as per ASTM D 6638 "Standard Method of Test for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units."

The available connection strength shall satisfy the design requirements and shall not be less than the maximum possible tensile force that the reinforcement layer under consideration may be subjected to.

2.57.6 CONSTRUCTION DETAILS *(cl. 3106 of MoRT&H)*

2.57.6.1 Depth of Foundation

A strip footing, minimum 350 mm wide and 150 mm thick in M15 grade plain concrete, shall be provided at founding level to receive the facia or the bottom most reinforcement.

The depth of embedment below the finished ground level at the foot of the wall shall not be less than 1000 mm. In case rock is met above founding level, the depth of embedment shall be adjusted as per ground conditions.

2.57.6.2 Laying of Reinforcement

The reinforcing elements shall be placed at right angles to the face of the wall or design axis, with greater cross-sectional dimension in the horizontal plane and the length shall be as shown in the drawings. Reinforcing elements such as geogrids, shall be stretched and held taut by driving nails or pegs at the farther end.

2.57.6.3 Facing Batter

It may be necessary to set facing unit at an additional batter than as provided in the drawings since there is a tendency for initially positioned units of facia to lean outward as the fill material is placed and compacted. Care and caution shall be taken to accommodate this phenomenon. At the end of the construction, the face may have a slight residual inward batter.

2.57.6.4 Drainage

Drainage bay shall be provided as shown in the drawings. The width of the drainage bay shall be 600 mm behind the facing element.

The drainage material shall conform to the specifications of the filter media as per Clause 2504.2.2 of MoRT&H Specifications.

2.57.6.5 Laying and Compaction

The reinforcing elements shall be laid free from all kinks, damage and displacement during placing, spreading, leveling and compaction of the fill. The programme of filling shall be such that no construction plant moves directly on the reinforcement.

All construction plant having a mass exceeding 1500 kg shall be kept at least 2.0 m away from the face of slope or wall.

In the area up to 2.0 m from the face of slope or wall, the following compaction plant shall be used:

i) Vibratory roller having a weight per metre width not exceeding 1300 kg with total weight not exceeding 1500 kg

ii) Vibratory plate compactor of maximum weight 1000 kg

iii) Vibro tamper having a weight not exceeding 75 kg

Before allowing the movement of vehicles over the reinforcement, a minimum compacted thickness of 150 mm shall be provided over the reinforcement and the speed of the vehicles shall be restricted to 10 km/hr.

During construction of reinforced fill, the retained material beyond the reinforcement at the rear of the structure shall be maintained at the same level as reinforced fill.

Fill shall not be placed on surface that contains mud, organic soil or area that have not met compaction requirement.

The thickness of compacted layer shall not be more than 200 mm, compacted to 97 percent of maximum laboratory density measured as per IS:2720 (Part 8).

2.57.6.6 Construction and Serviceability Tolerances

The construction tolerances shall be as per the following:

Casting of pre-cast RCC panels: All elements shall be manufactured within the following tolerances:

All dimensions within ± 5 mm Evenness of the front face: ± 5 mm over 1500 mm Difference between lengths of two diagonals: 5 mm max. Thickness: + 5 mm (-) 0 mm

Table 110 : Tolerances for Faces of Retaining Walls and Abutments *(Table 3100-2 of MoRT&H)*

	Tolerance
Location of plane of structure	± 50 mm - metallic reinforcement ± 75 mm - synthetic reinforcement
Bulging (Vertical) and Bowing (Horizontal)	± 20 mm in 4.5 m template (Metallic) ± 30 mm in 4.5 m template (Synthetic)
Steps at joints	± 10 mm

Dimensional Tolerances for Modular Blocks

Dimensions of modular concrete blocks shall not differ more than ± 2.5 mm for length and width and ± 1.5 mm in height.

Minimum Vertical Movement Capacities of Facing Systems

Minimum vertical movement capacities required for facing systems to cope with vertical internal settlement of reinforced fill shall be as below:

Table 111: Minimum Vertical Movement Capacities of Facing Systems *(Table 3100-3 of MoRT&H)*

Structural Form	Minimum Vertical Movement Capacity of System
Discrete panels	Joint closure of 1 in 150 relative to panel height
Full height panels	Vertical movement capacity of connections 1 in 150 relative to panel height
Semi-elliptical facings	Vertical distortion of 1 in 150 relative to panel height
Geotextile/ Geogrid wrap-around facings	No specific limit except for appearance or serviceability considerations

2.57.6.7 Capping Beam, Crash Barrier and Friction Slab

Capping beam, crash barrier and friction slab shall be provided as per the design and drawings.

Table 112: Minimum Stack Height & Allowance for Sinkage and/or Shrinkage for Different Materials

Sl. No.	Materials	Minimum stack height (cm)	Deduction in volume for sinkage and/or shrinkage
1.	Stone metal, slag, ballast, chips, shingles/gravels, Moorum, bajree	35	1/13
2.	Stone boulders of size below 15 cm., jhama metal, khoa or chips	45	1/9
3.	Carried earth, rubbish (building or kiln)	35	1/9
3.	Sand (necessary deduction for bulkage may be applied after deduction for sinkage/shrinkage)	50	1/8
4.	Stone dust	50	1/8
5.	Stone boulders of size 15 cm or above, jhama/brick bats	55	1/7
6.	Lime	60	1/5

Quality Control Test for Basic Construction Materials

1. For Concrete Works

1.1 Coarse Aggregate :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Particle Size and Shape** a) Sieve Analysis b) Flakiness Index and Elongation Index	1. At the beginning for approval of each source and change of source. 2. Once in a week.	IS: 383-1970 IS: 2386 (Part I)-1963	As per Table 1000-1 of MoRT&H. 35 % Maximum value of combined Elongation and Flakiness Index .
2)	**Deleterious Materials**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part II)-1963	**Deleterious Material** — **Percentage by weight (maximum)** 1. Coal & lignite — 1 2. Clay Lumps — 1 3. Material finer than 75 micron IS Sieve — 3 4. Soft fragment — - 5. Shale — - Total — 5
3)	**Specific Gravity & Density**	1. At the beginning for approval of each source and change of source. 2. Once in a Fortnight.	IS: 383-1970 IS: 2386 (Part III)-1963	Test is required for maintaining uniformity of material brought from the source.
4)	**Mechanical Properties** a) Aggregate Crushing Value b) Impact Value c) 10 per cent Fines d) Abrasion Value	1. At the beginning for approval of each source and change of source. 2. Once in a week. 1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part IV)-1963	45 % Maximum by Weight 45 % Maximum by Weight 5T Minimum 50 % Maximum by Weight
5)	**Soundness**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part V)-1963	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -12% (ii) tested with Magnesium Sulphate -18%
6)	**Surface moisture content**	1. At the beginning for approval of each source and change of source. 2. At every change of mix design 3. Every time making the concrete	IS: 383-1970 IS: 2386 (Part III)-1963	Test required to adjust the water content in the mix design before starting any concrete mixing.
7)	**Alkali Reactivity**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part VII)-1963	Innocuous Aggregate.

1.2 Fine Aggregate :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Particle Size and Shape**	1. At the beginning for approval of each source and change of source. 2. Once in a month.	IS: 383-1970 IS: 2386 (Part I)-1963	Fine Aggregate should be of grading from Zone-I to Zone-III as per Table 1000-1 of MoRT&H.
2)	**Deleterious Materials**	1. At the beginning for approval of each source and change of source. 2. Once in a month.	IS: 383-1970 IS: 2386 (Part II)-1963	**Deleterious Material** — **Percentage by weight (maximum)** 1. Coal & lignite — 1 2. Clay Lumps — 1 3. Material finer than 75 micron IS Sieve — 3 4. Soft fragment — - 5. Shale — - Total (1 to 5 above) — 5
3)	**Silt Content**	1. At the beginning for approval of each source and change of source. 2. Once daily.		Maximum 8 % or as specified in the tender.
4)	**Specific Gravity & Density**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part III)-1963	Test is required for maintaining uniformity of material brought from the source.
5)	**Water Absorption**	1. At the beginning for approval of each source and change of source. 2. Once daily.	IS: 383-1970 IS: 2386 (Part III)-1963	Test required for adjusting the water content in the mix design before starting any concrete mixing.
6)	**Soundness**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.	IS: 383-1970 IS: 2386 (Part V)-1963	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -10% (ii) tested with Magnesium Sulphate -15%

1.3 Water :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Analysis**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months. 3. Chemical Tests daily in the site Laboratory with testing kits.		Fine Aggregate should be of grading from Zone-I to Zone-III as given below.
	a) pH value		IS: 456-2000	Minimum 6.
	b) Chlorides (as Cl)		IS:3025 (Part 24)	500 mg/l.
	c) Sulphates (as SO_3)		IS:3025 (Part 32)	400 mg/l
	d) Neutralisation with NaOH (with phenolphthalein as indicator)		IS:3025 (Part 22)	Maximum 5 ml of .02 normal NaOH to neutralise 100 ml of water.
	e) Neutralisation with H_2SO_4 (with mixed indicator)		IS:3025 (Part 23)	Maximum 25 ml of .02 normal H_2SO_4 to neutralise 100 ml of water.
2)	**Physical Properties**	1. At the beginning for approval of each source and change of source. 2. Once in 3 months.		
	a) Suspended matter		IS:3025 (Part 17)	2000 mg/l maximum
	b) Organic matter		IS:3025 (Part 18)	200 mg/l maximum
	c) Inorganic matter		IS:3025 (Part 18)	3000 mg/l maximum

2. Steel / Iron

2.1 Reinforcement bars (CTD, TMT)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Carbon b) Sulphur c) Phosphorus d) Sulphur + Phosphorus	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 1786-2008	0.30 maximum 0.06 maximum 0.06 maximum 0.11 maximum
2)	**Physical Test** a) Ultimate Tensile Strength. b) 0.2% Proof stress c) Percentage Elongation d) Bend and Rebend Test e) Mass per meter run (Kg)	1. At the beginning for approval of each source and change of source 2. Once for every lot 3. Once in 3 months		10% more than the actual 0.2% proof stress but not less 485 MPa. 415 MPa minimum 14.5 minimum To be satisfactory - 6.31 ± 3% for 32 mm dia, 4.830 ± 3% for 28 mm dia, 3.85 ± 3% for 25 mm dia, 2.470 ± 3% for 20 mm dia 1.58 ± 5% for 16 mm dia, 0.888 ± 5% for 12 mm dia

2.2 H. T. Strands (Uncoated Stress relieved low relaxation seven ply strand)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Sulphur b) Phosphorus	1. At the beginning for approval of each source and change of source. 2. Once for every lot.	IS:228 (Part-3) -1987 IS:228 (Part-9) -1989	Not greater than 0.05% Not greater than 0.05%
2)	**Dimension, Tolerance & Mass** a) Tolerance in Diameter b) Nominal area c) Nominal Mass of strands d) Difference in dia of central course and surrounding wires e) Length of lay	1. At the beginning for approval of each source and change of source. 2. Once for every lot.	IS: 14268-1995	**Nominal Dia.** (mm) / **Tolerance** (mm) / **Nominal Area of Strands** (mm²) / **Nominal Mass of Strands** (kg/Km) 12.7 / +0.66-0.15 / 98.7 / 775 15.2 / +0.66-0.15 / 140.0 / 1102 Centre wire at least 1 .5 percent greater in diameter than the surrounding wires 12 to 16 times the nominal diameter.
3)	**Physical Properties** a) Breaking Strength of strands b) 0.2% Poof load c) Elongation d) Modulus of Elasticity	1. At the beginning for approval of each source and change of source. 2. Once for every lot.	IS: 14268-1995	**Nominal Dia. (mm)** / **Breaking Strength (kN)** / **0.2% Proof load (kN)** 12.7 / 183.7 / 165.3 15.2 / 260.7 / 234.6 Minimum 3.5 % on minimum gauge length of 600 mm 18870to20910Kg/sqmm
4)	**Relaxation Properties** a) 100 hours	1. At the beginning for approval of each source and change of source. 2. Once for every lot.	IS: 14268-1995	Relaxation Losses not more than 1.8% when loaded to 70% of specified minimum breaking load.

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
	b) 1000 hours	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.		Relaxation Losses not more than 2.5% when loaded to 70% of specified minimum breaking load

2.3 Cast Steel (For bearings grade 280-520W)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests**	1. Once in the beginning for source. 2. During execution depending upon the nature of use. 3. Once in a project for every source.	IS: 1030-1989	C- 0.25% Maximum Mn- 1.20 Si - 0.60 P- 0.0.10 S - 0.035 Ni- 0.40 Cr- 0.35 Cu - 0.40 Mo- 0.15 V - 0.05
2)	**Physical Test** a) Ultrasonic Tests. b) Magnetic Particle Examination c) Liquid Penetration Examination d) Radiographic Examination	1. Once in the beginning for source. 2. During execution depending upon the nature of use. 3. Once in a project for every source.	IS: 1030-1989	No deformations should be observed.

2.4 Mild Steel

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards							
1)	**Chemical Composition**	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	IS: 2062-1999	Grade equal	Designation value maximum	C	Mn	S	P	Si	Carbon
				A	Fe410WA	0.23	1.5	0.005	0.05	0.04	0.42
				B	Fe410WB	0.22	1.5	0.046	0.045	0.04	0.41
				C	Fe410WC	0.20	1.5	0.040	0.04	0.04	0.39
				Nitrogen Content P 0.012% Nb, V & Ti content (all or any) 0.2%							

2.5 Stainless Steel

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Carbon b) Silicon	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	IS: 6911-1992	C - 0.08% Maximum ±0.01 % Si-1% Maximum ± 0.05 %

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
	c) Manganese d) Nickel e) Chromium f) Molybdenum g) Sulphur h) Phosphorus	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	IS: 6911-1992	Mn - 2% Maximum ± 0.04 % Ni- 10% to 14% Maximum ±0.15 % Cr-16% to 18% Maximum ± 0.20 % Mo - 2% to 3% Maximum ±0.10% S - 0.03% Maximum ±0.05 % P-0.045% Maximum ±0.01 %
2)	**Mechanical Tests** a) Tensile Test b) Yield Strength c) Hardness Test d) Elongation	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	IS:1663:1972 IS: 1608:1972 IS:1500:1983 IS:1501:1984 IS: 1586:1988	Minimum 440 MPa Minimum 200 MPa Brinell - maximum 192, Rockwell - Maximum 95 Minimum 40 % in 50 mm

2.6 Galvanising

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Mass of Zinc Coating**	One Test per lot	IS:6745-1972	400g/m2 minimum total mass of Zinc (inside and outside) per surface area (inside and outside) of the coated surface.
2)	**Visual Test**	One Test per lot	IS:2629-1985	The Zinc coating shall be free from imperfection like flux, ash and dross inclusions, bare patches, black spots, pimples, lumpiness, rums rust stain, blister, white deposit etc.
3)	**Free Bore Test**	One Test per lot	IS:2633-1986	A 230 mm long shall be passed through the tube to ensure a free bore. Nominal bore of tube after galvanising — dia of rod 8 mm — 4 mm 10 mm — 6 mm 15 mm — 11 mm 20 mm — 16 mm 25 mm — 21 mm
4)	**Uniformity of Glavanised Coating**	One Test per lot	IS.-4736-1986	The galvanized coating shall with stand 4 one minute dips.
5)	**Adhesion Test**	One Test per lot	IS:2629-1985	Galvanised tubes upto and including 50mm nominal bore when bent cold through 90° round grooved, former having radius at the bottoms of groove equal to 8 times its outer dia shall not develop any crack in the coating. For tubes more than 50mm nominal bore, this shall be tested by pivoted hammer test.

3. Cement

3.1 Cement (OPC-53 grade)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Chlorides (as cl) b) Ratio of Alumina to that of Iron Oxide c) Magnesium (MgO) d) Total sulphate content e) Loss on Ignition f) Insoluble Residue g) Lime saturation factor.	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 12269-1987	0.05% max 0.66 min 6.0% max 3.0% max 4.0% max 3.0% max 0.8-1.02
2)	**Physical Test** a) Setting Time i) Initial ii) Final b) Soundness (Le Chatelier Expansion) c) Compressive Strength i) At 3 Days ii) At 7 days iii) At 28 days d) Fineness	1. At the beginning for approval of each source and change of source 2. Once for every lot 3. Once in 3 months	IS: 12269-1987	Not less than 30 minutes. Not more than 10 hours. 10mm (maximum) and 0.8% (maximum) Not less than 27 MPa Strength Not less than 37 MPa Strength Not less than 53 MPa Strength 225 m^3 / Kg Minimum.

3.2 Cement (OPC-43 grade)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Chlorides (as cl) b) Ratio of Alumina to that of Iron Oxide c) Magnesium (MgO) d) Total sulphate content e) Loss on Ignition f) Insoluble Residue g) Lime saturation factor.	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 8112-1989	0.05% max 0.66 min 6.0% max 3.0% max 5.0% max 2.0% max 0.66-1.02
2)	**Physical Test** a) Setting Time i) Initial ii) Final	1. At the beginning for approval of each source and change of source 2. Once for every lot 3. Once in 3 months	IS: 8112-1989	Not less than 30 minutes. Not more than 10 hours.

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
	b) Soundness (Le Chatelier Expansion) c) Compressive Strength i) At 3 Days ii) At 7 days iii) At 28 days d) Fineness			10mm (max.) and 0.8% (max.) Not less than 23 MPa Strength Not less than 33 MPa Strength Not less than 43 MPa Strength 225 m^2 / Kg Minimum.

3.3 Cement (OPC-33 grade)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Chlorides (as cl) b) Ratio of Alumina to that of Iron Oxide c) Magnesium (MgO) d) Total sulphate content e) Loss on Ignition f) Insoluble Residue g) Lime saturation factor.	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 8112-1989	0.05% max 0.66 min 6.0% max 3.0% max 5.0% max 4.0% max 0.66-1.02
2)	**Physical Test** a) Setting Time i) Initial ii) Final b) Soundness (Le Chatelier Expansion) c) Compressive Strength i) At 3 Days ii) At 7 days iii) At 28 days d) Fineness	1. At the beginning for approval of each source and change of source 2. Once for every lot 3. Once in 3 months	IS: 8112-1989	Not less than 30 minutes. Not more than 10 hours. 10mm (maximum) and 0.8% (maximum) Not less than 16 MPa Strength Not less than 22 MPa Strength Not less than 33 MPa Strength 225 m^3 / Kg Minimum.

3.4 Portland Slag cement

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Chemical Tests** a) Magnesium oxide (MgO) b) Sulphur Trioxide (SO_3) c) Sulphide Sulphur(S) d) Loss on Ignition e) Insoluble Residue f) Chloride Content	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 455-1989 IS: 4032-1985	8.0 % Maximum 3.0 % Maximum 1.5 % Maximum 5.0 % Maximum 4.0 % Maximum 0.05 % Maximum

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
2)	**Physical Test** a) Fineness (Blain's Air permeability method) b) Soundness i) Le-Chateliers Method ii) Auto clave expansion c) Setting time i) Initial ii) Final d) Compressive Strength i) 72 ± 1 h ii) 168 ± 2 h iii) 672 ± 4	1. At the beginning for approval of each source and change of source 2. Once for every lot 3. Once in 3 months	IS: 4031 (Part 2): 1988 IS: 4031 (Part 3): 1988 IS: 4031 (Part5): 1988 IS : 4031 (Part 6): 1988	Specific Surface shall not be less than 225 m^2/Kg Expansion shall not be more than 5 mm Expansion shall not be more than 0.6% Initial setting time not less than 30 minutes Final setting time not more than 60 minutes Not Less than 16 MPa Not Less than 22 MPa Not Less than 33 MPa

4. Plasticiser (Normal and Retarding Type Super Plasticiser)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Water content, per cent of control sample**	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 9103-1999	80 Maximum
2)	**Slump**			Not more than 15 mm below that of the control mix concrete
3)	**Time of Setting, allowable deviation from control sample** a) Initial b) Final			Maximum +4 for Retarding type and nil for Normal Minimum +1 for Retarding type and +1.5 for Normal Maximum ±3 for Retarding type and ± 1.5 for Normal
4)	**Compressive strength, per cent of control sample** a) 1 day b) 3 days c) 7 days d) 28 days e) 6 months f) 1 year			140 minimum for Normal only 125 minimum for Normal as well as Retarding type 125 minimum for Normal as well as Retarding type 115 minimum for Normal as well as Retarding type 100 minimum for Normal as well as Retarding type 100 minimum for Normal as well as Retarding type
5)	**Flexural Strength, per cent of control sample** a) 3days b) 7 days c) 28 days			110 minimum 100 minimum 100 minimum
6)	**Length change per cent increase over control sample** a) 28 days b) 6 months c) 1 year			0.01 maximum 0.01 maximum 0.01 maximum

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
7)	**Bleeding, per cent increase over control sample.**	1. At the beginning for approval of each source and change of source. 2. Once for every lot. 3. Once in 3 months.	IS: 9103-1999	5 maximum
8)	**Loss of workability**			At 45 minutes for Normal type admixture and at 2 hours for Retarding type admixture, the slump shall not be less than that of control mix concrete at 15 minutes.
9)	**Air content (%) over control specimen**			1.5 maximum
10)	**Uniformity Tests** a) Dry Material Content b) Ash content c) Relative Density d) Chlorides ion content e) pH			Within 3% of the value stated by the manufacturer. Within 1% of the value stated by the manufacturer. Within 0.02 of the value stated by the manufacturer. Within 10% of the value or within 0.2 % whichever is greater as stated by the manufacturer. 7 – 8

5. Water Proofing Compound

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Permeability**	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	IS: 2645-1975	Permeability to water of the standard cylindrical specimens prepared with the recommended proportion of the water proofing compound shall be less than 50% of permeability similar specimens prepared without waterproofing compound
2)	**Setting Time**			Initial Setting Time - Not less than 30 minimum Final Setting time - Not more than 600 minimum
3)	**Compressive Strength**			Compressive strength at 72 hrs. - Not less than 160kg/cm2 or 80% of the 3 day Compressive strength of cubes prepared without waterproofing compound. Compressive Strength at 168 hrs. - Not less than 220 kg/cm2 or 80% of the 7 day compressive strength of cubes prepared without waterproofing compound.
4)	**Chloride Content**			As per the values given by the manufacturer
5)	**Sulphate Content**			As per the values given by the manufacturer

6. Pre-stressing System

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Static Load test with tendon - anchorage assembly**	1. Once at the start of work for the approval of the Prestressing system 2. Once in project for each prestressing system for every source of strands	FIP Recommendation	1. The increase in the displacements between the anchorage components as well as between the pre-stressing steel & anchorage components should not be disproportionate to the increase in .tendon force. 2. The above relative displacement during $0.8F_{pk}$ load should stabilise within first thirty minutes of the load duration of one hour. 3. The mode of failure & tendon should be by the fracture of the pre-stressing steel. 4. Anchorage Efficiency ($\eta_a \geq 0.95$ 5. Total elongation £„ in the free length of the tendon under the measured ultimate force (Fru shall be ≥ 2 %.
2)	**Dynamic Load Test with Tendon - anchorage assembly**	1. Manufacturer's test certificate for every source		Fatigue failure of anchorage components should not occur. Minimum fatigue strength of post tensioning system = 80 Mpa.

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
3)	**Load transfer Test**	1 . Once at the start of work for the approval of the Prestressing system 2. Once in project for each prestressing system for, every source of strands		1. Crack width upon first attainment of upper force 0.8 F_{pk} ≤ 0.10 mm 2. Crack width upon last attainment of lower force 0.12 F_{pk} ≤0.10mm 3. Crack width upon final attainment of upper force 0.8 F_{pk} ≤0.25 mm 4. Reading of longitudinal & Transverse strains should have stabilised during cyclic loading (increase in strain in last 2 load cycles <5%) 5. Reading of crack width should have stabilised (increase in crack width in last 2 load cycles > .02 mm) 6. Measured failure Load Fu ≥ F_{pk} ($f_{cm,e}/f_{ck.o}$) and ≥ 1.1 F_{pk}

7. R. C. C. Pipes

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Tolerances in Dimensions** a) Wall Thickness	1. At the beginning for approval of each source and change of source. 2. Once for every Lot.	IS:458:1988 IS:3597:1985	Up to and including 30 mm ± 2mm Over 30 mm and up to and including 50 mm ± 3mm Over 50 mm and up to and including 65 mm ± 4mm Over 65 mm and up to and including 80 mm ± 5mm Over 80 mm and up to and including 95 mm ± 6mm, Over 95 mm ± 7mm
	b) Internal Dia. of Pipe or Socket			Up to and including 300 mm ± 3mm Over 300 mm and up to and including 600 mm ± 5mm Over 600 mm and up to and including 1200 mm ± 7mm Over 1200 mm ± 10mm
	c) Overall Length			± 1 % of standard Length
2)	**Three Edge Bearing**			Shall withstand the design Load
3)	**Water absorption**			After 10 minutes, 2.5 % of dry Mass Maximum and total absorption at the end of 24 Hours shall not exceed 6.5 % of dry mass
4)	**Hydrostatic Pressure**			No leakage under the design pressure
5)	**Straightness**			Maximum 3 mm for every m length
6)	**Reinforcement**			On breaking the Pipe and extracting the reinforcement, it shall be as per the provision
7)	**Cube Strength**			As per the design strength

8. Thermoplastic Paints

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Binder content**	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	BS:3262 and Clause 803 of MoRT&H Specification	18% Minimum by weight

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
2)	**Glass Beads**	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	BS:3262 and Clause 803 of MoRT&H Specification	30 -40% Gradation of Glass beads **IS Sieve** **Percentage Passing** 1.18 mm 0-3 850 micron 5-20 425 micron 65-95 180 micron 0-10
3)	**Titanium Dioxide content**			10% Minimum
4)	**Calcium Carbonate & Inert fillers**			42% Max for white paint and at discretion of manufacturer subject to meeting other specification for yellow paint.
5)	**Yellow Pigments**			At direction of manufacturer subject to meeting of other specifications
6)	**Luminance (Daylight)**			65% Minimum at 45% for white paint and 45% Minimum at 45% for yellow paint
7)	**Drying Time**			15 Minutes Maximum
8)	**Skid Resistance**			Not less than 45
9)	**Cracking Resistance at low temperature**			No cracking on application to concrete blocks.
10)	**Softening Point**			102.5±9.5°C
11)	**Flow resistance**			Not more than 25%
12)	**Yellowness Index**			Not more than 0.1 2

9. Geotextile

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Thickness**	1. At the beginning for approval of each source and change of source. 2. Once in a project for every source.	ASTM D 4355	Not less than 2mm
2)	**Weight**			Not less than 225 gm/sqm
3)	**Tensile Strength**			Minimum 30Kg per 5cm in either direction
4)	**Fiber Composition**			100% polypropylene non-woven
5)	**Chemical Resistance** a) Against NaOH b) Against HCl			No appreciable change in breaking strength.
6)	**Resistance against photo oxidation**			200-250 hrs.

10. Bentonite

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Density**	1. At the beginning for approval of each source and change of source. 2. Once for every day of Pilling.	MOST Specification for Road & Bridge Works	1.05g/cc
2)	**Marsh Cone Viscosity**			30 to 40
3)	**pH value**			9.5 to 12
4)	**Silt content**			less than 1 %
5)	**Liquid limit**			not less than 400%

10. Lime (for Bituminous Works)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	$CaCO_3$ content	At the beginning for approval of each source and change of source.	IS: 1195-1978	80% Minimum.
2)	Sieve Analysis	One Test for every 5 MT of lime consumption.		100% though 75 mm sieve.

11. Paving Bitumen (Viscosity) Grade (for BM, DBM, BC)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards			
1)	Specific Gravity at 27°C	1. At the beginning for approval of each source and change of source. 2. For every Lot per plant.	IS: 73-2013 IS: 1202-1978	0.99 Minimum			
2)	Water, percent by mass		IS:1211-1978	0.2 Maximum			
3)	Flash Point, Cleveland open cup, °C		IS:1209:1978	220 Minimum			
4)	Softening point (R&B), °C, Min	1. At the beginning for approval of each source and change of source. 2. For every Lot per plant.	IS:1205:1978	Requirements for Grade			
				VG 10	VG 20	VG 30	VG 40
				40	45	47	50
5)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min		IS:1203:1978	80-100	60-80	50-70	40-60
6)	Penetration Ratio		IS:1208:1978	35 Minimum			
7)	Ductility at 25°C		IS:1208:1978	Minimum 75 for VG 10, 50 for VG 20, 40 for VG 30 and 25 for VG 40.			
8)	Paraffin Wax Content, percent by mass		IS:1208:1983	4.5 Maximum			
9)	Frass breaking point °C		IS:9381:1979				
10)	Loss an heating		IS:1212-1978	Maximum 1% by mass			
11)	Retained Penetration after thin film oven test, 25°C,100g , 5 sec., 1/10mm		IS:9382-1979				
12)	Matter soluble in trichloroethylene		IS:1216-1978	99 % Minimum			
13)	Viscosity (in Poise) at		IS:1206 (Part-2) - 1978 IS:1206 (Part-3)- 1978	Requirements for Grade			
				VG 10	VG 20	VG 30	VG 40
	a) 60°C,			800-1200	1600-2400	2400-3600	3200-4800
	b) 135 °C			250	300	350	400

12. Industrial Bitumen (for Mastic Asphalt)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Specific Gravity at 27°C**	1. At the beginning for approval of each source and change of source. 2. For every Lot per plant.	18:702 IS: 1202	Minimum 1.05 g/cc
2)	**FlashPoint**		IS: 1209	Minimum 225°C
3)	**Softening point**		IS: 1205	80-90°C
4)	**Penetration at 25°C,100g , 5 sec., 1/10mm**		IS: 1203	10-20 mm
5)	**Ductility at 27°C**		IS:1208	3 cm Minimum
6)	**Loss an heating**		IS:1212	0.3 % Maximum
7)	**Solubility in Tri-chloroethylene**		IS:1216	99 % Minimum

Quality Control Test for Site Activities

1. Mix Design including Trial Mix and Acceptance Criteria

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Trial Mix** a) Target Mean Strength	1. For every design Mix. 2. For every change in source of any material.	IRC : 21-2000	Initially. Target Mean Strength = specified Characteristic Strength + current Margain Current Margain = 1 1 M Pa for M 25, 12 MPa for M30, M 35 and M 40, 1 3 MPa for M 45 and M 55 & 14 MPa for M 55 and M 60 Later on Target Mean Strength = specified Characteristic Strength + 1 .64 x Standard Deviation from at least 40 samples.
2)	**Acceptance Criteria**	Qty. of Concrete (m3) — No. of Samples 1-5 — 1 6-15 — 2 16-30 — 3 31-50 — 4 51 and above each — 4+ Plus 1 for 50 m^3 or part thereof	IRC : 21-2000	1. Mean strength of any group of 4 consecutive samples = Specified Characteristic Strength + 3Mpa 2. Strength of any sample Specified > Characteristic Strength - 3 Mpa

2. R.C.C. work

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Workability**	Every Transit Mixer	IRC 516-1959	As per requirement of the item under execution
2)	**Compressive Strength** a) 7 Days Strength b) 28 Days Strength	As per clause 25.	IRC : 21	As per clause 25.
3)	**Flexure Test**	Once for every design Mix	MOST Specification for Road & Bridge Works	
4)	**Permeability Test**	Once in a month		Maximum 25mm on a specimen of 150mm<j) and 160mm height
5)	**Density** a) Fresh concrete b) Hardened concrete	Once in a month		 97.5% of the specified value 97.5% of the specified value

3 Piling

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Initial Tests** a) Vertical	Minimum 2 tests	IS : 2911 (Part-4) - 1985	The safe vertical load shall be minimum of i) 50% of the final load corresponding to 12mm displacement ii) Final load at which displacement in 5mm iii) Load corresponding to any other specified displacement as per performance requirements
2)	**Routine Tests** a) Vertical Test b) Lateral Load Test c) Integrity Test	 Upto 2% of total piles Upto 2% of total piles Upto 2% of total piles	IS : 2911 (Part-4) - 1985	 Maximum settlement at a test load of 1.5 times the working load shall not exceed 12mm Safe Lateral load shall be the minimum of i) 50% of the final load corresponding to 12mm displacement ii) Final load at which displacement is 5mm. iii) Load corresponding to any other specified displacement as per performance requirements. There shall be no unacceptable flaws in concrete as per the recommendation of the specified agency carrying out the test.

4 Embankment Construction

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Atterberg Limits** a) Liquid Limit b) Plasticity Index	1. Once for each kind of soil. 2. Once at beginning of supply. 3. 2 tests per 3000 m^3.	IS : 2720 (Part 5)	 Maximum 70 Maximum 45
2)	**Clay Content**		IS:2720 (Part 4)	Maximum 10 %.
3)	**Deleterious Content Test**		S: 2720 Part 27	Material should be free from swamp, marshes and bogs It should not be Peat, log, sump and perishable material
4)	**Classification of Soil**		S:1498	Soil should not be classified as OL, OI, OH or Pt

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
5)	**CBR**	1. Once for each kind of soil. 2. Once at beginning of supply. 3. 2 tests per 3000 m³.	S- 2720 Pan 16	Minimum 4% (under fully soaked condition)
6)	**OMC and Maximum Dry Density**		S: 2720 Part 8	Determined to control water content for achieving maximum density.
7)	**Density**		S: 2720 Part 8	1.80 to 2.15gm/cc
8)	**Grading**		S: 2720 Part 4	The size of coarse material should not exceed 75 mm in embankment and 50 mm in subgrade
9)	**Moisture Content**	One test to be conducted for every 1000 m² of embankment in the lower layers and 500 m² in the top 60 cm of the embankment (20cm thickness). Each test shall comprise of tests at five locations.	MORTH Specification for Road & Bridge Works	The moisture content shall be in the range of-1 % to +2% of the OMC.
10)	**Dry Density**		IS: 2720 (Part -2) IS: 2720 (Part-8)	The dry density shall be 95% of the Maximum Dry Density (MOD) in the lower layers of embankment and 100% of MDD in the top 60 cm of the embankment

5 Sub-Bases And Bases (Excluding Bitumen Bound Bases)

5.1 Granular and mechanically Stabilised Soil Sub Base :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Gradation**	1. At the beginning for approval of each source and change of source. 2. One test per 400 m³.	IS: 383-1970 IS: 2386 (Part I)-1963	As per Table 400-1 of MORT&H.
2)	**Atterberg's limits.** a) Liquid Limit b) Plasticity Index		IS : 2720 (Part V)	 Maximum 25 % Maximum 6 %
3)	**Moisture content prior to compaction**			2% Maximum.
4)	**Density of compacted layer**	One test per 1000 m²		
5)	**Deleterious constituents.**	As required	IS: 383-1970 IS: 2386 (Part II)-1963	Free from Organic and other deleterious constituents.
6)	**CBR**	-do-	IS:2720 (Part V)	At 98% dry density - Minimum 30 unless otherwise specified in the Contract

5.2 Lime/Cement Stabilised Soil Sub-base :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of lime/cement -**	One test for each consignment subject to a minimum of one test per 5 tonnes	IS: 1514 / IS:269, 455 or 1489	Lime shall have purity of not less than 70% by wt. of Quick-lime (CaO) / Cement for stabilization shall either is OPC, PSC or PPC.
2)	**Lime/Cement content**	Regularly through procedural checks		The mix design shall be done to arrive at the appropriate qty. of lime to be added.
3)	**Degree of pulverization**	Periodically as considered necessary		Minimum percent by weight passing the sieve: 26.5 mm – 100% & 5.6 mm – 80%.
4)	**CBR or Unconfined Compressive Strength test on a set of 3 specimens**	As required		The laboratory CBR/UCS value shall be at least 1.5 times the min. field value of CBR/UCS.
5)	**Moisture content prior to compaction**	One test per 500 m2	IS:2720 (Part II)	Neither be less than the optimum moisture content corresponding to IS:2720 (Part VIII) nor more than 2 % above it.
6)	**Density of compacted layer**	One test per 500 m2	IS:2720 (Part VIII)	At least 98 percent of the maximum dry density
7)	**Deleterious constituents**	As required		

5.3 Water Bound Macadam :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Grading of aggregate**	One test per 250 m^3 of aggregate	IS: 383-1970 IS: 2386 (Part I)-1963	As per Table 400-9 & 400-10 of MORT&H.
1)	**Aggregate Impact Value**	One test per 1000 m^3 of aggregate	IS: 2386 (Part IV)	30 % Maximum by Weight
3)	**Combined Flakiness & Elongation Indices**	One test per 500 m^3 of aggregate	IS: 2386 (Part I)	35 % Maximum by Weight
Sl.	**Test**	**Frequency**	**Ref. Codes**	**Acceptance Standards**
4)	**Atterberg Limits of binding Material**	One test per 50 m^3 of aggregate.	IS:2720 (Part V)	PI ≤ 6
5)	**Atterberg's limit of screenings**	One test per 100 m^3 of aggregate	IS: 383-1970 IS: 2386 (Part I)-1963	Maximum 10%

5.4 Wet Mix Macadam :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Grading of aggregate**	One test per 200 m^3 of aggregate	IS: 383-1970 IS: 2386 (Part I)-1963	As per Table 400-13 of MORT&H.
2)	**Aggregate Impact Value**	One test per 1000 m^3 of aggregate	IS: 2386 (Part IV)	30 % Maximum by Weight
3)	**Combined Flakiness Index & Elongation Index**	One test per 500 m^3 of aggregate	IS: 2386 (Part I)	35 % Maximum by Weight
4)	**Atterberg Limits of portion of aggregate passing 425 micron sieve**	One test per 200 m^3 of aggregate	IS:2720 (Part V)	PI ≤ 6
5)	**Density of compacted layer**	One set of three tests per 1000 m^2	IS:2720 (Part VIII)	At least 98 % of MDD

6 Bituminous Construction Works

6.1 Prime coat :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	Cationic Bitumen Emulsion SS1 grade conforming to IS: 8887.
2)	**Binder temperature for application**	At regular close intervals		140-160 for VG-10, 145-165 for VG-20, 150-165 for VG-30 & 160-170 for VG-40
3)	**Rate of spread of Binder**	Three tests per day		For WBM/WMM Surface: 0.7-1.0 kg/sq.m & For Stabilised soil base/Crusher Run Macadam Surface: 0.9-1.2 kg/sq.m.

6.2 Tack coat :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	Cationic Bitumen Emulsion RS1 grade conforming to IS: 8887/IS: 217
2)	**Binder temperature for application**	At regular close intervals		140-160 for VG-10, 145-165 for VG-20, 150-165 for VG-30 & 160-170 for VG-40
3)	**Rate of spread of Binder**	Three tests per day		Bituminous surfaces: 0.20-0.30 Kg per sq.m, Granular surfaces treated with primer: 0.25-0.30 Kg per sq.m & Cement concrete pavement: 0.30-0.35 Kg per sq.m

6.3 Bituminous Macadam (BM) :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	The bitumen shall be viscosity grade paving bitumen complying with IS:73.
2)	**Aggregate Impact Value** **Los Angeles Abrasion Value**	One test per 200 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS: 2386 (Part-IV)	30 % Maximum by Weight 40 % Maximum by Weight
3)	**Combined Flakiness and Elongation Indices**	One test per 350 m3 of aggregate of each source	IS: 2386 (Part-I)	35 % Maximum by Weight
4)	**Stripping Value of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS: 6241	Min. retained coating 95%
5)	**Water absorption of aggregates**	- do -	IS: 2386 (Part-III)	Max. 2%
6)	**Water sensitivity of mix**	- do -	AASHTO 283	Min. 80%
7)	**Grading of aggregates**	Two tests per day	IS: 2386 (Part-I)	As per Table 500-7 of MORT&H.
8)	**Soundness** (Sodium / Magnesium Sulphate)	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -12% (ii) tested with Magnesium Sulphate -18%
9)	**Percentage of fractured faces**	One test per 100 m3 of aggregate		
10)	**Binder content**	Two tests per day per plant	MORTH's Specification for Road & Bridge Works	3.3% for 80-100 mm th. & 3.4 % for 50-75 mm th. (In case aggregates have specific gravity > 2.7, bitumen content can be reduced proportionately. Further, for regions where HDM air temp. ≤ 30°C and LDM air temp. ≤ -10°C, it may be increased by 0.5 %.)
11)	**Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling.**	At Regular interval		As per Table 500-2 of MORT&H.
12)	**Density of compacted layer**	One test per 700 m2 of area		
13)	**Rate of spread of mixed material**	At Regular intervals		

6.4 Dense Bituminous Macadam (DBM)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot	IS: 73: 2013, IS: 217 & IS: 8887	The bitumen shall be viscosity grade paving bitumen complying with IS:73
2)	**Aggregate Impact Value** **Los Angeles Abrasion Value**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS: 383-1970 IS: 2386 (Part IV)-1963	27 % Maximum by Weight 35 % Maximum by Weight
3)	**Combined Flakiness and Elongation Indices**	- do -		35 % Maximum by Weight
4)	**Soundness (Magnesium Sulphate/ Sodium Sulphate**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -12% (ii) tested with Magnesium Sulphate -18%
5)	**Water absorption of aggregates**	- do -	IS : 2386 (Part III)	Max. 2%
6)	**Sand equivalent test**	- do -	IS : 2720 (Part 37)	Minimum 50
7)	**Plasticity Index**	- do -	IS : 2720 (Part 5)	Minimum 4
8)	**Polished stone value**	- do -	BS: 812-114	Min 55

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
9)	**Mix grading**	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant	IS: 2386 (Part I)-1963	As per Table 500-10 of MORT&H.
10)	**Stability and voids analysis of mix including theoretical maximum specific of loose mix**	Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to a minimum of two tests per day per plant	AASHTO T 245	Minimum stability (at 60°C) : 9.0 kN, Minimum flow : 2-4 mm, Air voids : 3-5 Percent
11)	**Moisture Susceptibility of mix**	One test for each mix type whenever there is change in the quality or source of coarse or fine aggregates	AASHTO T 283	Min. 80%
12)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction**	At regular intervals		Same as mentioned in 6.4 (Bituminous Macadam)
13)	**Binder content**	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant	MORTH's Specification for Road & Bridge Works	Min. 4.0 % for 75-100 mm th. & Min. 4.5 % for 50 - 75 mm th. (In case aggregates have specific gravity > 2.7, bitumen content can be reduced proportionately. Further, for regions where HDM air temp. ≤ 30°C and LDM air temp. ≤ -10°C, it may be increased by 0.5 %.)
14)	**Rate of spread of mixed material**	After every 5th truck load		
15)	**Density of compacted layer**	One test per 700 m2 of area	ASTM D 2041	Minimum field density equal to or more than 98% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction.

6.5 Sand Asphalt Base Course

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot and tests as per IS:73 or IRC:SP:53, IS:15462	IS: 73: 2013	The bitumen shall be paving bitumen of viscosity grade VG 30 or VG 20, as specified in the Contract, conforming to IS:73
2)	**Aggregate Impact Value / L.A. Abrasion value**	One test per 200 cu.m of each source and whenever there is change in the quality of aggregate.	IS: 2386 Part IV	40 max.
3)	**Sand equivalent test**	One test for each source and whenever there is change in the quality of aggregates	IS: 2720 Part 37	30 min.
4)	**Plasticity Index**	- do -		6 max.
5)	**Mix grading**	Two tests per day		As per Table 500-14 of MoRT&H.
6)	**Binder content**			Approx. 5% by weight of the total mixture.
7)	**Stability of Mix**	Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to a minimum of two tests per plant per day		Minimum stability (at 60°C) : 2.0 kN, Minimum flow : 2 mm, Air voids : 3-5 Percent VMA – 16 min. & VFB – 65-75.
8)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and rolling**	At regular intervals		Same as mentioned in 6.4 (Bituminous Macadam)
9)	**Thickness of layer**			Max. 80 mm
10)	**Density of compacted layer**	One test per 700 m2 of area		Number of blows – 2 x 75

6.6 Semi-Dense Bituminous Concrete (SDBC)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot	IS: 73: 2013, IS: 217 & IS: 8887	The bitumen shall be viscosity grade paving bitumen complying with IS:73
2)	**Aggregate Impact Value** **Los Angeles Abrasion Value**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS: 383-1970 IS: 2386 (Part IV)-1963	35% Maximum by Weight 27% Maximum by Weight
3)	**Combined Flakiness and Elongation Indices**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.		30% Maximum by Weight
4)	**Soundness (Magnesium Sulphate/ Sodium Sulphate**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -12% (ii) tested with Magnesium Sulphate -18%
5)	**Water absorption of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part III)	Max. 2%
6)	**Sand equivalent test**	One test for each source and whenever there is change in the quality of aggregates	IS : 2720 (Part 37)	Minimum 50
7)	**Plasticity Index**	One test for each source and whenever there is change in the quality of aggregates	IS : 2720 (Part 5)	Minimum 4
8)	**Polished stone value**	One test for each source and whenever there is change in the quality of aggregates	BS: 812-114	Min 55
9)	**Mix grading**	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant	IS: 2386 (Part I)-1963	As per Table 43.
10)	**Stability and voids analysis of mix including theoretical maximum specific of loose mix**	Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to a minimum of two tests per day per plant	AASHTO T 245	Minimum stability (at 60°C) : 8.2 kN, Minimum flow : 2-4 mm, Air voids : See table 38
11)	**Moisture Susceptibility of mix**	One test for each mix type whenever there is change in the quality or source of coarse or fine aggregates	AASHTO T 283	Min. 80%
12)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction**	At regular intervals	MORTH's Specification for Road & Bridge Works	Same as mentioned in 6.4 (Bituminous Macadam)
13)	**Binder content**	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant		Min. 4.5 % for 35 - 40 mm thick & Min. 5.0 % for 25 - 30 mm thick (In case aggregates have specific gravity > 2.7, bitumen content can be reduced proportionately. Further, for regions where HDM air temp. ≤ 30°C and LDM air temp. ≤-10°C, it may be increased by 0.5 %.)
14)	**Rate of spread of mixed material**	After every 5th truck load		
15)	**Density of compacted layer**	One test per 700 m2 of area	ASTM D 2041	Minimum field density equal to or more than 98% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction.

6.7 Bituminous Concrete (BC)

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot	IS: 73: 2013, IS: 217 & IS: 8887	The bitumen shall be viscosity grade paving bitumen complying with IS:73
2)	**Aggregate Impact Value** **Los Angeles Abrasion Value**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS: 383-1970 IS: 2386 (Part IV)-1963	24% Maximum by Weight 30% Maximum by Weight
3)	**Combined Flakiness and Elongation Indices**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.		35 % Maximum by Weight
4)	**Soundness (Magnesium Sulphate/ Sodium Sulphate**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (iii) tested with Sodium Sulphate -12% (iv) tested with Magnesium Sulphate -18%
5)	**Water absorption of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part III)	Max. 2%
6)	**Sand equivalent test**	One test for each source and whenever there is change in the quality of aggregates	IS : 2720 (Part 37)	Minimum 50
7)	**Plasticity Index**	One test for each source and whenever there is change in the quality of aggregates	IS : 2720 (Part 5)	Minimum 4
8)	**Polished stone value**	One test for each source and whenever there is change in the quality of aggregates	BS: 812-114	Min 55
9)	**Mix grading**	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant	IS: 2386 (Part I)-1963	As per Table 500-17 of MoRT&H.
10)	**Stability and voids analysis of mix including theoretical maximum specific of loose mix**	Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to a minimum of two tests per day per plant	AASHTO T 245	Minimum stability (at 60°C) : 9.0 kN, Minimum flow : 2-4 mm, Air voids : 3-5 Percent
11)	**Moisture Susceptibility of mix**	One test for each mix type whenever there is change in the quality or source of coarse or fine aggregates	AASHTO T 283	Min. 80%
12)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction**	At regular intervals	MORTH's Specification for Road & Bridge Works	Same as mentioned in 6.4 (Bituminous Macadam)
13)	**Binder content**	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant		Min. 5.2 % for 50 mm thick & Min. 5.4 % for 30 - 40 mm thick (In case aggregates have specific gravity > 2.7, bitumen content can be reduced proportionately. Further, for regions where HDM air temp. ≤ 30°C and LDM air temp. ≤-10°C, it may be increased by 0.5 %.)
14)	**Rate of spread of mixed material**	After every 5th truck load		
15)	**Density of compacted layer**	One test per 700 m2 of area	ASTM D 2041	Minimum field density equal to or more than 98% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction.

6.8 Surface Dressing :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	The binder shall be bitumen conforming to IS: 73 or Rapid setting cationic bitumen emulsion (RS-2) conforming to IS: 8887.
2)	**Aggregate Impact Value/ Los Angeles Abrasion Value**	One test per 200 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part IV)	Max. 27% Max. 35%
3)	**Combined Flakiness and Elongation Indices**	One test per 100 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part I)	Max. 35%
4)	**Stripping Value of aggregates** (Immersion Tray Test)	One test for each source and whenever there is change in the quality of aggregates	IS: 6241	Minimum retained coating 95%
5)	**Water absorption of aggregate**	- do -	IS : 2386 (Part III)	Max. 1%
6)	**Water sensitivity of mix**	- do -	AASHTO 283	Min 80%
7)	**Grading of aggregate**	Two tests per day	MORTH's Specification for Road & Bridge Works	As per Table 500-21 of MoRT&H.
Sl.	**Test**	**Frequency**	**Ref. Codes**	**Acceptance Standards**
8)	**Soundness** (Magnesium Sulphate / Sodium Sulphate)	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles, tested with (i) Sodium Sulphate - 12% & (ii) Magnesium Sulphate -18%
9)	**Polished Stone Value** (not applicable for SAM/SAMI)	- do -	BS: 812 (Part-114)	Not less than 60
10)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction.**	At regular intervals	MORTH's Specification for Road & Bridge Works	Same as mentioned in 6.4 (Bituminous Macadam)
11)	**Rate of spread of materials**	Three tests per day		19 mm: 0.014-0.015 cu.m/m^2; 13 mm: 0.009-0.011 cu.m/m^2
12)	**Percentage of fractured faces** (When gravel is used)	One test per 100 m3 of aggregate		

6.9 Open-graded Premix Surfacing :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	The binder shall be bitumen conforming to IS: 73
2)	**Aggregate Impact Value/ Los Angeles Abrasion Value**	One test per 200 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part IV)	Max. 30% Max. 40%
3)	**Combined Flakiness and Elongation Indices**	One test per 100 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part I)	Max. 35%
4)	**Stripping Value of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS: 6241	Minimum retained coating 95%

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
5)	**Water absorption of aggregates**	- do -	IS : 2386 (Part III)	Maximum 1%
6)	**Water sensitivity of mix**	- do -	AASHTO 283	Min 80%
7)	**Grading of aggregates**	Two tests per day		As per Table 500-23 of MoRT&H.
8)	**Soundness** (Magnesium Sulphate/ Sodium Sulphate)	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles, tested with (i) Sodium Sulphate - 12% & (ii) Magnesium Sulphate -18%
9)	**Polished Stone Value**	- do -	BS:812-114	Not less than 55
10)	**Temperature of binder at application**	At regular intervals		140-160 for VG-10, 145-165 for VG-20, 150-165 for VG-30 & 160-170 for VG-40
11)	**Binder content**	Two tests per day per plant		a) For 0.1 8m3 of 13.2 mm nominal size stone of 52 kg bitumen per m3 b) For 0.09m3 of 11.2 mrn nominal size stone of 56 kg bitumen per m3
12)	**Percentage of fractured faces**	One test per 100 m3 of aggregate		

6.10 Seal coat :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	The binder shall be bitumen conforming to IS: 73 & Cationic bitumen emulsion of Medium Setting (MS) grade complying with IS: 8887.
2)	**Aggregate Impact Value/ Los Angeles Abrasion Value**	One test per 200 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part IV)	Max. 27% Max. 35%
3)	**Combined Flakiness and Elongation Indices**	One test per 100 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS : 2386 (Part I)	Max. 35%
4)	**Stripping Value of aggregates** (immersion Tray Test)	One test for each source and whenever there is change in the quality of aggregates	IS: 6241	Minimum retained coating 95%
5)	**Water absorption of aggregate**	- do -	IS : 2386 (Part III)	Maximum 1%
6)	**Water sensitivity of mix**	- do -	AASHTO 283	Min 80%
7)	**Grading of aggregate**	Two tests per day		**Type A -** Stone chips shall be of 6.7 mm size defined as 100 % passing through 11.2 mm sieve and retained on 2.36 mm sieve **Type B -** The aggregate shall pass 2.36 mm sieve & be retained on 180 micron sieve.
8)	**Soundness** (Magnesium Sulphate / Sodium Sulphate)	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles, tested with (i) Sodium Sulphate - 12% & (ii) Magnesium Sulphate -18%
9)	**Polished Stone Value** (not applicable for SAM/SAMI)	- do -	BS:812-114	Not less than 55
10)	**Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction.**	At regular intervals		Same as mentioned in 6.4 (Bituminous Macadam)
11)	**Rate of spread of materials**	Three tests per day		9.8 kg/10 sq.m for Type A, and 6.8 kg for Type B seal coat. Where bituminous emulsion is used as a binder, the quantities for Type A and Type B seal coats shall be 15 kg and 10.5 kg respectively.
12)	**Percentage of fractured faces** (When gravel is used)	One test per 100 m3 of aggregate		

6.11 Slurry Seal :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of Aggregate**	One per source / site.		
2)	**Sand Equivalent Value**		IS: 2720 (Part 37)	Min. 50%
3)	**Water Absorption**		IS: 2720 (Part 3)	Max. 2%
4)	**Soundness Test** (Sodium / Magnesium Sulphate Test).		IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles, tested with (i) Sodium Sulphate - 12% & (ii) Magnesium Sulphate -18%
5)	**Quality of Emulsion**	One per lot of 20t	IS:8887	The bitumen emulsion shall be a cationic slow setting type SS 2, conforming to the requirements of IS:8887
6)	**Aggregate Moisture**	Two per day		
7)	**Aggregate Gradation**	Two per day at site		As per Table 500-27 of MoRT&H.
8)	**Binder content**	Two per lane per Km		10 to 16 for type I, 7.5 to 13.5 for Type II & 6.5 to 12 for Type III
9)	**Calibration of Machine**	Once per Project	Appendix 7 of IRC:SP:81	
10)	**Quantity of Slurry (By weight of aggregate**	Daily (Travel time of Machine)		4.3 to 6.5 kg/m^2 for type I, 8.4 to 9.8 kg/m^2 for Type II & 10.1 to 12 for Type III

6.12 Fog Spray :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS: 73: 2013, IS: 217 & IS: 8887	Cationic Bitumen Emulsion SS1 grade conforming to IS: 8887
2)	**Binder temperature for application**	At regular close intervals		140-160 for VG-10, 145-165 for VG-20, 150-165 for VG-30 & 160-170 for VG-40
3)	**Rate of spread of Binder**	Three tests per day		0.5 – 1.0 litres per sq.m.

6.13 Mastic Asphalt :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot.	IS:1203 IS:1205 IS:1212 IS:1216 IS:1217	Penetration at 25°C - 15±5, Softening point, °C - 65±10 Loss on heating for 5h at 163°C, % by mass Max. – 2.0 Solubility in trichloroethylene, % by mass Min. – 95 Ash (mineral matter), % by mass Max. – 1.0
2)	**Aggregate Impact Value/ L.A. Abrasion value**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS:2386 (Part-IV)	Max. 30% Max. 40%
3)	**Combined Flakiness and Elongation Indices**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS:2386(Part-I)	Max. 35%
4)	**Stripping Value of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS: 6241	Minimum retained coating 95%
5)	**Water Sensitivity of mix**	- do -	AASHTO 283	Min. 80%

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
6)	**Grading of aggregates**	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer	IS : 2386 (Part-I) IS : 383	As per Table 500-40 of MoRT&H.
7)	**Water absorption of aggregates**	One test for each source and whenever there is change in the quality of aggregates	IS:2386 (Part-III)	Max. 2%
8)	**Soundness** (Magnesium Sulphate/ Sodium Sulphate)	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (i) tested with Sodium Sulphate -12% (ii) tested with Magnesium Sulphate -18%
9)	**Percentage of fractured faces**	One test per 50 m3 of aggregate when crushed gravel is used		
10)	**Binder Content and aggregate grading**	Two tests per day per plant	IS : 1195-1978	14 to 17 % by weight of total mixture
Sl.	**Test**	**Frequency**	**Ref. Codes**	**Acceptance Standards**
11)	**Control of temperature of binder in boiler, aggregate in dryer and mix** at the time of laying and compaction	At regular close intervals		Same as mentioned in 6.4 (Bituminous Macadam)
12)	**Rate of spread of mixed material**	Regular control through check of layer thickness		
13)	**Hardness Number**	Minimum two tests per day.	IS : 1195-1978	• without coarse aggregate at 25 C - 50-70 • with coarse aggregate at 25°C - 10-20

6.14 Bituminous & Cold Mix (Including Gravel Emulsion) :

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards
1)	**Quality of binder**	Number of samples per lot	IS:8887 IS:217	The bitumen shall be a slow/medium setting bitumen emulsion conforming to IS:8887 or a medium curing cut-back conforming to IS:217
2)	**Aggregate Impact Value** **Los Angeles Abrasion Value**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.	IS: 383-1970 IS: 2386 (Part IV)-1963	24% Maximum by Weight 30% Maximum by Weight
3)	**Combined Flakiness and Elongation Indices**	One test per 350 m3 of aggregate of each source and whenever there is change in the quality of aggregate.		35 % Maximum by Weight
4)	**Soundness (Magnesium Sulphate/ Sodium Sulphate)**	One test for each source and whenever there is change in the quality of aggregates	IS : 2386 (Part V)	Maximum Average Loss of Weight after 5 cycles (v) tested with Sodium Sulphate -12% (vi) tested with Magnesium Sulphate -18%
5)	**Water absorption of aggregates**	- do -	IS : 2386 (Part III)	Max. 2%
6)	**Sand equivalent test**	- do -	IS : 2720 (Part 37)	Minimum 50
7)	**Plasticity Index**	- do -	IS : 2720 (Part 5)	Minimum 4
8)	**Polished stone value**	- do -	BS: 812-114	Min 55
9)	**Mix grading**	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant	IS: 2386 (Part I)-1963	As per Table 500-44 of MoRT&H.

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards		
10)	**Stability and voids analysis of mix** including theoretical maximum specific of loose mix	Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to a minimum of two tests per day per plant	AASHTO T 245	**Parameter**	**Emulsion**	**Cutback**
				Minimum Stability	2.2 kN at 22.2°C for paving	2.2 kN at 25°C for maintenance 3.3 kN at 25°C for paving
				Percent maximum stability loss on soaking	503	254
				Minimum flow (mm)	2	2
				Compaction level number of blows)	50	75
				Per cent air voids	3-55	3-5
				Per cent minimum coating	50	
				Per cent voids in mineral aggregate (VMA)	9.5 mm – 16.0%, 12.5 mm – 15.0%, 19.0 mm – 14.0%, 25.0 mm – 13.0% & 37.5 mm – 12.05	
11)	**Moisture Susceptibility of mix**	One test for each mix type whenever there is change in the quality or source of coarse or fine aggregates	AASHTO T 283	Min. 80%		
12)	**Temperature of binder in boiler, aggregate in dryer and mix** at the time of laying and compaction	At regular intervals		Same as mentioned in 6.4 (Bituminous Macadam)		
13)	**Binder content**	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant		Min. 5.2 % for 50 mm thick & Min. 5.4 % for 30 - 40 mm thick		
14)	**Rate of spread of mixed material**	After every 5th truck load				
15)	**Density of compacted layer**	One test per 700 m2 of area	ASTM D 2041	Minimum field density equal to or more than 98% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction.		

7 Reinforced Earth System

Sl.	Test	Frequency	Ref. Codes	Acceptance Standards	
1)	**Lug Pull Out Test**	1 for 500 m2 of Panels	ASTM D 6706	As per the structural design requirement for RE Wall system.	
2)	**Strip Pull Out Test**	1 set of tests (at every 1.5 m height of backfill) for 500 m2 of Panels			
3)	**Structural behaviour of Panels**	1 for 500 m2 of Panels		Structural Form	Minimum Vertical Movement Capacity of System
				Discrete panels	Joint closure of 1 in 150 relative to panel height
				Full height panels	Vertical movement capacity of connections 1 in 150 relative to panel height
				Semi-elliptical facings	Vertical distortion of 1 in 150 relative to panel height
				Geotextile/ Geogrid wrap-around facings	No specific limit except for appearance or serviceability considerations
4)	**Impact Test on Precast Crash barrier over RE Wall**	1 test for 200 m length of crash barrier			

Approximate requirement of materials for different items of Works

3.0 Approximate requirement of materials different items of works:

General Notes:

1. Consumption of materials of construction in the corresponding contract items of works shall be computed on the basis of the quantities shown in the following sections, subject to a variation of plus / minus five percent except for Bitumen/CRMB/Emulsion. The variation in consumption of Bitumen/CRMB/Emulsion may be allowed upto plus/minus one percent. Where, however, the circumstances of work so required, the Engineer-in-charge shall have the authority to allow (with recorded reasons) for a greater variation.

   For open graded mixes, having no specific job mix formula, the quantities as shown in the following tables shall be applicable for estimating the rate of the items.

2. In case of any design mix, the consumption shall be guided by the specific approved job mix formula and relevant provisions of "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" published by MoRT&H (5th Revision). However, for Preliminary estimating purposes, the following quantities may be considered for all cases. However it is advisable to have a mix design with source and type of materials intended to be used in the work and the estimate should be framed according to the quantities of materials as determined in mix design.

3.1 DELETED

TABLE 3.1–1: DELETED

3.2 Approximate requirement of materials for Design Mix Concrete Works items

TABLE 3.2–1: APPROXIMATE QUANTITIES OF MATERIALS REQUIRED FOR DESIGN MIX CONCRETE ITEMS

Concrete Grade	Cement Content / m^3 of Concrete	Recommended type of Cement	Coarse Aggregates & Fine Aggregate/ m^3 of Concrete	Remarks
1	*2*	*3*	*4*	*5*
M-10	280.00 kg	OPC 33 /PSC / PPC	Stone aggregates 0.9 m^3 Sand 0.45 m^3	*1. The quantities given in the table are only for estimating purpose. Actual quantities however, shall be ascertained by proper Mix Design following BSI / IRC/ACI or any standard method approved by Engineer in charge.*
M-15	350.00 kg	OPC 33 /PSC / PPC	Do	
M-20	400.00 kg	OPC 33 /PSC / PPC	Do	
M-25	420.00 kg	OPC 33 /PSC / PPC	Do	*2. During the execution of the item necessary quantity of approved plasticizers to obtain the desired workability and strength is to be added, cost of which has been incorporated in the rate of the item.*
M-30	430.00 kg	OPC 33 /PSC / PPC	Do	
M-35	440.00 kg	OPC 43/53	Do	*3. For under water concrete 10% extra cement over the quantity stated in col.2 is to be added.*
M-40	450.00 kg	OPC 43/53	Do	
M-45	450.00 kg	OPC 53	Do	*4. Add the cost of 60 kg, 75 kg and 90 kg Silica fume for M45, M50 & M55 grade of concrete respectively.*
M-50	450.00 kg	OPC 53	Do	
M-55	450.00 kg	OPC 53	Do	

3.3 Approximate requirement of materials for Sub-base, Bases (Bituminous & Non-bituminous) and Surface Courses items

TABLE 3.3–1: APPROXIMATE QUANTITIES OF MATERIALS REQUIRED FOR SUB-BASE, BASES & SURFACE COURSES ITEMS

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
CH. 4	**SUB-BASES, BASES (NON- BITUMINOUS) :**			
4.08 (A) & (B)	Granular Sub-base with Graded Material (Table:- 400-1)			
	Grading I:	Cum	37.5 mm chips 22.4 mm chips 11.2 mm chips 5.6 mm chips Sand	0.3456 m³ 0.2944 m³ 0.1280 m³ 0.1280 m³ 0.3840 m³
	Grading II:	Cum	37.5 mm chips 22.4 mm chips 11.2 mm chips 5.6 mm chips Sand	0.1920 m³ 0.1280 m³ 0.1280 m³ 0.1536 m³ 0.6784 m³
	Grading III:	Cum	26.5 mm chips 5.6 mm chips Sand	0..4480 m³ 0.5760 m³ 0.2560 m³
	Grading IV:	Cum	26.5 mm chips 5.6 mm chips Sand	0..4480 m³ 0.5120 m³ 0.3200 m³
	Grading V:	Cum	37.5 mm chips 22.4 mm chips 11.2 mm chips 5.6 mm chips Sand	0.2560 m³ 0.2560 m³ 0.1920 m³ 0.3200 m³ 0.2560 m³
	Grading VI:	Cum	37.5 mm chips 22.4 mm chips 11.2 mm chips 5.6 mm chips Sand	0.1536 m³ 0.1536 m³ 0.1536 m³ 0.2816 m³ 0.5376 m³
4.12	Wet Mix Macadam Base Course	Cum	26.5 mm chips 13.2 mm chips 5.6 mm chips Stone dust	0.3960 m³ 0.2640 m³ 0.3564 m³ 0.3036 m³
4.17	Cement Treated Crushed Rock or combination as per clause 403.2 and table 400-4 in Sub base/ Base	Cum	Grading of material for sub-base / Base course per cum of work : 37.5 mm stone metal 20 mm stone metal 10 mm stone metal 5.6 mm stone metal Sand 600 – 75 micron Note: Quantities of aggregates provided under 'a' above are uncompacted quantities for per cum of work (Conform to Table 400-4 of MoRT&H's Specification for Road & Bridge Works -5th Rev.)	 0.030 m³ 0.320 m³ 0.060 m³ 0.060 m³ 0.800 m³

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
CH. 5	**BASES AND SURFACE COURSES (BITUMINOUS) :**			
5.01	(i) Primer coat (for WBM/WMM Surface)	Sqm	Cationic Bituminous Emulsion (SS1 grade) conforming to IS: 8887.	0.85 kg
	(ii) Primer coat (for Stabilised soil bases/ Crusher Run Macadam Surface)	Sqm	-Do-	1.05 kg
5.02	(i) Tack coat (Over Bituminous surfaces.)	Sqm	Cationic Bituminous Emulsion (RS1 grade) conforming to IS: 8887 or suitable low viscosity paving bitumen of VG: 10 grade conforming to IS: 73.	0.250 kg
	(ii) Tack coat (Over Granular surfaces treated with primer.)	Sqm	- Do-	0.275 kg
	(iii) Tack coat (Over Cement Concrete Pavement.)	Sqm	- Do-	0.325 kg
5.03	Bituminous Macadam :			
	A. Grading – 1 (40 mm) (80 to 100 mm thickness.)	Cum	Bitumen (Packed/Bulk)	72.00 kg
			Aggregates:	*1.4151 m^3*
			26.5 mm chips (20%)	0.2831 m^3
			22.4 mm chips (30%)	0.4245 m^3
			11.2 mm chips (30%)	0.4245 m^3
			5.6 mm chips (10%)	0.1415 m^3
			Stone Dust with grit (10%)	0.1415 m^3
	B. Grading – 2 (19 mm) (50 to 75 mm thickness.)	Cum	Bitumen (Packed/Bulk)	75.00 kg
			Aggregates:	*1.4137 m^3*
			22.4 mm chips (30%)	0.4241 m^3
			13.2 mm chips (20%)	0.2827 m^3
			11.2 mm chips (25%)	0.3534 m^3
			5.6 mm chips (15%)	0.2121 m^3
			Stone Dust with grit (10%)	0.1414 m^3
5.05	Dense Bituminous Macadam :			
	A. Grading – 1 (37.5 mm) (75 to 100 mm thickness.)	Cum	Bitumen (Packed/Bulk) or CRMB (Packed/Bulk)	99.00 kg
			Aggregates:	*1.4723 m^3*
			37.5 mm chips (20%)	0.2945 m^3
			26.5 mm chips (10%)	0.1472 m^3
			22.4 mm chips (15%)	0.2208 m^3
			11.2 mm chips (20%)	0.2945 m^3
			5.6 mm chips (10%)	0.1472 m^3
			Stone Dust with grit (25%)	0.3681 m^3
			Filler @ 2% (Lime stone dust/cement)	44.00 kg
	B. Grading – 2 (26.5 mm) 50 to 75 mm thickness.	Cum	Bitumen (Packed/Bulk) or CRMB (Packed/Bulk)	111.00 kg
			Aggregates:	*1.4646 m^3*
			26.5 mm chips (15%)	0.2197 m^3
			22.4 mm chips (15%)	0.2197 m^3
			11.2 mm chips (25%)	0.3662 m^3
			5.6 mm chips (15%)	0.2197 m^3
			Stone Dust with grit (30%)	0.4394 m^3
			Filler @ 2% (Lime stone dust/cement)	44.00 kg
5.06	Sand Asphalt Base Course :	Cum	Bitumen @ 5 per cent	110.00 kg
			Filler (lime) @ 2 per cent	44.00 kg
			Sand or grit of size 4.75 to 0.075 mm	1.408 m^3

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
5.07	Semi-Dense Bituminous Concrete (SDBC) :			
	A. Grading – 1 (13 mm) (35 to 40 mm thickness.)	Cum	Bitumen (Packed/Bulk) or CRMB (Packed/Bulk)	104.00 kg
			Aggregates:	*1.4398 m³*
			13.2 mm chips (10%)	0.1469 m³
			11.2 mm chips (20%)	0.2938 m³
			5.6 mm chips (40%)	0.5877 m³
			Stone dust with grit (28%)	0.4114 m³
			Filler @ 2% (Lime stone dust)	44.00 kg
	B. Grading – 2 (10 mm) (25 to 30 mm thickness.)	Cum	Bitumen (Packed/Bulk) or CRMB (Packed/Bulk)	115.00 kg
			Aggregates:	*1.4323 m³*
			11.2 mm chips (20%)	0.1462 m³
			5.6 mm chips (20%)	0.8769 m³
			Stone dust with grit (40%) Filler @ 2% (Lime stone dust)	0.4092 m³ 44.00 kg
5.08	Bituminous Concrete (BC) :			
	A. Grading – 1 (19 mm) (50 mm thickness.)	Cum	Bitumen (Packed/Bulk) orCRMB (Packed/Bulk)	130.00 kg
			Aggregates:	1.4843 m³
			22.4 mm chips (20%)	0.4453 m³
			13.2 mm chips (20%)	0.1485 m³
			11.2 mm chips (15%)	0.2226 m³
			5.6 mm chips (15%)	0.2226 m³
			Stone dust with grit (30%)	0.4453 m³
			Filler @ 2% (Lime stone dust)	45.00 kg
	B. Grading – 2 (13.2mm) (30 / 40 mm thickness.)	Cum	Bitumen (Packed/Bulk) orCRMB (Packed/Bulk)	137.00 kg
			Aggregates:	1.4796 m³
			13.2 mm chips (20%)	0.2959 m³
			11.2 mm chips (20%)	0.2959 m³
			5.6 mm chips (20%)	0.2959 m³
			Stone dust with grit (40%)	0.5919 m³
			Filler @ 2% (Lime stone dust)	45.00 kg
5.09	Surface dressing			
	(A) Single coat or 1st coat	Sqm	Bitumen (Packed/Bulk)	1.20 kg
			13.2 mm chips	0.15 m³
	(B) Second coat or renewal coat	Sqm	Bitumen (Packed/Bulk)	1.00 kg
			11.2 mm chips	0.010 m³
5.10 & 5.11	Open-Graded Premix Surfacing using Penetration grade Bitumen	Sqm	Bitumen (Packed/Bulk)	1.46 kg
			Aggregates:	0.027 m³
			13.2 mm chips	0.018 m³
			11.2 mm chips	0.009 m³
5.12	Open Graded Premix Surfacing using Cationic Bitumen Emulsion	Sqm	Bitumen (Packed/Bulk)	2.15 kg
			Aggregates:	0.027 m³
			13.2 mm chips	0.018 m³
			11.2 mm chips	0.009 m³
5.13	Seal Coat : Type A			
	(i) With Hot Bitumen Binder	Sqm	Bitumen (Packed/Bulk)	0.98 kg
			5.6 mm chips	0.009 m³
	(ii) With Bitumen Emulsion	Sqm	Cationic Bitumen Emulsion	1.50 kg
			5.6 mm chips	0.009 m³
	Seal Coat : Type B			
	(i) With Hot Bitumen Binder	Sqm	Bitumen (Packed/Bulk)	0.68 kg
			Sand/Stone Grit	0.006 m³
	(ii) With Bitumen Emulsion	Sqm	Cationic Bitumen Emulsion	1.05 kg
			Sand/Stone Grit	0.006 m³

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
5.14	Mastic Asphalt			
	(i) 25 mm thick	Sqm	Bitumen (Packed/Bulk) 10/20 [For cold climatic region (temperature <10°C, use VG-40 grade bitumen]	5.71 kg
			Bitumen (Packed/Bulk) 60/70	0.0143 kg
			Coarse aggregates:	
			5.6 mm chips (50%)	0.0079 m³
			11.2 mm chips (50%)	0.0079 m³
			Fine aggregates:	
			Medium Sand/stone dust/mixture of both	0.0111 m³
			Lime stone powder	10.29 kg
			13.2 mm chips	0.0005 m³
	(ii) 50 mm thick	Sqm	Bitumen (Packed/Bulk) 10/20 [For cold climatic region (temperature <10°C, use VG-40 grade bitumen]	11.43 kg
			Bitumen (Packed/Bulk) 60/70	0.0143 kg
			Coarse aggregates:	
			5.6 mm chips (50%)	0.0157 m³
			11.2 mm chips (50%)	0.0157 m³
			Fine aggregates:	
			Medium Sand/stone dust/mixture of both	0.0224 m³
			Lime stone powder	20.48 kg
			13.2 mm chips	0.0005 m³
5.15	Slurry Seal			
	(i) 5 mm thickness	Sqm	Cationic Bitumen Emulsion	1.21 kg
			Stone Grit	0.0064 m³
			Cement Filler	0.22 kg
	(ii) 3 mm thickness	Sqm	Cationic Bitumen Emulsion	0.86 kg
			Sand	0.37 m³
			Cement Filler	0.132
	(iii) 1.5 mm thickness	Sqm	Cationic Bitumen Emulsion	0.53 kg
			Sand	0.0018 m³
			Cement Filler	0.066 kg
5.16	Fog Spray	Sqm	Cationic Bitumen Emulsion	0.75 kg
5.17	Bituminous Cold Mix (Including Gravel Emulsion)			
	(i) With 13.2 mm nominal size aggregate	Cum	Bitumen (Packed/Bulk) orCRMB (Packed/Bulk)	176.00 kg
			Aggregates:	*1.3170 m³*
			13.2 mm chips (14%)	0.1829 m³
			11.2 mm chips (14%)	0.1829 m³
			5.6 mm chips (32%)	0.4244 m³
			Stone dust with grit (40%)	0.5268 m³
			Filler @ 2% (Lime stone dust)	44.00 kg
	(ii) With 26.5 mm nominal size aggregate	Cum	Bitumen (Packed/Bulk) orCRMB (Packed/Bulk)	176.00 kg
			Aggregates:	*1.3170 m³*
			26.5 mm chips (14%)	0.1829 m³
			22.4 mm chips (14%)	0.1829 m³
			22.4 mm chips (32%)	0.4390 m³
			5.6 mm chips (20%)	0.2561 m³
			Stone dust with grit (20%)	0.2561 m³
			Filler @ 2% (Lime stone dust)	44.00 kg

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
5.18	Crack Prevention Courses			
	(i) Stress absorbing membrane (SAM) crack width less than 6 mm	Sqm	Modified Binder 5.6 mm chips	0.90 kg 0.010 m³
	(ii) Stress absorbing membrane (SAM) with crack width 6 mm to 9 mm	Sqm	Modified Binder 11.2 mm chips	1.10 kg 0.006 m³
	(iii) Stress absorbing membrane (SAM) crack width above 9 mm and cracked area above 50 per cent	Sqm	Modified Binder 11.2 mm chips	1.50 kg 0.012 m³
	(iv) Bitumen impregnated geotextile	Sqm	Modified Binder Geogrid	1.05 kg 1.10 m^2
5.20	Recycling of Bituminous Pavement with Central Recycling Plant (Considering percentage of mix require fresh aggregate = 70 % = 1.0304 cum.)	Cum	Bitumen Coarse aggregates: 37.5–25 mm chips (23%) 25-10 mm chips (15%) 10 – 5.6 mm chips (20%) Below 5.6 mm chips (40%) Filler (cement) @ 2% of 2.3 t	81.00 kg *1.0304 m3* 0.237 m3 0.155 m3 0.206 m3 0.412 m3 46.00 kg
5.21	20 mm thick Mix Seal Surfacing (MSS) :	Sqm.	Type – A : Stone dust Stone Chips 5.6 mm Bitumen Type –B : Stone dust Stone Chips 5.6 mm Stone Chips11.2 mm Bitumen	 0.007 cum 0.020 cum 2.20 kg. 0.0041 cum 0.0162 cum 0.0067 cum 1.900 kg.
5.22	Micro Surfacing			
	(i) Type – II (4 to 6 mm thick)	Sqm	Polymer modified emulsion for Micro Surfacing 5.6 mm stone metal Stone grit Stone dust Cement (OPC)	1.254 kg 0.001285 m3 0.003880 m3 0.002017 m3 0.12 kg
	(ii) Type – III (6 to 8 mm thick)	Sqm	Polymer modified emulsion for Micro Surfacing 5.6 mm stone metal Stone grit Stone dust Cement (OPC)	1.686 kg 0.004638 m3 0.003341 m3 0.002532 m3 0.171
5.23	Stone Matrix Asphalt (SMA)			
	(i) 13 mm SMA with layer thickness 40-50 mm	Cum	Bitumen (Packed / Bulked) or CRMB (Packed / Bulked) 13.2 mm stone metal 11.2 mm stone metal 5.6 mm stone metal Stone dust Lime	131.46 kg 0.07819 m3 0.70991 m3 0.49820 m3 0.24219 m3 64.034 kg
	(i) 19 mm SMA with layer thickness 45-75 mm	Cum	Bitumen (Packed / Bulked) or CRMB (Packed / Bulked) 13.2 mm stone metal 11.2 mm stone metal 5.6 mm stone metal Stone dust Lime	129.844 kg 0.27811 m3 0.62351 m3 0.36919 m3 0.23930 m3 63.270 kg

Item No. Vide Chapter	Brief Description	Unit	Materials	Quantity
10.06	Pre-coating Chips	Cum	Bitumen (Packed/Bulk) 11.2 mm chips	56.00 kg 1.00 m³
10.07	Repairing pot-holes Using Mobile HMP (Light duty)	Cum	Bitumen (Packed/Bulk) Coarse aggregates	54.00 kg 1.00 m³
	(i) By grouting method	Cum	Bitumen (Packed/Bulk) Coarse aggregates mm chips / Bajree (key aggregates)	70.00 kg 1.00 m³ 0.10 m³
10.08	Repairing pot-holes (ii) (using Cationic Bitumen Emulsion)	Cum	Bitumen Emulsion 22.4 mm chips / Bajree 11.2 mm chips / Bajree	70.70 kg 0.60 m³ 0.40 m³

SCHEDULE OF RATES

BASIC COST OF MATERIALS

AND

ISSUE RATES

BASIC COST OF MATERIALS

TABLE NO. I – 1 : BASIC RATES OF CEMENT & STEEL MATERIALS

Item No.	Description of Items	Unit	Issue Rate(₹) (Supplied by Department)		Basic Price(₹) (Supplied by Contractor)	
			South Bengal	North Bengal	South Bengal	North Bengal
1.	Cement :					
	PPC / PSC / OPC33	MT	*6289.00*	*6460.00*	*5717.00*	*5873.00*
	OPC (43 Grade)	MT	*6289.00*	*6460.00*	*5717.00*	*5873.00*
	OPC (53 Grade)	MT	*6460.00*	*6662.00*	*5873.00*	*6056.00*
			Kolkata / Durgapur	Siliguri	Kolkata / Durgapur	Siliguri
2.	Steel materials :					
	(i) a. Mild Steel rods(SAIL/TATA/RINL)	MT	*51900.00*	*53900.00*	*46130.00*	*47950.00*
	b. Mild Steel rods (JSW/JSPL / Shyam / SRMB/ SSL/ BMASL / Electrosteel) *(Fe 250, conforms to IS: 432)*	MT	*49300.00*	*51300.00*	*43750.00*	*45600.00*
	c. Mild Steel rods (Other than Above) *(Fe 250 Conform to IS:432)*	MT	*49300.00*	*51300.00*	*43750.00*	*45600.00*
	(ii) a. Tor Steel rods / HYSD bars / TMT bars (SAIL/ TATA / RINL)	MT	*51900.00*	*53900.00*	*46130.00*	*47950.00*
			49300.00	*51300.00*	*43750.00*	*45600.00*
	b. Tor Steel rods / HYSD bars / TMT bars (JSW/ JSPL / Shyam / SRMB/ /SSL/ BMASL / Electrosteel)	MT				
	(Fe 415 /Fe 500 /Fe 500D, conforms to IS: 1786)	MT	*49300.00*	*51300.00*	*43750.00*	*45600.00*
	c. Tor Steel rods / HYSD bars / TMT bars. (Other than Above) *(Fe 415 /Fe 500 /Fe 500D Conform to IS:1786)*					
	(iii) CRS of approved brand.	MT	-	-	-	-
	(iv) H T Strand TATA SSL / USHA Martin or any other approved brand. *(Conforms to IS:6006 /IS:14268)*	MT	-	-	*74000.00*	*75500.00*
	(v) Steel plates : *(E 250 conforms to IS:2062-2006)*					
	(a) 6 – 10 mm.	MT	-	-	*46500.00*	*4800000*
	(b) 10 – 20 mm.	MT	-	-	*4650000*	*48000..00*
	(c) 25 – 40 mm.	MT	-	-	*46500.00*	*48000..00*
	(vi) Structural Steel (MS) angles, joists, channels, flats etc. *(E 250 conforms to IS:2062 & 808)*					
	(a) Up to 200mm size.	MT	-	-	*46000.00*	*47500.00*
	(b) Above 200mm & up to 400mm size.	MT	-	-	*46500.00*	*48000.00*
	(c) Above 400 mm size.	MT	-	-	*49000.00*	*50500.00*

Note: *The above rates are exclusive of GST, Overhead Charges & Contractor's Profit.*

Construction Wing is to add the cost of Cement and Steel to the concerned item to arrive at the complete Rate of the item according to calculation shown in FORMAT C, D, E and F for Cement and Steel as the case may be.

TABLE NO. I-2- EX-OUTLET PRICES OF BITUMEN

Sl. No.	Description of item	Unit	Rates at outlets (₹)	
			At Haldia	At Dhulagarh Jn. (on NH-6)
1.	Bitumen (Bulk) :VG-10 (80/100)	MT	*27160.00*	***
2.	Bitumen (Packed) :VG-10 (80/100)	MT	*30260.00*	***
3.	Bitumen (Bulk) :VG-30 (60/70)	MT	*27960.00*	***
4.	Bitumen (Packed) :VG-30 (60/70)	MT	*31060.00*	***
5.	Bitumen (Bulk) :VG-40 (30/40)	MT	*28560.00*	***
6.	Bitumen (Packed) :VG-40 (30/40)	MT	***	***
7.	Penetration grade Bitumen (Packed): (10/20)	MT	***	*34290.00*
8.	Bituminous Emulsion (Bulk) MS Type	MT	*23250.00*	***
9.	Bituminous Emulsion (Packed) MS Type	MT	***	*29000.00*
10.	CRMB – 55 (Bulk)	MT	*29790.00*	***
11.	CRMB – 55 (Packed)	MT	*33140.00*	***
12.	CRMB – 60 (Bulk)	MT	*30100.00*	***
13.	CRMB – 60 (Packed)	MT	*33450.00*	***
14.	Polymer Modified Emulsion for Micro Surfacing	MT	***	*37712.00*

Note –

1. *All the above rates (Sl.1 to13) under Col. 4 & 5 above are excluding GST, Overhead Charges &Contractor's Profit.*
2. *The rates of packed materials mentioned under column "Description of items" are also inclusive of cost of containers.*
3. *To evaluate the cost of Bitumen/CRMB/Bitumen emulsion, cost of drums of ₹1000/- per MT is to be considered.*
4. *To evaluate Issue Rate and cost at site of bitumen / CRMB / bituminous emulsion issued by the Department refer Format – A.*
5. *To evaluate cost at site of bitumen / CRMB / bituminous emulsion supplied by the Contractor refer Format – B.*
6. *Ex-outlet price of all types of Paving Bituminous product will be reviewed by the Schedule Committee at the beginning of every quarter of the Calendar Year and if it varies beyond ± 5%, necessary notification regarding the changes in price of all kinds of Paving Bitumen will be issued.*

Note - II : *For Penetration grade Bitumen (Packed): (10/20)The binder shall be a paving grade bitumen meeting the requirements given in table 500-29 of Specification of Road and Bridge Works and should be approved by the Engineer in charge.*

Note - III : **The figure in bracket in the description of the above table indicates the old equivalent penetration grade as per No. RW/NH-33041/3/2001-S & R (R) -Vol. III Dated 04.08.2008 of Director General (Road development) & SS of MORTH.**

FORMAT – A

Format for Analysis of Rates of Bitumen / Bitumen Emulsion / CRMB supplied by Department

Step - 1	Cost of materials including all taxes at the nearest source of the manufacturer as given in Table I – 2.	₹ (A)
Step – 2	Necessary cost for loading, unloading & stacking.	₹ (B)
Step – 3	Necessary carriage cost from source of the manufacturer to different departmental godown. *(Vide Appendix – I)*	₹ (C)
Step – 4	Add storage charge for storing the materials at departmental godown / stack yard (@ 1% of (A)	₹ (D)
	Departmental Issue Rate = (A) + (B) + (C) + (D)	₹ (E)
Step – 5	Add loading, unloading and carriage charges from departmental godown / stack yards to the work site.	₹ (F)
Step – 6	Deduct cost of container *(Vide Note I-3, Table I-2)* *(in case of packed bitumen, CRMB or bituminous emulsion is considered to be used)*	₹ (G)
	Rate of Material at Site = (E) + (F) – (G) =	**₹ (H)**

Note :

1. *The total rate marked '(E)' is the issue rate of bitumen / CRMB / bituminous emulsion, which will be deducted from the Contractor's bills against any bituminous works done with bitumen supplied by the Department.*

2. *The total rate marked '(H)' is the complete rate of the bitumen / CRMB / bituminous emulsion which has to be added to any item of bituminous work, where applicable, to arrive at the complete rate of the work.*

FORMAT – B

Format for Analysis of Rates of Bitumen / Bituminous Emulsion / CRMB supplied by Contractor

(Prior approval from concerned Superintending Engineer is necessary before framing an estimate by using this Format-B)

Step - 1	Cost of materials including all taxes at the nearest source of the manufacturer as given in Table I – 2 of the Schedule of Rates.	₹ (A)
Step - 2	Add Overhead Charges [@ 5% of (A)]	₹ (B)
Step - 3	Add Contractor's Profit [@ 10% of (A+B)]	₹ (C)
Step - 4	Necessary cost for loading, unloading and carriage cost from source of the manufacturer to the work site.	₹ (D)
Step - 5	Deduct cost of container *(Vide Note-3, Table I-2)* *(in case of packed bitumen, CRMB or bituminous emulsion is considered to be used)*	₹ (E)
	Rate of Material at Site = (A) + (B) + (C) + (D) – (E) =	**₹ (F)**

Note : *The total rate marked '(F)' is the complete rate of the bitumen / CRMB / bituminous emulsion which has to be added to any item of bituminous work, where applicable, to arrive at the complete rate of the work.*

FORMAT – C

Format for Analysis of Rate of Items involving use of Cement supplied by Contractor.

CASE (I): <u>For Items, where costs of cement is already included in the item rate:-</u>

Step - 1	Rate of item as per relevant section of this Schedule of Rates.	₹ (A)
Step - 2	Deduct: Cost of cement = (Quantity of cement required) x (Issue rate of Cement vide Item no. 1, column –4, Table I – 1 of the Schedule of Rates. ***Note:*** The quantity of cement shall be as per Section – 3 of this schedule of rates.	₹ (B)
Step - 3	Add: Cost of cement = (Quantity of cement required) x (Basic Price of Cement vide Item no. 1, column –5, Table I – 1 of the Schedule of Rates. ***Note:*** The quantity of cement shall be same as Step – 2.	₹ (C)
	Final Rate of Item = (A) + (B) + (C) =	**₹ (D)**

FORMAT – C

CASE (II): For Items, where costs of cement is to be added to the item rate to arrive at the complete rate:-

Step - 1	Rate of item as per relevant section of this Schedule of Rates.	₹ (A)
Step - 2	Add: Cost of cement = (Quantity of cement required) x (Basic Price of Cement vide Item no. 1, column –5, Table I – 1 of the Schedule of Rates. ***Note:*** The quantity of cement shall be as per Section – 3 of this schedule of rates.	₹ (B)
	Final Rate of Item = (A) + (B) =	**₹ (C)**

FORMAT – D

Format for Analysis of Rate of Items involving use of Cement supplied by Department.

Step – 1	Rate of item as per relevant section of this Schedule of Rates.	₹ (A)
Step – 2	Add: Cost of cement = (Quantity of cement) x (Issue rate of cement vide Item no. 1, column – 4, Table I – 1 of the Schedule of Rates). ***Note:*** The quantity of cement shall be as per Section – 3 of this Schedule of Rates.	₹ (B)
	Complete Rate of the Item involving use of Cement supplied by the Department = (A) + (B) =	**₹ (C)**

FORMAT – E

(Format for Analysis of Rate of Items involving use of Steel supplied by Contractor)

Step - 1	Rate of item as per relevant Section of the Schedule of Rates.	₹ (A)
Step - 2	Add: Cost of Steel = Quantity of Steel x Basic Price of Steel (vide Item no.2, Column –5, Table I – 1 of this Schedule of Rates).	₹ (B)
Step - 3	Add: Cost of Carriage including necessary loading - unloading from nearest Company Outlets /Stack yard/Godown to the site of execution (excluding Overhead Charges & Contractor's Profit)	₹ (C)
Step - 4	Add: Overhead Charges @ 5% /15% /20% of (B+C) as the case may be (vide Sl. 3 of PREMBLE).	₹ (D)
Step - 5	Add: Contractor's Profit @ 10% of (B+C+D)	₹ (E)
	Final Rate of Item = (A) + (B) + (C) + (D) + (E) =	**₹ (F)**

FORMAT – F

(Format for Analysis of Rate of Items involving use of Steel supplied by Department)

Step – 1	Rate of item as per relevant Section of the Schedule of Rates.	₹ (A)
Step – 2	Add: Cost of Steel = (Quantity of Steel) x (Issue rate of Steel vide Item no. 2, column – 4, Table I – 1 of the Schedule of Rates).	₹ (B)
Step – 3	Add: Cost of carriage of from Departmental Godown to the site of work including loading, unloading and stacking.	₹ (C)
	Final Rate of Item = (A) + (B) + (C) =	**₹ (D)**

TABLE II – 1 : SUPPLY OF DIFFERENT MATERIALS AS PER APPROVED SPECIFICATION.

Sl. No.	Description of Item	Unit	Kolkata/ 24 Pargnas (N & S)	Howrah/ Hooghly	East & West Burdwan	East Medinipur	West Medinipur	Bankura	Purulia	Birbhum	Nadia	Murshidabad	Malda	N & S Dinajpur	Cooch Behar	Jalpaiguri & Darjeeling plains	Darjeeling Hill Area
1.	**Coarse Sand** (Grading Zone I as per IS: 383-1970) stacked at site.	*Cum*	*1430.00*	*1114.00*	*655.00*	*798.00*	*714.00*	*536.00*	*536.00*	*536.00*	*952.00*	*952.00*	*834.00*	*1012.00*	*774.00*	*774.00*	*1655.00*
2.	**Medium Sand** (Grading Zone II as per IS:383-1970) stacked at site.	*Cum*	*1180.00*	*867.00*	*476.00*	*625.00*	*476.00*	*416.00*	*416.00*	*416.00*	*834.00*	*774.00*	*714.00*	*834.00*	*655.00*	*655.00*	*1547.00*
3.	**Fine Sand** (Grading Zone III as per IS:383-1970) stacked at site.	*Cum*	*990.00*	*680.00*	*416.00*	*595.00*	*381.00*	*375.00*	*358.00*	*358.00*	*680.00*	*595.00*	*595.00*	*476.00*	*512.00*	*512.00*	*1370.00*
4.	**Silver Sand** Stacked at site.	*Cum*	*800.00*	*571.00*	*377.00*	*400.00*	*228.00*	*228.00*	-	-	*519.00*	*457.00*	*286.00*	*358.00*	*286.00*	*377.00*	-
5.	**Bricks / Jhama / Bats** Sorted& stacked at site.																
	(a) 1st Class bricks (kiln burnt)	*1000 Nos.*	*8095.00*	*8095.00*	*7381.00*	*8095.00*	*8095.00*	*6762.00*	*6190.00*	*6190.00*	*7381.00*	*7381.00*	*7381.00*	*7381.00*	*7381.00*	*7381.00*	*10000.00*
	(b) 2nd Class bricks (kiln burnt)	*1000 Nos.*	*5762.00*	*5762.00*	*5143.00*	*5476.00*	*5476.00*	*4571.00*	*4048.00*	*4048.00*	*5333.00*	*5333.00*	*5238.00*	*5333.00*	*5238.00*	*5143.00*	*7190.00*
	(c) 1st Class Picked Jhama bricks	*1000 Nos.*	*8000.00*	*8048.00*	*7286.00*	*7905.00*	*7905.00*	*6571.00*	*5762.00*	*5762.00*	*7286.00*	*7286.00*	*7286.00*	*7286.00*	*7286.00*	*7286.00*	*9810.00*
	(d) Flyash bricks (Modular)	*1000 Nos.*	*5524.00*	*5524.00*	*5238.00*	*5429.00*	*5429.00*	*5238.00*	*5238.00*	*5238.00*	*5429.00*	*5238.00*	*5238.00*	-	-	-	-
	(e) Jhama metal (kiln burnt)	*Cum*	*1667.00*	*1667.00*	*1162.00*	*1429.00*	*1429.00*	-	-	*1162.00*	*1162.00*	*1162.00*	*1429.00*	*1429.00*	*1429.00*	*1429.00*	-
	(f) Brick bats.	*Cum*	*1162.00*	*1162.00*	*952.00*	*1114.00*	*1095.00*	*857.00*	*857.00*	*857.00*	*952.00*	*952.00*	*1000.00*	*1000.00*	*1000.00*	*1000.00*	*2219.00*
	(g) Brick Aggregates (40 mm down)	*Cum*	*1386.00*	*1386.00*	*1176.00*	*1338.00*	*1319.00*	*1081.00*	*1081.00*	*1081.00*	*1176.00*	*1176.00*	*1224.00*	*1224.00*	*1224.00*	*1224.00*	*2443.00*
6.	Laterite Boulder(at Quarry)	*Cum*	-	-	-	-	*255.00*	*255.00*	-	-	-	-	-	-	-	-	-
7.	Moorum (at Quarry)	*Cum*	-	-	-	-	*117.00*	*117.00*	*117.00*	*117.00*	-	-	-	-	-	-	-

Sl. No.	Description of Item	Unit	Kolkata/ 24 Pargnas (N & S)	Howrah / Hooghly	Burdwan	East Medinipur	West Medinipur	Bankura	Purulia	Birbhum	Nadia	Murshidabad	Malda	N & S Dinajpur	Cooch Behar	Jalpaiguri & Darjeeling plains	Darjeeling Hill Area
8	**RCC Pipe: (Ex - outlet)**																
	a. 600 dia NP-3spigot	*M*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*	*2258.00*
	b. 600 dia NP-4spigot	*M*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*	*2614.00*
	c. 900 dia NP-3spigot	*M*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*	*3564.00*
	d. 900 dia NP-4spigot	*M*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*	*5200.00*
	e. 1000 dia NP-3spigot	*M*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*	*4396.00*
	f. 1000 dia NP-4spigot	*M*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*	*6297.00*
	g. 1200 dia NP-3spigot	*M*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*	*5703.00*
	h. 1200 dia NP-4spigot	*M*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*	*7366.00*
	i. 1400 dia NP-3 spigot	*M*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*	*7596.00*
	j. 1400 dia NP-4 spigot	*M*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*	*7976.00*
	k. 1800 dia NP-3 spigot	*M*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*	*11556.00*
	l. 1800 dia NP-4 spigot	*M*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*	*12133.00*
9	**ADMIXTURE:**																
	a) Supply of approved brand polycarboxylates based high grade super -plasticiser / water reducer.	*Kg*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*	*140.00*
	b) Supply of approved brand naphthalene based superplasticiser /water reducing admixture.	*Kg*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*	*51.00*
	c) Silica Fume (IS: 15388)	*Kg*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*	*24.00*
10	**Lime**	*Kg*	*4.20*	*4.20*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*3.70*	*4.80*

Note: 1. *The above rates are inclusive of all charges such as Royalty, Supervision Charges, etc. and also include allowance for sinkage, as applicable, and/or shrinkage and 10% Contractor's Profit but exclusive of GST.*

2. *Rates for Sand (Sl. No. 1 to 4) and Brick / Jhama / Bats items (Sl. No. 5) are complete rates at site and no other costs need to be considered. For other items, necessary loading-unloading & carriage charges are admissible.*

3. *Laterite Boulder & Moorum are available in the districts as mentioned in Sl. No. 6 & 7 respectively; remaining districts may add necessary carriage cost as applicable.*

TABLE III-1 : COST OF STONE AGGREGATES AT QUARRY SITES

Sl. No	Items	Unit	Source Name					
			Pakur	Nilgiri (Orissa)	RampurhatN alhati, Panchami	Dhadka	Hura, Puncha Malti Barabazar	Darjeeling Jalpaiguri &Coochbehar District
1	Stone chips 26.5 mm	m^3	*607*	*****	*563*	*655*	*606*	*595*
2	Stone chips 22.4 mm	m^3	*622*	*****	*628*	*833*	*731*	*660*
3	Stone chips 13.2 mm	m^3	*645*	*****	*676*	*942*	*774*	*671*
4	Stone chips 11.2 mm	m^3	*506*	*****	*471*	*579*	*595*	*671*
5	Stone chips 5.6 mm	m^3	*253*	*****	*276*	*319*	*379*	*379*
6	Stone Grit	m^3	*153*	*****	*205*	*246*	*303*	*****
7	Stone dust mixed with grit	m^3	*139*	*351*	*92*	*92*	*92*	*****
8	40 mm Nominal graded Stone aggregate	m^3	*570*	*****	*551*	*****	*623*	*603*
9	20 mm Nominal graded Stone aggregate	m^3	*561*	*****	*566*	*****	*669*	*639*
10	10 mm Nominal graded Stone aggregate	m^3	*430*	*****	*393*	*****	*505*	*556*
11	Grade - I (63 - 45mm) Stone Aggregates	m^3	*530*	*368*	*460*	*****	*319*	*400*
12	Grade - II (53 - 22.4 mm) Stone Aggregates	m^3	*552*	*411*	*519*	*****	*373*	*595*
13	Stone Screening Type - A	m^3	*335*	*****	*335*	*****	*444*	*****
14	Stone Screening Type - B	m^3	*141*	*****	*97*	*****	*97*	*****
15	Stone aggregates 37.5 mm	m^3	*548*	*411*	*519*	*****	*373*	*595*
16	Shingles 63 mm	m^3	*****	*****	*****	*****	*****	*206*
17	Shingles 37.5 mm	m^3	*****	*****	*****	*****	*****	*238*
18	Bajree 22.4 mm	m^3	*****	*****	*****	*****	*****	*325*
19	Broken Bajree 22.4 mm	m^3	*****	*****	*****	*****	*****	*346*
20	Bajree 13.2 mm	m^3	*****	*****	*****	*****	*****	*357*
21	Bajree 11.2 mm	m^3	*****	*****	*****	*****	*****	*325*
22	Boulder above 225 mm	m^3	*****	*****	*260*	*276*	*189*	*292*
23	Boulder 225 - 150 mm	m^3	*****	*****	*276*	*****	*216*	*271*
24	Boulder 30 / 45 kg	m^3	*332*	*****	*****	*****	*****	*****
25	River Bed Material	m^3	*****	*****	*****	*****	*****	*173*
26	River Grit	m^3	*****	*****	*****	*****	*****	*249*

Note : *1. The above rates are inclusive of all charges such as Royalty, Supervision Charges, etc. and also include allowance for sinkage and/or shrinkage, but excluding GST, Overhead Charges and Contractor's Profit. However in the analysis of rate of items, Overhead Charges and Contractor's profit are included.*

2. Payment will be made on the basis of net volume.

3. The Superintending Engineers of concerned Construction Circles may select the source(s) of stone aggregates considering the availability and applicability of aggregates for specific items of work.

TABLE III-2 : RATES OF PAKUR VARIETY STONE AGGREGATES AT DIFFERENT RAILWAY YARDS

Name of Railway Yards	Unit	Boulder 30 / 45 kg	Hand broken Aggregates		Stone Aggregates 37.5 mm	Machine made Stone Chips					Stone grit	Stone dust mixed wit grit	Stone Screening		Graded Aggregates		
			Grade - I aggregates (63 - 45mm)	Grade - II aggregates (53 - 22.4 mm)		26.5 mm	22.4 mm	13.2 mm	11.2 mm	5.6 mm			Type - A	Type - B	40 mm Nominal size	20 mm Nominal size	10 mm Nominal size
Adrajn.	Cum	1146.00	1344.00	1366.00	1362.00	1421.00	1436.00	1459.00	1320.00	1067.00	967.00	953.00	1149.00	955.00	1384.00	1375.00	1244.00
Andal	Cum	927.00	1125.00	1147.00	1143.00	1202.00	1217.00	1240.00	1101.00	848.00	748.00	734.00	930.00	736.00	1165.00	1156.00	1025.00
Asansol	Cum	983.00	1181.00	1203.00	1199.00	1258.00	1273.00	1296.00	1157.00	904.00	804.00	790.00	986.00	792.00	1221.00	1212.00	1081.00
Ballyganj	Cum	1201.00	1399.00	1421.00	1417.00	1476.00	1491.00	1514.00	1375.00	1122.00	1022.00	1008.00	1204.00	1010.00	1439.00	1430.00	1299.00
Bandel Jn.	Cum	1090.00	1288.00	1310.00	1306.00	1365.00	1380.00	1403.00	1264.00	1011.00	911.00	897.00	1093.00	899.00	1328.00	1319.00	1188.00
Bankura Jn.	Cum	1253.00	1451.00	1473.00	1469.00	1528.00	1543.00	1566.00	1427.00	1174.00	1074.00	1060.00	1256.00	1062.000	1491.00	1482.00	1351.00
Barasat	Cum	1201.00	1399.00	1421.00	1417.00	1476.00	1491.00	1514.00	1375.00	1122.00	1022.00	1008.00	1204.00	1010.00	1439.00	1430.00	1299.00
Barrackpur	Cum	1146.00	1344.00	1366.00	1362.00	1421.00	1436.00	1459.00	1320.00	1067.00	967.00	953.00	1149.00	955.00	1384.00	1375.00	1244.00
Baruipurjn.	Cum	1253.00	1451.00	1473.00	1469.00	1528.00	1543.00	1566.00	1427.00	1174.00	1074.00	1060.00	1256.00	1062.00	1491.00	1482.00	1351.00
Berhampur Court	Cum	1416.00	1614.00	1636.00	1632.00	1691.00	1706.00	1729.00	1590.00	1337.00	1237.00	1223.00	1419.00	1225.00	1654.00	1645.00	1514.00
Bishnupur	Cum	1307.00	1505.00	1527.00	1523.00	1582.00	1597.00	1620.00	1481.00	1228.00	1128.00	1114.00	1310.00	1116.00	1545.00	1536.00	1405.00
Bongaon	Cum	1253.00	1451.00	1473.00	1469.00	1528.00	1543.00	1566.00	1427.00	1174.00	1074.00	1060.00	1256.00	1062.00	1491.00	1482.00	1351.00
Burdwan In.	Cum	927.00	1125.00	1147.00	1143.00	1202.00	1217.00	1240.00	1101.00	848.00	748.00	734.00	930.00	736.00	1165.00	1156.00	1025.00
Chandrakona Road	Cum	1526.00	1724.00	1746.00	1742.00	1801.00	1816.00	1839.00	1700.00	1447.00	1347.00	1333.00	1529.00	1335.00	1764.00	1755.00	1624.00
Contai roads	Cum	1526.00	1724.00	1746.00	1742.00	1801.00	1816.00	1839.00	1700.00	1447.00	1347.00	1333.00	1529.00	1335.00	1764.00	1755.00	1624.00
Dalkhola	Cum	983.00	1181.00	1203.00	1199.00	1258.00	1273.00	1296.00	1157.00	904.00	804.00	790.00	986.00	792.00	1221.00	1212.00	1081.00
Dankuni	Cum	1090.00	1288.00	1310.00	1306.00	1365.00	1380.00	1403.00	1264.00	1011.00	911.00	897.00	1093.00	899.00	1328.00	1319.00	1188.00
Dhupguri	Cum	1361.00	1559.00	1581.00	1577.00	1636.00	1651.00	1674.00	1535.00	1282.00	1182.00	1168.00	1364.00	1170.00	1599.00	1590.00	1459.00
Durgapur	Cum	927.00	1125.00	1147.00	1143.00	1202.00	1217.00	1240.00	1101.00	848.00	748.00	734.00	930.00	736.00	1165.00	1156.00	1025.00
Falakata	Cum	1416.00	1614.00	1636.00	1632.00	1691.00	1706.00	1729.00	1590.00	1337.00	1237.00	1223.00	1419.00	1225.00	1654.00	1645.00	1514.00
Haldia	Cum	1471.00	1669.00	1691.00	1687.00	1746.00	1761.00	1784.00	1645.00	1392.00	1292.00	1278.00	1474.00	1280.00	1709.00	1700.00	1569.00
Jhargram	Cum	1526.00	1724.00	1746.00	1742.00	1801.00	1816.00	1839.00	1700.00	1447.00	1347.00	1333.00	1529.00	1335.00	1764.00	1755.00	1624.00

Name of Railway Yards	Unit	Boulder 30 / 45 kg	Hand broken aggregates		Stone aggregates 37.5 mm	Machine made chips					Stone grit	Stone dust mixed wit grit	Stone screening		Graded Aggregates		
			Grade - I aggregates (63 - 45mm)	Grade - II aggregates (53 - 22.4 mm)		26.5 mm	22.4 mm	13.2 mm	11.2 mm	5.6 mm			Type - A	Type - B	40 mm Nominal size	20 mm Nominal size	10 mm Nominal size
Kalyani	Cum	1146.00	1344.00	1366.00	1362.00	1421.00	1436.00	1459.00	1320.00	1067.00	967.00	953.00	1149.00	955.00	1384.00	1375.00	1244.00
Kharagpur Jn.	Cum	1416.00	1614.00	1636.00	1632.00	1691.00	1706.00	1729.00	1590.00	1337.00	1237.00	1223.00	1419.00	1225.00	1654.00	1645.00	1514.00
Krishnanagar City	Cum	1253.00	1451.00	1473.00	1469.00	1528.00	1543.00	1566.00	1427.00	1174.00	1074.00	1060.00	1256.00	1062.00	1491.00	1482.00	1351.00
Maldah Town	Cum	762.00	960.00	982.00	978.00	1037.00	1052.00	1075.00	936.00	683.00	583.00	569.00	765.00	571.00	1000.00	991.00	860.00
Midnapore	Cum	1471.00	1669.00	1691.00	1687.00	1746.00	1761.00	1784.00	1645.00	1392.00	1292.00	1278.00	1474.00	1280.00	1709.00	1700.00	1569.00
New Farakka	Cum	762.00	960.00	982.00	978.00	1037.00	1052.00	1075.00	936.00	683.00	583.00	569.00	765.00	571.00	1000.00	991.00	860.00
New Alipore	Cum	1201.00	1399.00	1421.00	1417.00	1476.00	1491.00	1514.00	1375.00	1122.00	1022.00	1008.00	1204.00	1010.00	1439.00	1430.00	1299.00
New Alipurduar	Cum	1526.00	1724.00	1746.00	1742.00	1801.00	1816.00	1839.00	1700.00	1447.00	1347.00	1333.00	1529.00	1335.00	1764.00	1755.00	1624.00
New Coochbehar	Cum	1526.00	1724.00	1746.00	1742.00	1801.00	1816.00	1839.00	1700.00	1447.00	1347.00	1333.00	1529.00	1335.00	1764.00	1755.00	1624.00
New Jalpaiguri	Cum	1253.00	1451.00	1473.00	1469.00	1528.00	1543.00	1566.00	1427.00	1174.00	1074.00	1060.00	1256.00	1062.00	1491.00	1482.00	1351.00
Panskura	Cum	1307.00	1505.00	1527.00	1523.00	1582.00	1597.00	1620.00	1481.00	1228.00	1128.00	1114.00	1310.00	1116.00	1545.00	1536.00	1405.00
Purulia	Cum	1035.00	1233.00	1255.00	1251.00	1310.00	1325.00	1348.00	1209.00	956.00	856.00	842.00	1038.00	844.00	1273.00	1264.00	1133.00
Raniganj	Cum	927.00	1125.00	1147.00	1143.00	1202.00	1217.00	1240.00	1101.00	848.00	748.00	734.00	930.00	736.00	1165.00	1156.00	1025.00
Sainthia	Cum	762.00	960.00	982.00	978.00	1037.00	1052.00	1075.00	936.00	683.00	583.00	569.00	765.00	571.00	1000.00	991.00	860.00
Salimar	Cum	1201.00	1399.00	1421.00	1417.00	1476.00	1491.00	1514.00	1375.00	1122.00	1022.00	1008.00	1204.00	1010.00	1439.00	1430.00	1299.00
Sealdah	Cum	1201.00	1399.00	1421.00	1417.00	1476.00	1491.00	1514.00	1375.00	1122.00	1022.00	1008.00	1204.00	1010.00	1439.00	1430.00	1299.00
Serampore	Cum	1146.00	1344.00	1366.00	1362.00	1421.00	1436.00	1459.00	1320.00	1067.00	967.00	953.00	1149.00	955.00	1384.00	1375.00	1244.00
Suri	Cum	762.00	960.00	982.00	978.00	1037.00	1052.00	1075.00	936.00	683.00	583.00	569.00	765.00	571.00	1000.00	991.00	860.00
Tamluk	Cum	1361.00	1559.00	1581.00	1577.00	1636.00	1651.00	1674.00	1535.00	1282.00	1182.00	1168.00	1364.00	1170.00	1599.00	1590.00	1459.00
Tarakeswar	Cum	1090.00	1288.00	1310.00	1306.00	1365.00	1380.00	1403.00	1264.00	1011.00	911.00	897.00	1093.00	899.00	1328.00	1319.00	1188.00

Note : ***1.*** *The above rates are inclusive of all charges such as Royalty, Supervision Charges, etc. and also include allowance for sinkage and/or shrinkage but excluding GST, Overhead charges and Contractor's Profit .* ***However in the analysis of rate of items, Overhead Charges and Contractor's profit are included .***

2. *Payment will be made on the basis of net volume.*

3. The Superintending Engineer of concerned Construction Circle may select the source(s) of stone aggregates considering the availability and applicability of aggregates for specific items of works.

ROAD WORKS

CHAPTER - 1
CARRIAGE OF MATERIALS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
1.01	Loading materials in to Railway Wagon including necessary carriage by head load within a lead of 50 m.				*N.B.- The Contractor is required to bring materials to the station when wagons are available and stack the material at the railway yard or station for loading, within permissible time limit. The Contractor shall be liable to pay any wharfage demurrage that may have to be paid or any transit arrangement that the contractor may make to avoid such wharfage for delay, at his own expense.*
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	33.00	33.00	
	(c) Sand, Stone aggregate below 40 mm nominal size	cum	42.00	42.00	
	(d) Stone aggregate 40 mm nominal size and above	cum	45.00	45.00	
	(e) Bricks.	1000 nos.	78.00	78.00	
	(g) Cement	tonne	28.00	28.00	
	(h) Steel	tonne	52.00	52.00	
	(i) Tar, Bitumen etc.	tonne	30.00	30.00	
1.02	Unloading materials from Railway Wagon and loading into Truck including necessary carriage by head load within a lead of 50 m.				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	56.00	56.00	
	(c) Sand, Stone aggregate below 40 mm nominal size	cum	70.00	70.00	
	(d) Stone aggregate 40 mm nominal size and above	cum	76.00	76.00	
	(e) Bricks.	1000 nos.	131.00	131.00	
	(g) Cement	tonne	47.00	47.00	
	(h) Steel	tonne	87.00	87.00	
	(i) Tar, Bitumen etc.	tonne	51.00	51.00	
1.03	Loading, unloading and stacking by Manual Means. A. Loading in to trucks at the lifting point, unloading at destination, stacking properly in go downs or yard etc. as directed including carriage by head load up to a lead of 50.00 m at each of the two points.				*The apportionment of cost may be considered as follows:* *Loading : 40%* *Unloading: 35%* *Stacking : 25%*
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	62.00	62.00	
	(b) Earth	cum	77.00	77.00	
	(c) Sand, Stone aggregate below 40 mm nominal size	cum	77.00	77.00	
	(d) Stone aggregate 40 mm nominal size and above	cum	83.00	83.00	
	(e) Bricks.	1000 nos.	144.00	144.00	
	(f) Stone blocks ,G.I., C.I. pipes below 100 mm dia and other heavy material	tonne	56.00	56.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(g) Cement	tonne	52.00	52.00	
	(h) Steel	tonne	96.00	96.00	
	(i) Tar, Bitumen etc.	tonne	56.00	56.00	
	(j) R.C.C. pipes , C.I. pipes and unreinforced Cement pipes				
	i) 600, 700, 750 & 800 mm dia	100 mtr.	2592.00	2592.00	
	ii) 900 mm dia	100 mtr.	4320.00	4320.00	
	iii) 1000, 1100 & 1200 mm dia	100 mtr.	5184.00	5184.00	
	iv) 1400 & 1800 mm dia	100 mtr	6480.00	6480.00	
	B. Extra carriage for addl. 50 m or part thereof				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	14.00	14.00	
	(b) Earth	cum	17.00	17.00	
	(c) Sand, Stone aggregate below 40 mm nominal size	cum	17.00	17.00	
	(d) Stone aggregate 40 mm nominal size and above	cum	19.00	19.00	
	(e) Bricks.	1000 nos.	32.00	32.00	
	(f) Stone blocks, G.I., C.I. pipes below 100 mm dia and other heavy material	tonne	8.00	8.00	
	(g) Cement	tonne	8.00	8.00	
	(h) Steel	tonne	14.00	14.00	
	(i) Tar, Bitumen etc.	tonne	8.00	8.00	
	(j) R.C.C. pipes, C.I. pipes and unreinforced Cement pipes				
	i) 600, 700, 750 & 800 mm dia	100 mtr.	390.00	390.00	
	ii) 900 mm dia	100 mtr.	650.00	650.00	
	iii) 1000, 1100,1200 mm dia	100 mtr.	781.00	781.00	
	iv) 1400 & 1800 mm dia	100 mtr	976.00	976.00	
1.04	Unloading from truck and loading in to boat at ferry crossing where loaded trucks are not allowed to be ferried across including carriage by head load with necessary lead & lift.				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	63.00	63.00	
	(b) Sand, Stone aggregate below 40 mm nominal size	cum	79.00	79.00	
	(c) Stone aggregate 40 mm nominal size and above	cum	85.00	85.00	
	(d) Bricks.	1000 nos.	147.00	147.00	
	(e) Cement	tonne	53.00	53.00	
	(f) Steel	tonne	98.00	98.00	
	(g) Tar, Bitumen etc.	tonne	57.00	57.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
1.05	Unloading from boat and loading in to truck at ferry crossing where loaded trucks are not allowed to be ferried across including carriage by head load with necessary lead & lift.				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	63.00	63.00	
	(b) Sand, Stone aggregate below 40 mm nominal size	cum	79.00	79.00	
	(c) Stone aggregate 40 mm nominal size and above	cum	85.00	85.00	
	(d) Bricks.	1000 nos.	147.00	147.00	
	(e) Cement	tonne	53.00	53.00	
	(f) Steel	tonne	98.00	98.00	
	(g) Tar, Bitumen etc.	tonne	57.00	57.00	
1.06	Loading into boat and unloading the same at the opposite bank where loaded trucks are not allowed to be ferried across including carriage by head load with necessary lead & lift.				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	61.00	61.00	
	(b) Sand, Stone aggregate below 40 mm nominal size	cum	75.00	75.00	
	(c) Stone aggregate 40 mm nominal size and above	cum	81.00	81.00	
	(d) Bricks.	1000 nos.	141.00	141.00	
	(e) Cement	tonne	51.00	51.00	
	(f) Steel	tonne	94.00	94.00	
	(g) Tar, Bitumen etc.	tonne	55.00	55.00	
1.07	Loading into boat and unloading the same and loading into truck at the opposite bank or destination where loaded trucks are not allowed to be ferried across including carriage by head load with necessary lead & lift.				
	(a) Lime, Moorum, Building rubbish and similar miscellaneous materials	cum	63.00	63.00	
	(b) Sand, Stone aggregate below 40 mm nominal size	cum	79.00	79.00	
	(c) Stone aggregate 40 mm nominal size and above	cum	85.00	85.00	
	(d) Bricks.	1000 nos.	147.00	147.00	
	(e) Cement	tonne	53.00	53.00	
	(f) Steel	tonne	98.00	98.00	
	(g) Tar, Bitumen etc.	tonne	57.00	57.00	
1.08	Cost of Carriage excluding Loading and Unloading:				
	(As per Table 1 : Road Transportation & Carriage Works and Table 2 : Carriage by Boat.)				

TABLE 1 : ROAD TRANSPORTATION & CARRIAGE WORKS

Item No.	Description of Items	Unit	Zone	Any distance up to 5 km	Above 5 km up to 10 km (per km)	Above 10 km up to 20 km (per km)	Above 20 km up to 50 km (per km)	Above 50 km up to 100 km (per km)	Above 100 km (per km)
1.	Carriage of Sand, **Moorum** and similar materials over pucca road.	Cum	A	124.00	10.90	10.10	9.50	8.40	7.90
			B	185.00	16.40	15.20	14.30	12.60	11.90
2.	Carriage of **Lime, Surki, Cinder**, and similar miscellaneous materials over pucca road.	Cum	A	93.00	8.20	7.60	7.10	6.30	5.90
			B	139.00	12.30	11.40	10.70	9.50	8.90
3.	Carriage of **Brick-bats, Boulder, Stone metal, Stone chips, Gravel, Slag metal, Shingle** and similar miscellaneous materials over pucca road.	Cum	A	124.00	10.90	10.10	9.50	8.40	7.90
			B	185.00	16.40	15.20	14.30	12.60	11.90
4.	Carriage of **Cement** (in bags), **tar** or **asphalt** (in drums), **timber** and similar miscellaneous materials over pucca road.	MT	A	82.00	7.30	6.70	6.30	5.60	5.30
			B	124.00	11.00	10.10	9.50	8.40	8.00
5.	Carriage of **Steel materials** over pucca road.	MT	A	82.00	7.30	6.70	6.30	5.60	5.30
			B	124.00	11.00	10.10	9.50	8.40	8.00
6.	Carriage of **Brick** over pucca road.	1000 Nos.	A	297.00	26.00	24.00	23.00	20.00	19.00
			B	445.00	39.00	36.00	34.50	30.00	28.50
7.	Carriage of **RCC pipes** over pucca road upto 600 mm diameter.	M	A	49.00	4.40	4.00	3.80	3.40	3.20
			B	74.00	6.60	6.00	5.70	5.10	4.80
8.	Carriage of **RCC pipes** over pucca road upto 900 mm diameter	M	A	74.00	6.60	6.00	5.70	5.10	4.70
			B	111.00	9.90	9.00	8.60	7.70	7.10
9.	Carriage of **RCC pipes** over pucca road upto1800 mm diameter.	M	A	148.00	13.10	12.10	11.40	10.10	9.50
			B	222.00	19.70	18.20	17.10	15.20	14.30
10.	Carriage of **Boundary Pillars, R.C. Guard posts, Km Posts** etc. from godown or stackyard to work site as per direction.	Each	A	*11.00*					
			B	*16.00*					

Item No.	Description of Items	Unit	Zone	Any distance up to 5 km	Above 5 km up to 10 km (per km)	Above 10 km up to 20 km (per km)	Above 20 km up to 50 km (per km)	Above 50 km up to 100 km (per km)	Above 100 km (per km)
11.	Carriage of **Bitumen in bulk** in insulated tanks from refinery to work site including loading, unloading the same at hot mix plant / Bitumen storage tanks / empty bitumen drums / tar boiler as per direction of the Engineer–in–Charge at specified temperature including necessary heating arrangements during transfer & transit with all incidental charges.	MT	A	654.50					5.30
			B	985.00					8.00

TABLE 2 : CARRIAGE BY BOAT INCLUDING LOADING, UNLOADING & STACKING (AS NECESSARY)

(This item is applicable for Zone – A only when carriage by road by any means is not feasible)

Item No.	Description of Items	Unit	Zone	Any distance up to 5 km	Above 5 km upto 16 km (per km)	Above 16 km (per km)
1.	Carriage of **Stone materials, Sand, Brick bats** and similar materials by boat	Cum	River	38.00	4.00	2.00
			Canal	26.50	4.50	2.00
2.	Carriage of **Bricks** by boat.	1000 Nos.	River	108.00	9.50	7.00
			Canal	94.50	8.00	6.50
3.	Carriage of **Bitumen** (in drums), **cement** (in bags) by boat.	MT	River	65.00	6.00	5.00
			Canal	55.00	7.50	6.00
4.	Carriage of **Steel materials** by boat.	MT	River	65.00	6.00	5.00
			Canal	55.00	7.50	6.00

Notes : **1.** *For carriage of 7m or longer unbent steel rounds, the contractor is required to arrange for trailer trucks for such purpose or to make improved arrangements. In exceptional cases, the Engineer-in-Charge may, at his discretion, permit bending double with large loops, in such a case the contractor shall have to do the looping and straightening the same back at destination to the satisfaction of the Engineer-in-Charge. The contractor will be entitled for these works to an additional payment of Rs.20.00 per metric ton of steel rounds.*

2. *For carriage of heavy section RSJ 460mm x 150mm and above exceeding 7.5m length, add extra 40% over schedule rate of relevant items.*

3. *In case of Tar or Bitumen, the weight of the container along with contents should be considered.*

4. *For Sandakhphu – Phalut Road above Manebhanjan, rates of road transport carriage shall be fixed by the concerned Superintending Engineer.*

5. *The Carriage rates of different items for all districts of West Bengal and plains of Siliguri Sub-division of Darjeeling districts* ***(Zone –A)*** *are furnished in the following tables. The figures appearing in parenthesis are applicable for Darjeeling Hill area* ***(Zone – B)****.*

CHAPTER - 2
SITE CLEARANCE

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
2.01	**Cutting of Trees including Cutting of Trunks, Branches and Removal of Stumps**				
	Cutting of trees, including cutting of trunks, branches and removal of stumps & roots, refilling, compaction of backfilling and stacking of serviceable material by manual means with all lifts as per Technical Specifications Clause 201 for Rural Roads of MORD.				
	A. Lead upto 100 m				
	i) Girth above 300 mm to 600 mm	each	211.00	213.00	
	ii) Girth above 600 mm to 900 mm	each	366.00	371.00	
	iii) Girth above 900 mm to 1800 mm	each	726.00	733.00	
	iv) Girth above 1800 mm to 2700 mm	each	1386.00	1396.00	
	v) Girth above 2700 mm to 4500 mm	each	2847.00	2871.00	
	vi) Girth above 4500 mm	each	8365.00	8412.00	
	B. Lead upto 1000 m				
	i) Girth above 300 mm to 600 mm	each	225.00	228.00	
	ii) Girth above 600 mm to 900 mm	each	409.00	416.00	
	iii) Girth above 900 mm to 1800 mm	each	783.00	792.00	
	iv) Girth above 1800 mm to 2700 mm	each	1471.00	1485.00	
	v) Girth above 2700 mm to 4500 mm	each	2942.00	2970.00	
	vi) Girth above 4500 mm	each	8601.00	8660.00	
2.02	**Uprooting and Removing Stumps & Roots**				
	Uprooting and Removing Stumps & roots, compaction of backfilling and stacking of serviceable material by manual means as per Technical Specifications Clause 201 for Rural Roads of MORD.				
	A. Lead upto 100 m				
	i) Girth above 300 mm to 600 mm	each	127.00	128.00	
	ii) Girth above 600 mm to 900 mm	each	202.00	203.00	
	iii) Girth above 900 mm to 1800 mm	each	428.00	429.00	
	iv) Girth above 1800 mm to 2700 mm	each	843.00	845.00	
	v) Girth above 2700 mm to 4500 mm	each	1699.00	1705.00	
	vi) Girth above 4500 mm	each	4806.00	4823.00	
	B. Lead upto 1000 m				
	i) Girth above 300 mm to 600 mm	each	131.00	131.00	
	ii) Girth above 600 mm to 900 mm	each	214.00	215.00	
	iii) Girth above 900 mm to 1800 mm	each	442.00	444.00	
	iv) Girth above 1800 mm to 2700 mm	each	861.00	865.00	
	v) Girth above 2700 mm to 4500 mm	each	1722.00	1729.00	
	vi) Girth above 4500 mm	each	4924.00	4948.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
2.03	**Clearing Grass and Removal of Rubbish**				
	Clearing grass and removal of rubbish up to a distance of 30 m outside the periphery of the area as per Technical Specifications Clause 201 for Rural Roads of MORD. **By Manual Means**	hectare	11868.00	11868.00	
2.04	**Clearing and Grubbing Road Land**				
	Clearing and grubbing road land including uprooting wild vegetation, grass, bushes, shrubs, saplings and trees of girth upto 300 mm, removal of stumps of such trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, upto a lead of 1000 m including removal and disposal of top organic soil not exceeding 150 mm in thickness as per Technical Specifications Clause 201 for Rural Roads of MORD.				
	(I) By Manual Means				
	a) In area of non-thorny jungle	hectare	44978.00	45002.00	
	b) In area of thorny jungle	hectare	60286.00	60334.00	
	(II) By Mechanical Means				
	a) In area of non-thorny jungle	hectare	23363.00	24472.00	
	b) In area of thorny jungle	hectare	28533.00	29871.00	
Note:	The top soil removed during clearing and grubbing of site, if suitable for re-use shall be transported, conserved and stacked as directed by the Engineer and shall be incidental to the work.				
2.05	**Dismantling of Structures**				
	Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, steel work, including T&P and scaffolding wherever necessary, sorting the dismantled material, disposal of unserviceable material and stacking the serviceable material with all lifts and lead of 1000 m as per Technical Specifications Clause 202 for Rural Roads of MORD.				
	(I) By Manual Means				
	a) Lime Concrete	cum	340.00	345.00	
	b) Cement Concrete	cum	399.00	404.00	
	c) Reinforced Cement Concrete	cum	1011.00	1016.00	
	(II) By Mechanical Means				
	a) Cement Concrete	cum	470.00	488.00	
	b) Reinforced Cement Concrete	cum	773.00	797.00	
2.06	**Dismantling Brick/Tile Work**				
	Dismantling of existing structures like culverts, bridges, retaining walls and other structures comprising of brick masonry, including disposal of unserviceable material and stacking the serviceable material with all lift and lead of 1000 m as per Technical Specifications Clause 202 for Rural Roads of MORD.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(a) Lime mortar	cum	221.00	226.00	
	(b) Cement mortar	cum	280.00	285.00	
	(c) Mud Mortar	cum	197.00	202.00	
	(d) Dry Brick Pitching or Brick Soling	cum	185.00	190.00	
2.07	**Dismantling Stone Masonry as per Technical Specification Clause 202.**				
	Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of stone masonry, including disposal of unserviceable material and stacking the serviceable material with all lift and lead of 1000 m as per Technical Specifications Clause 202 for Rural Roads of MORD.				
	(a) Rubble Stone Masonry in Lime Mortar	cum	245.00	250.00	
	(b) Rubble Stone Masonry in Cement Mortar	cum	280.00	285.00	
	(c) Rubble Stone Masonry in Mud Mortar	cum	221.00	226.00	
	(d) Dry Rubble Masonry	cum	209.00	214.00	
	(e) Dismantling Stone Pitching / Dry Stone Spalls	cum	197.00	202.00	
	(f) Dismantling boulders laid in wire crates including opening of crates and stacking dismantled materials	cum	221.00	226.00	
2.08	**Dismantling Wood Work** Wrought and Planed Fixed in Frames of Trusses upto a height of 5 m above Plinth Level as per Technical Specifications Clause 202 for Rural Roads of MORD.	cum	496.00	501.00	
2.09	**Dismantling Steel Work** in all Types of Sections upto a height of 5 m above Plinth Level excluding Cutting of rivet as per Technical Specifications Clause 202 for Rural Roads of MORD.				
	(a) Including dismembering	tonne	1241.00	1245.00	
	(b) Excluding dismembering	tonne	889.00	893.00	
	(c) Extra over Items (A) and (B) for cutting rivets	tonne	9.00	9.00	
2.10	**Scraping of bricks dismantled from brick work** including stacking as per Technical Specification Clause 202 for Rural Roads of MORD.	1000 nos.	1038.00	1038.00	
2.11	**Scraping of Stone from Dismantled Stone Masonry** as per Technical Specification Clause 202 for Rural Roads of MORD.				
	In Cement or Lime Mortar	cum	417.00	417.00	
2.12	**Scraping Plaster in Lime or Cement Mortar from Brick / Stone Masonry** as per Technical Specification Clause 202 for Rural Roads of MORD	sqm	13.00	13.00	
2.13	**Removing all types of Hume pipes** and stacking within a lead of 1000 m including Earthwork and Dismantling of Masonry Works as per Technical Specification Clause 202 for Rural Roads of MORD.				
	(a) Upto 600 mm dia Hume pipe	metre	154.00	154.00	
	(b) Above 600 mm to 900 mm dia Hume pipe	metre	208.00	208.00	
	(c) Above 900 mm dia Hume pipe	metre	357.00	357.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
Note:	The excavation of earth, dismantling of stone masonry work in head walls and protection works is not included which is to be measured and paid separately.				
	Credit for retrieved stone from masonry work may be taken as per actual availability.				
2.14	**Dismantling of Flexible Pavements**				
	Dismantling of flexible pavements and disposal of dismantled materials upto a lead of 100 m, stacking serviceable and unserviceable materials separately as per Technical Specifications Clause 202 for Rural Roads of MORD.				
	(I) By Manual Means				
	a) Bituminous Courses	cum	625.00	634.00	
	b) Granular Courses	cum	453.00	461.00	
	(II) By Mechanical Means				
	Bituminous Courses	cum	277.00	286.00	
2.15	**Dismantling of Cement Concrete Pavements**				
	Dismantling of cement concrete pavements by mechanical means using pneumatic tools breaking to pieces not exceeding 0.02 cum in volume and stock piling at designated locations and disposal of dismantled materials upto a lead of 1000 m, stacking serviceable and unserviceable materials separately as per Technical Specification Clause 202 for Rural Roads of MORD.	cum	1046.00	1083.00	
2.16	**Dismantling Guard Rails**				
	Dismantling guard rails by manual means and disposal of dismantled material with all lifts and upto a lead of 1000 m, stacking serviceable materials and unserviceable materials separately as per Technical Specification Clause 202 for Rural Roads of MORD.	rm	68.00	69.00	
2.17	**Dismantling Kerb Stones**				
	Dismantling kerb stones by manual means and disposal of dismantled material with all lifts and upto a lead of 1000 m as per Technical Specification Clause 202 for Rural Roads of MORD.	rm	14.00	14.00	
2.18	**Dismantling Kerb Stone Channels**				
	Dismantling kerb stone channels by manual means and disposal of dismantled material with all lifts and upto a lead of 1000 m as per Technical Specification Clause 202 for Rural Roads of MORD.	rm	21.00	22.00	
2.19	**Dismantling Kilometre Stones**				
	Dismantling of kilometre stones including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and backfilling of pit as per Technical Specification Clause 202 for Rural Roads of MORD.				
	a) 5th km Stone	each	294.00	297.00	
	b) Ordinary km Stones	each	186.00	188.00	
	c) 200 m Stones	each	39.00	40.00	
Note:	Rate for boundary pillar will be same as that of 200 m stone.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
2.20	**Dismantling of Fencing**				
	Dismantling of barbed wire fencing / wire mesh fencing including posts, foundation concrete, backfilling of pit by manual means including disposal of dismantled material with all lifts and upto a lead of 1000 m, stacking serviceable material and unserviceable material separately as per Technical Specification Clause 202 for Rural Roads of MORD	rm	42.00	42.00	
2.21	**Dismantling of CI Water Pipe Line**				
	Dismantling of CI water pipe line 600 mm dia including disposal with all lifts and lead upto 1000 m and stacking of serviceable material and unserviceable material separately under supervision of concerned department as per Technical Specification Clause 202 for Rural Roads of MORD.	rm	104.00	106.00	
Note:	The rate analysis does not include any excavation in earth or dismantling of masonry works which are to be measured and paid separately.				
2.22	**Removal of Cement Concrete Pipe of Sewer Gutter**				
	Removal of cement concrete pipe of sewer gutter 1500 mm dia under the supervision of concerned department including disposal with all lifts and upto a lead of 1000 m and stacking of serviceable and unserviceable material separately but excluding earth excavation and dismantling of masonry works as per Technical Specification Clause 202 for Rural Roads of MORD.	rm	158.00	162.00	
Note:	The rate analysis does not include any excavation in earth or dismantling of masonry works which are to be measured and paid separately.				
2.23	**Removal of Telephone/Electric Poles and Lines**				
	Removal of telephone/electric poles with wires including excavation and dismantling of foundation concrete and lines under the supervision of concerned department, disposal with all lifts and upto a lead of 1000 m and stacking the serviceable and unserviceable material separately as per Technical Specification Clause 202 for Rural Roads of MORD.	each	149.00	150.00	

CHAPTER - 3
EARTH WORK, EROSION CONTROL AND DRAINAGE

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.01	**Earthwork in excavation from borrow pits** (land owned/arranged by the Department) and depositing in layers of 250 mm. including breaking clods in embankment works and to fill up back of abutments, depressions and ruts with an initial lead up to 50 m and initial lift up to 1.5 m making bunds at top as directed dressing complete. (Borrow pit measurement)				
	(i) In ordinary soil	cum	89.90	89.90	
	(ii) In mixed soil (i,e. clay mixed with kankar, pebbles, moorum etc.)	cum	99.90	99.90	
	(iii) In mixed hard soil (i,e hard moorum and soil containing laterite and boulders which do not require blasting)	cum	119.90	119.90	
3.02	**Extra for carriage** of all kinds of soil for each additional unit lead of 50 m (or part thereof) including loading and unloading. (Borrow pit measurement)				
	(i) Beyond the initial lead of 50 m up to total lead of 200 m.	cum	12.50	12.50	
	(ii) Beyond 200 m & up to total lead of 500 m	cum	15.00	15.00	
	(iii) Beyond 500 m & up to total lead of 1000 m	cum	26.10	28.80	
3.03	**Extra for every additional lift** of 1.5 m or part thereof in all kind of soil. (Borrow pit measurement)	cum	10.00	10.00	
3.04	**Earthwork in cutting** to form road section in correct profile including removal of spoils not exceeding initial lead of 50m and initial lift of 1.5m (Mode of measurement: pre works and post works)				
	(i) In ordinary soil	cum	79.90	79.90	
	(ii) In mixed soil (i,e. clay mixed with kankar, pebbles, moorum etc.)	cum	89.90	89.90	
	(iii) In mixed hard soil (i,e hard moorum and soil containing laterite and boulders which do not require blasting)	cum	109.90	109.90	
3.05	**Extra for manual compaction** of earth by rammers / hand roller in 250 mm layers including watering etc. if required. (Borrow pit measurement).	cum	20.00	20.00	
Note:	For compensation for earth for land owned and arranged by Contractor add ₹ 25.00 per m³ extra over rate of E/W for land owned / arranged by the Department & for royalty charge on earth @ ₹ 18.00 per m³ as per Govt. notification which will be paid on production of necessary documents in support of payment made towards the royalties. During initial payment of bill, a deduction @ ₹ 18.00 per m³ may be made.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.06	**Excavation in Soil using Hydraulic Excavator CK 90 and Tippers with disposal upto 1000 metres.** Excavation for roadwork in soil with hydraulic excavator of 0.9 cum bucket capacity including cutting and loading in tippers, trimming bottom and side slopes, in accordance with requirements of lines, grades and cross sections, and transporting to the embankment location within all lifts and lead upto 1000m as per Clause 301 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (Mode of measurement: pre works and post works)	cum	37.30	39.10	
3.07	**Excavation in Ordinary Rock using Hydraulic Excavator CK-90 and Tippers with disposal upto 1000 metres** Excavation for roadway in ordinary rock with hydraulic excavator of 0.9 cum bucket capacity including cutting and loading in tippers, transporting to embankment site within all lifts and lead upto 1000 m, trimming bottom and side slopes in accordance with requirements of lines, grades and cross sections as per Clause 301 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (Mode of measurement: pre works and post works)	cum	49.20	51.50	
3.08	**Excavation in Hard Rock (blasting prohibited)** Excavation for roadway in hard rock (blasting prohibited) with rock breakers including breaking rock, loading in tippers and disposal within all lifts and lead upto 1000 metres, trimming bottom and side slopes in accordance with requirements of lines, grades and cross sections as per Clause 301 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (Mode of measurement: pre works and post works)	cum	431.00	444.00	
3.09	**Excavation in Marshy Soil** Excavation for roadway in marshy soil with hydraulic excavator 0.9 cum bucket capacity including cutting and loading in tippers and disposal with a lift upto 1.5 m and lead upto 1000 m, trimming of bottom and side slopes in accordance with requirements of lines, grades and cross- sections as per Technical Specification Clause 302.3.6 for Rural Roads of MORD. (Mode of measurement: pre works and post works)	cum	41.00	42.90	
3.10	**Removal of Unserviceable Soil with Disposal upto 1000 metres** Removal of unserviceable soil including excavation, loading and disposal upto 1000 metres lead but excluding replacement by suitable soil which shall be paid separately as per Technical Specification Clause 302.3.11 for Rural Roads of MORD. (Mode of measurement: pre works and post works)	cum	27.90	29.30	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.11	**Construction of Embankment with Material Obtained from Borrow Pits** Construction of embankment with approved material obtained from borrow pits with a lift upto 1.5 m, transporting to site, spreading, grading to required slope and compacting to meet requirement of Tables 300.1 and 300.2 with a lead upto 1000 m as per Technical Specification Clause 301.5 for Rural Roads of MORD. (Mode of measurement: pre works and post works)	cum	85.60	89.80	
3.12	**Construction of Embankment with Material Deposited from Roadway Cutting.** Construction of embankment with approved materials deposited at site from roadway cutting and excavation from drain and foundation of other structures graded and compacted to meet requirement of Tables 300.1 and 300.2 as per Technical Specification Clause 301.5 for Rural Roads of MORD including carriage of material for a distance of 1 km.	cum	46.80	49.00	*Calculation of Earthwork may be made using the following relation: 100 m^3 of naturally occurring earth = 90 m^3 of mechanically compacted earth at OMC =120 m^3 of loose earth.*
3.13	**Embankment Construction with Fly ash / Pond ash available from coal or lignite burning Thermal Plants as waste material** Construction of embankment with fly ash conforming to table 1 of IRC: SP: 58 - 2001 obtained from coal or lignite burning thermal power stations as waste material, spread and compacted in layer of 200mm thickness each at OMC, all as specified in IRC: SP: 58-2001 and as per approved plans with lead upto 1000 m as per Technical Specification Clause 306 for Rural Roads of MORD.	cum	86.60	90.70	
3.14	**Construction of Subgrade and Earthen Shoulders** Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts and leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of Table 300.2 with lead upto 1000 m as per Technical Specification Clause 303.1 for Rural Roads of MORD. (Borrow pit /pre work post work measurement)	cum	94.80	99.40	
3.15	**Extra for carriage of all kinds of earth by Mechanical Transport:**				
	(a) Carriage up to total lead of 1.0 km.	cum	95.00	142.50	***Note :*** *Measurement would be as per finished compacted embankment earth work.*
	(b) Carriage up to total lead of 2.0 km.	cum	106.90	160.40	
	(c) Carriage up to total lead of 3.0 km.	cum	118.80	178.20	
	(d) Carriage up to total lead of 4.0 km.	cum	130.70	196.10	
	(e) Carriage up to total lead of 5.0 km.	cum	142.60	213.90	
	(f) **Extra for carriage** of all kinds of soil for each additional km (or part thereof) above 5.0 km & up to total lead of 10.0 km.	cum	10.50	15.80	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.16	**Box cutting or filling in Road embankment** in all sorts of soil including spreading the spoils properly over the flank as necessary or on berm to approximate grade & camber and rolling the sub-grade with power roller to proper camber and grade as per direction and satisfaction of Engineer-in-charge including uprooting and removing plants and jungles when and where necessary.				
	(a) Depth up to 150 mm.	sqm	14.40	14.40	
	(b) For each additional Depth of 150mm and part thereof.	sqm	19.00	19.00	
3.17	**Compacting Original Ground**				
	A. Compacting original ground supporting subgrade Loosening of the ground upto a level of 300 mm below the subgrade level, watered, graded and compacted in layers to meet requirement of Tables 300.1 and 300.2 for subgrade construction as per Clause 305.3.4 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	55.50	58.20	
	B. Compacting original ground supporting embankment Loosening, Leveling and Compacting original ground supporting embankment to facilitate placement of first layer of embankment, scarified to a depth of 150 mm, mixed with water at OMC and then compacted by rolling so as to achieve minimum dry density as given in Tables 300.1 and 300.2 for embankment construction as per Clause 305.3.4 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	24.10	25.30	
3.18	**Providing and laying Sand Blanket** with medium sand to required thickness, in layers not exceeding 150 mm to proper gradient and camber, inundating each layer by water and packing and ramming layer by layer to achieve desired compaction including lighting, guarding, barricading and making 1.0 m wide earthen bundh on both the sides, curing with water as per direction, mending cracks and depressions by ramming wherever necessary. (The payment is to be made on the basis of the finished compacted volume.)	cum	226.00	389.00	
Note	Labour rate per cubic meter is provided, cost of sand to be added to arrive at the consolidated rate. The compaction factor for dry, clean sand is 0.835.				
3.19	**Lime Stabilisation for Improving Subgrade** Laying and spreading available soil in the subgrade on a prepared surface, pulverising, mixing the spread soil in place with rotavator with 3 % slaked lime having minimum content of 70% of CaO, grading with motor grader and compacting with the road roller at OMC to the desired density to form a layer of improved sub grade as per Clause 402 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (Mode of measurement pre work and post work)	cum	330.00	391.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.20	**Turfing with Sods** Furnishing and laying of the live sods of perennial turf forming grass on embankment slope, verges or other locations shown on the drawing or as directed by the Engineer including preparation of ground, fetching of sods and watering as per Clause 307 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	17.20	17.60	
3.21	**Seeding and Mulching** Preparation of seed bed on previously laid top soil, furnishing and placing of seeds, fertilizer, mulching material, applying bituminous emulsion at the rate of 0.23 litres per sqm and laying and fixing jute netting, including watering for 3 months all as per Clause 308 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	87.30	88.00	
3.22	**Surface Drains in Soil** Construction of unlined surface drains of average cross-sectional area 0.40 sqm in soil to specified lines, grades, levels and dimensions as per Clause 309 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). Excavated material to be used in embankment with a lift upto 3m and lead of 50 m.	metre	49.30	51.40	
Note:	Where lining of drain is provided, quantity shall be worked out based on approved design and drawing and priced on rate of cement concrete of approved grade or stone/brick masonry as the case may be.				
3.23	**Sub Surface Drains with Perforated Pipe** Construction of Subsurface drain with perforated pipe of 100 mm internal diameter of metal / asbestos cement / cement concrete / PVC, closely jointed, perforations ranging from 3 mm to 6 mm depending upon size of material surrounding the pipe, with 150 mm bedding below the pipe and 300 mm cushion above the pipe, cross section of excavation 450 x 550 mm. as per Clause 309 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). Excavated material to be utilised in roadway at site.	metre	566.00	702.00	
3.24	**Aggregate Sub- Surface Drains** Construction of aggregate sub surface drain 300 mm x 450 mm with 22.4 mm (60%) and 11.2 mm (40%) size stone aggregates @ 1.35 m^3 (loose volume) per metre length, as per Clause 309 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). Excavated material to be utilised in roadway.	metre	259.00	335.00	
3.25	**Underground Drain at Edge of Pavement** Construction of an underground drain 1 m x 1 m (inside dimensions) lined with RCC-20 cm thick and covered with RCC slab 10 cm in thickness on Urban Roads as per Clause 309 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	metre	3044.00	3544.00	
3.26	**Repairs of Damages Caused by Rain / Spillage of Water** Preparation and surface treatment of formation by removing mud and slurry, watering to the extent -	sqm	1.10	110	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	needed to maintain the desired moisture content, trimming to the required line, grade, and profile and rolling with three wheels 80-100 kN static roller, complete as per Technical Specification Clause 301.5.5.1 for Rural Roads of MORD.				
3.27	**Chute Drains** Providing Chute drains 250 x 300 mm (inside dimensions) across Embankment Slopes in approaches of Bridges and on horizontal curves consists of earthwork in excavation for foundations of structures as per drawings and technical specifications Clause 307 for Rural Roads of MORD including setting out construction of shoring and bracing deleterious matter, dressings of sides and bottom and backfilling with approved material (By manual means), Plain Cement Concrete (1:2:4), 125 mm thick Brick Masonry followed by 20 mm thick plastering (1:4) and 75 mm thick Coping with M-20 Concrete on top of the Chute Walls as per specification, drawing and direction of the Engineer-in-Charge.	metre	1153.00	1373.00	
3.28	**Land Slide Clearance in Soil** Clearance of land slides in soil and ordinary rock by a bull-dozer D 80 A-12, 180 HP and disposal of the same on the valley side.	cum	59.00	61.80	
3.29	**Landslide Clearance in Hard Rock Requiring Blasting** Clearing of land slide in hard rock requiring blasting for 50 per cent of the boulders and disposal of the same on the valley side.	cum	99.40	102.50	
3.30	**Supplying and laying open mesh Jute Geotextile (JGT)** for slope protection in road embankments, having overall weight of 500gm/m2, thickness 5 mm, width 1220 mm, strength 10 KN/m (in warp direction) and 7.5 KN/m (in weft direction) on slopes of embankments dressed and cut to a stable gradient, providing side lapping of 100 mm and horizontal lapping of 250 mm including cutting and anchoring trenches upto 150 mm depth at top and bottom of slope and refilling the same with excavated earth as per direction complete.	sqm	29.60	29.60	
Note	Payment of this item will be made on the finished area of the jute geotextile.				
3.31	**Supplying, testing and installation of 1.0-2.0 m wide Woven Jute Geotextile (JGT)** 724 gm/sqm possessing tensile strength of 25 kN/m (+10%, -5% tolerance) with a porometry around 150 to 400 micron and thickness 2 mm. Jute fabric should be laid with overlaps of 150 mm crosswise and 300 mm longitudinally duly secured to subgrade by U-shaped M.S. staples (11 gauge)/ round head country nail of 150 mm length at an interval of 750 mm or as per direction of the Engineer-in-Charge.				
	(a) Using Untreated Woven Jute Geotextile	sqm	73.70	73.70	
	(b) Using Treated Woven Jute Geotextile with approved rot-resistant (eco-friendly) additive.	sqm	96.70	96.70	
Note	Payment of this item will be made on the finished area of the jute geotextile.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
3.32 (New)	**Construction of Subgrade with Fly ash / Pond ash available from coal or lignite burning Thermal Plants as waste material (70%) and fine Sand (30%):** Construction of Subgrade with fly ash (70%) conforming to table 1 of IRC: SP: 58 - 2001 obtained from coal or lignite burning thermal power stations as waste material and fine sand (30%) properly mixed by mechanical means, spread and compacted in layer of 200mm thickness each so as to achieve 98% of maximum dry density, as specified in IRC: SP: 58-2001 and as per approved plans with lead upto 1000 m as per direction of Engineer-in-Charge.	cum	139.00	-	
Note:	1. Construction wing is to add cost and carriage of Fly ash and sand including statutory govt. taxes.				
	2. The cost of earth cover on sides of the fly ash has not been included; the same is to be added wherever necessary.				
	3. Construction wing will determine the required mix proportion of sand & fly ash to achieve maximum required dry density of the mix as per Table 300-1, Clause 305.2.1.5 and CBR value as per Clause 305.2.1.6 of Specifications for Road & Bridge Works of MORT&H (5^{th} Revision).				

CHAPTER - 4
SUB-BASES, BASES (NON- BITUMINOUS) AND SHOULDERS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.01	**Lime, Fly ash Stabilised Soil Sub-Base** Construction of Sub-base using Lime – Fly ash admixture with granular soil, free from organic matter / deleterious material or clayey silts and low plasticity clays having PI between 5 and 20 and liquid limit less than 25 and commercial dry lime, slaked at site or pre-slaked with CaO content not less than 50 per cent, fly ash to conform to gradation as per clause 4.3 of IRC: 88-1984, lime + fly ash content ranging between 10 to 30 per cent, the minimum un-confined compressive strength and CBR value after 28 days curing and 4 days soaking to be 7.5kg/sq,cm and 25 per cent respectively, all as specified in IRC: 88-1984.	cum	348.00	419.00	***N.B. :*** *Initial lead of 1 Km. for soil and fly ash has been considered.* *Construction wing should add cost of extra carriage beyond the Initial lead from source to work site both for soil and fly ash as per actual lead.*
Note:	1. Compensation for earth will vary from place to place and will have to be assessed realistically as per particular ground situation. In case earth is available from Govt. land, compensation for earth will not be required. The position is required to be clearly stated in the cost estimate.				
	2. Cost of Fly ash has not been considered in the analysis as the same will be available free of cost, only carriage of Fly ash upto 1KM has been incorporated.				
	3. Lime + Flyash have been taken as 20 per cent of total mass and ratio of lime and Flyash as 1:4 for estimating purposes. Total quantities will be as per approved design.				
4.02	**Lime Treated Soil for Sub- Base** Providing, laying and spreading soil on a prepared sub grade, pulverising, mixing the spread soil in place with Rotavator with 3 per cent slaked lime with minimum content of 70 per cent of CaO, grading with motor grader and compacting with the road roller at OMC to achieve at least 98 per cent of the max dry density to form a layer of sub base, as per Clause 402 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	356.00	419.00	
4.03	**Cement Treated Soil Sub Base / Base** Providing, laying and spreading soil on a prepared sub grade, pulverising, adding the designed quantity of cement to the spread soil, mixing in place with Rotavator, grading with the motor grader and compacting with the road roller at OMC to achieve the desired unconfined compressive strength and to form a layer of sub-base/base, as per Clause 403 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (**Using 4 per cent cement by weight of compacted soil mass**).	cum	657.00	677.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.04	**Supplying, spreading and consolidating Moorum** to a depth of **75 mm** at desired density and C.B.R. as per specification with power roller to proper gradient and camber including watering as necessary, and lighting, guarding, barricading and making adequate earthen bundh where necessary to protect the edges and curing with water for 2 to 3 days, mending cracks by rolling where necessary including all incidental charges of roller, cost of fuel & lubricants etc. complete as per specification.	cum	172.00	-	
Note:	Add cost at site of the materials to arrive at the complete rate. The compaction factor may be taken as 0.67.				
	(The payment is to be made on the basis of the finished compacted volume of moorum.)				
4.05	**Supplying, spreading and compacting Sand** to required thickness, in layers not exceeding 150 mm to proper gradient and camber, inundating each layer by water and packing and ramming layer by layer to achieve desired compaction, including lighting, guarding, barricading and making adequate earthen bundh where necessary, curing with water as per direction, mending cracks and depressions by ramming wherever necessary.	cum	215.00	363.00	
Note:	Add cost at site of the materials to arrive at the complete rate. The compaction factor for dry, clean sand may be taken as 0.835.				
	(The payment is to be made on the basis of the finished compacted volume.)				
4.06	**Supplying, spreading and consolidating Stone Dust** to a depth of 100 mm and above at desired density and C.B.R. as per Specification with power roller to proper gradient and camber including watering as necessary, and lighting, guarding, barricading and making adequate earthen bundh where necessary to protect the edges and curing with water for 2 to 3 days, mending cracks and depressions by rolling where necessary including all incidental charges of roller, cost of fuel & lubricants complete as per specification.	cum	207.00	211.00	
Note:	Add cost at site of the materials to arrive at the complete rate. The compaction factor is 0.70.				
	(The payment is to be made on the basis of the finished compacted volume of stone dust.				
4.07	**Spreading blindage** for road topping using sand / moorum / kiln rubbish etc. in approximately 6mm thick layer, including watering and rolling complete.	sqm	6.30	6.90	
Note:	To add cost at site of 0.006 m3 of blinding material for complete rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.08	**Granular Sub-base with Graded Material (Table:- 400-1)**				
	A. Plant Mix Method: Construction of granular sub-base by providing graded material, mixing in Wet Mix Plant at OMC, carriage of mixed material to work site, spreading in uniform layers with Motor grader on prepared surface in proper grade and camber, compacting with vibratory power roller to achieve the desired density, including lighting, guarding, barricading, including cost of all materials, machinery, tools and plants and cost of quality control complete as per Clause 401 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) Grading – I	cum	399.00	468.00	
	(ii) Grading – II	cum	393.00	495.00	
	(iii) Grading – III	cum	381.00	436.00	
	(iv) Grading – IV	cum	384.00	445.00	
	(v) Grading – V	cum	391.00	449.00	
	(vi) Grading – VI	cum	389.00	478.00	
Note:	Add cost at site of 1.28 m³ of the materials as per specified **Grading** vide Table 3.3-1 of Section 3 to arrive at the complete rate.				
	B. By Mix in Place Method : Construction of granular sub-base by providing graded material, mixing by mix in place method with Rotavator at OMC, spreading in uniform layers with Motor grader on prepared surface in proper grade and camber, compacting with vibratory roller to achieve the desired density, including lighting, guarding, barricading, including cost of all materials, machinery, tools and plants including cost of quality control complete as per Clause 401 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) Grading – I	cum	214.00	266.00	
	(ii) Grading – II	cum	203.00	281.00	
	(iii) Grading – III	cum	198.00	237.00	
	(iv) Grading – IV	cum	199.00	244.00	
	(v) Grading – V	cum	208.00	252.00	
	(vi) Grading – VI	cum	201.00	269.00	
Note:	Add cost at site of 1.28 m³ of the materials as per specified **Grading** vide Table 3.3-1 of Section 3 to arrive at the complete rate.				
N.B.:	When the width of laying is not adequate for mechanical operation or in case of small sized jobs, suitable mixing and spreading equipment capable of mixing the material to the desired degree and spreading -the mixed materials uniformly according to required line and level to the satisfaction of E-in-C may be approved by the Engineer-in-charge, but the rate of the item is to be reduced by ₹ 30.00/cum.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.09	**Construction of Sub Base using Local Materials:**				
	Construction of Sub Base using Local Materials, spreading in uniform layers with Motor grader on prepared surface, including screening the metal as necessary, mixing by mix in place method with Rotavator at OMC, and compacting with vibratory roller to achieve the desired density, lighting, guarding and barricading including cost and carriage of all materials and making necessary earthen bundh of one metre wide on each side to protect the edges complete as per Clause 401 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) For Construction of Sub Base by compacting 1st class brick aggregates (40 mm down) and sand (in proportion of 60:40).	cum	317.00	507.00	
Note:	Add cost at site of 0.90 m^3 of brick aggregates and 0.48 m^3 of medium sand (loose volume) to arrive at the consolidated rate.				
	(ii) For Construction of Sub Base by compacting stone chips and sand (in proportion of 40:60).	cum	210.00	320.00	
Note:	Add cost at site of 0.51 m^3 of 5.6 mm stone chips and 0.77 m^3 of medium sand (loose volume) to arrive at the consolidated rate.				
	(iii) For Construction of Sub Base by compacting gravel, coarse sand and moorum (A.I. value of more than 6)**:** (in proportion of 35:40:25)	cum	226.00	-	
Note:	Add cost at site of 0.45 m^3 of gravel 0.32 m^3 of moorum and 0.51 m^3 coarse sand (loose volume) to arrive at the consolidated rate.				
	(iv) For Construction of Sub Base by compacting river bed materials.	cum	152.00	157.00	
Note:	Add cost at site of 1.28 m^3 of materials to arrive at the complete rate.				
4.10	**Water Bound Macadam Sub Base**				
	Water Bound Macadam Sub Base by consolidating Jhama metal / Laterite chelly or stone metal / shingles of specific size in hard crust to requisite thickness (measured after compaction) in layers including screening of metals etc. as necessary, hand packing, sweeping, watering and rolling in stages with power roller to proper line, grade and camber, lighting, guarding & barricading and making necessary earthen bundh of one metre width on each side where necessary to protect edges and preparing the bed by necessary cutting or filling and rolling all complete including the cost of all materials and hire and labour charges of all men and machineries and compacting to the required density, as per Clause 404 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) For Construction of Sub Base by consolidating Jhama metal (63 mm to 45 mm) **with moorum screening :**	cum	408.00	-	
Note:	Add cost at site of 1.09 m3 of jhama metal and 0.26 m3 of moorum screening (loose volume) to arrive at the consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(ii) For Construction of Sub Base by consolidating Laterite (90 mm to 45 mm)**:**	cum	260.00	-	
Note:	Add cost at site of 1.45 m³ of materials to arrive at the complete rate.				
	(iii) For Construction of Sub Base by consolidating broken shingles (53 mm to 22.4 mm) **with Type-A screening :**	cum	-	232.00	
Note:	Add cost at site of 1.12 m^3 of broken shingles and 0.24 m^3 of Type A screening (loose volume) to arrive at the consolidated rate.				
4.11	**Water Bound Macadam Base Course**				
	Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with vibratory roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening / binding materials to fill up the interstices of coarse aggregate, watering including lighting, guarding, barricading and making necessary earthen bundh of one metre width on each side and preparing the bed by necessary cutting or filling, including cost of all materials and hire and labour charges of all men and machinery and compacting to the required density, as per Clause 404 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) Grading-I Aggregate (63 mm to 45 mm) **Using Stone Screening Type A** (13.2 mm)				Costs of binding materials where required is to be added @ 0.08 m³ per cum.
	A. Mechanical Means	cum	213.00	193.00	
	B. Manual Means	cum	350.00	327.00	
Note:	Add cost at site of 1.21 m³ of Grading-I Aggregates & 0.16 m³ Stone Screening Type-A to arrive at the complete rate.				
	(ii) Grading-I Aggregate (63 mm to 45 mm) **Using Stone Screening Type B** (11.2 mm)				
	A. Mechanical Means	cum	210.00	190.00	
	B. Manual Means	cum	347.00	324.00	
Note:	Add cost at site of 1.21 m³ of Grading-I Aggregates & 0.24 m³ Stone Screening Type-B to arrive at the complete rate.				
	(iii) Grading-II Aggregate (53 mm to 22.4 mm) **Using Stone Screening Type B** (11.2 mm)				
	A. Mechanical Means	cum	214.00	226.00	
	B. Manual Means	cum	351.00	361.00	
Note:	Add cost at site of 1.21 m³ of Grading-2 Aggregates & 0.24 m³ Stone Screening Type-B to arrive at the complete rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.12	**Wet Mix Macadam Base Course** Providing, laying, spreading and compacting graded stone aggregate to Wet Mix Macadam specification including screening of aggregates and granular materials, premixing the material with water at OMC in Wet Mix Plant, carriage of mixed material by tipper to site, laying in uniform layers with Paver in Sub- base / Base course on well prepared surface and compacting with Vibratory Roller to achieve the desired density, including supply of all materials, machinery, fuel and lubricants, including incidental costs for lighting, guarding, barricading, making earthen bundh to protect the edges including cost of quality control complete as per Clause 406 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	334.00	357.00	
4.13	**Construction of Median and Island**				
	A. Construction of Median and Island with Soil Taken from Roadway Cutting Construction of Median and Island above road level with approved material deposited at site from roadway cutting and excavation for drain and foundation of other structures, spread, graded and compacted as per Clause 408 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	134.00	137.00	
	B. Construction of Median and Island with Soil Taken from Borrow Areas Construction of median and Island above road level with approved material brought from borrow pits, spread, sloped and compacted as per clause 408 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	231.00	240.00	
4.14	**Construction of Shoulders**				
	A. Earthen Shoulders				
	The rate as applicable for sub-grade construction may be adopted.				
	B. Hard Shoulders				
	Rate as applicable for sub-base and or base may be adopted as per approved design.				
	C. Paved shoulders				
	The rate may be adopted as applicable for different layers of pavement depending upon approved design of paved shoulders				
4.15	**Footpaths and Separators**				
	Construction of footpath / separator by providing a 150 mm compacted granular sub base as per clause 401 followed by 25 mm thick cement concrete grade (1:2:4), over laid with pre-cast concrete tiles in cement mortar 1:3 including provision of all drainage arrangements but excluding kerb channel and as per clause 410 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	1452.00	1619.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
4.16	Supplying, spreading and consolidating an uniform and homogeneous mixture of **Stone Dust and Sand** (mixed in proportion of **3 : 1** by volume and by any approved method as per direction of Engineer-in-Charge) to the required thickness in layers at 97% Proctor Density (not less than 1.7 gm/cc) with power roller to proper gradient and camber, including watering as necessary, lighting, guarding, barricading and making adequate earthen bundh where necessary to protect the edges and curing with water for 2 to 3 days, mending cracks and depressions by rolling where necessary complete as per Specification including all incidental charges of roller, cost of fuel & lubricants.	cum	155.00	202.00	
Note:	Labour rate per cubic meter is provided, cost of stone dust and sand to be added to arrive at the consolidated rate. The compaction factor is 0.67.				
	(The payment is to be made on the basis of the finished compacted volume of mixture of stone dust and sand.)				
4.17	**Cement Treated Crushed Rock or combination as per clause 403.2 and table 400-4 in Sub base/ Base**				
	Providing, laying and spreading Material on a prepared sub grade, adding the designed quantity of cement to the spread Material, mixing in place with rotavator, grading with the motor grader and compacting with the road roller at OMC to achieve the desired unconfined compressive strength and to form a layer of sub-base/base (Reference to MoRT&H's specification 403). **For Sub-Base course / Base course**	cum	800.00	906.00	
Note:	Add cost at site of materials as per requirement vide Table 3.3-1 of section-3 under item no. 4.17**.**				

CHAPTER - 5
BASES AND SURFACE COURSES (BITUMINOUS)

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
5.01	**Prime Coat**				
	Providing and applying primer coat with Cationic Bitumen Emulsion of approved grade conforming to IS: 8887-1978 and requisite quantity on prepared surface of granular base including cleaning of road surface and spraying primer using Mechanical means including cost and carriage of bitumen emulsion and all other incidental costs of work complete as per Clause 502 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) For WBM / WMM Surface: (with primer @ 0.70-1.0 kg/sqm)	sqm	1.50	1.50	
	(ii) For Stabilised soil bases / Crusher Run Macadam Surface: (with primer @ 0.90-1.2 kg/sqm)	sqm	1.60	1.70	
Note:	Add cost and carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.02	**Tack Coat**				
	Providing and applying tack coat with Cationic Bitumen Emulsion of approved grade conforming to IS: 8887-1978 on the prepared surface cleaned with Hydraulic broom, moistening the surface including cost and carriage of emulsion, hire charges of machinery and labour, cost of fuel and lubricants all complete as per Clause 503 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) On Bituminous Surface (Using Bitumen Emulsion at the rate of 0.20 to 0.30 kg per sqm.)	sqm	1.30	1.40	
	(ii) On Granular surfaces treated with primer (Using Bitumen emulsion at the rate of 0.25 to 0.30 kg per sqm.)	sqm	1.30	1.40	
	(iii) On Cement concrete pavement (Using Bitumen emulsion at the rate of 0.30 to 0.35 kg per sqm.)	sqm	1.30	1.40	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.03	**Bituminous Macadam using Hot Mix Plant (HMP)**				
	Providing and laying bituminous macadam with Hot Mix Plant using approved crushed aggregates of specified grading as per Table 500.7 premixed with bituminous binder, transported to site laid over a previously prepared surface at specified laying temperature with paver finisher to the required grade, level and alignment and rolled with suitable power roller for break down, inter-mediate and finished rolling as per specification to achieve the desired -				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	compaction including cost and carriage of stone materials and bitumen, hire charges of machinery and equipment, cost of fuel and lubricants and wages of operational staff, quality control complete as per Clause 504 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	A. For Grading 1 (40 mm nominal size, **80-100 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1241.00	1311.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1154.00	1221.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1132.00	1197.00	
	B. For Grading 2 (19 mm nominal size, **50-75 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1239.00	1311.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1153.00	1221.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1131.00	1197.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.04	**Bituminous Macadam using Mobile Hot Mix Plant (Light Duty)**				
	Providing and laying bituminous macadam with Mobile Hot Mix Plant (Light Duty) using approved crushed aggregates of specified grading as per Table 500.7 premixed with bituminous binder, transported to site laid over a previously prepared surface at specified laying temperature by means of approved and suitable arrangements to the required grade, level and alignment and rolled with suitable power roller for break down, inter-mediate and finished rolling as per specification to achieve the desired compaction including cost and carriage of stone materials and bitumen, hire charges of machinery and equipment, cost of fuel and lubricants and wages of operational staff, quality control complete as per Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	A. For Grading 1 (40 mm nominal size, **80-100 mm thick.**)	cum	941.00	980.00	
	B. For Grading 2 (19 mm nominal size, **50-75 mm thick.**)	cum	940.00	981.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
5.05	**Dense Bituminous Macadam**				
	Providing and laying dense bituminous macadam with Hot Mix Plant producing an average output of 75 tonnes per hour using coarse aggregate, fine aggregate, filler and bituminous binder as per design Job Mix Formula conforming Marshall Method as per specification, including screening, cleaning of chips and preparing a uniform and quality mix in Hot Mix Plant and ensuring a homogeneous mix, in which all particles of the mineral aggregates are coated uniformly, transporting the hot mix to work site, laying the mixed materials at specified laying temperature with a hydrostatic paver finisher with sensor control to the required grade, level and alignment over prepared surface coated with tack coat, rolling with smooth wheeled, vibratory and tandem rollers for break down, inter-mediate and finished rolling to achieve the desired density of at least 98% of that of Laboratory Marshall specimen, hand packing and pinning to give an even surface including cost and carriage of bitumen, coarse and fine aggregates and filler materials and hire charges of machinery and equipment for construction and quality control, fuels and lubricants and wages of operational staff complete as per Clause 505 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	A. For Grading 1 (37.5 mm nominal size, **75-100 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1301.00	1378.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1203.00	1276.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1191.00	1268.00	
	B. For Grading 2 (26.5 mm nominal size, **50-75 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1292.00	1371.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1194.00	1268.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1183.00	1256.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.06	**Sand Asphalt Base Course**				
	Providing, laying and rolling sand-asphalt base course composed of sand, mineral filler and bituminous binder on a prepared sub-grade or sub-base to the lines, levels, grades and cross sections as per the drawings including mixing in Hot Mix Plant of suitable type and capacity, transporting, laying, compacting and finishing as per Clause 506 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1313.00	1517.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1222.00	1417.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1197.00	1390.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.07	**Semi-dense Bituminous Concrete**				
	Providing & laying Semi-dense Bituminous Concrete (SDBC) as wearing coarse by Hot Mix Plant, using coarse aggregates, fine aggregates, filler materials and binder of required specification and grading as per approved job mix formula, over thoroughly cleaned surface coated with tack coat, including screening, cleaning of aggregates, mixing the components as per approved Job Mix Formula with hot binder, carrying the mixture by tipper truck or any other approved suitable arrangements, laying the mixture uniformly, maintaining the specified laying temperature, thorough rolling with power roller with necessary hand packing and pinning to give an uniform surface to achieve the desired density of at least 98% of that of Laboratory Marshall specimen, including the cost and carriage of aggregates, filler and binder, heating the binder, preheating the aggregates, and filler to the specified temperature, including the hire charges of Hot Mix Plant and other machineries, pay of operators, cost of fuel and lubricants and all other incidental charges complete.				
	A. For Grading 1 (13 mm nominal size, **35-40 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1273.00	1357.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1174.00	1253.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1150.00	1228.00	
	B. For Grading 2 (10 mm nominal size, **25-30 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1258.00	1343.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1159.00	1239.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1135.00	1214.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate(₹)	Remarks
5.08	**Bituminous Concrete**				
	Providing and laying bituminous concrete with Hot Mix Plant using coarse aggregates, fine aggregates, filler materials and bituminous binder of required specification including screening, cleaning of chips and preparing a uniform and quality mix in Hot Mix Plant and ensuring a homogeneous mix, in which all particles of the mineral aggregates are coated uniformly, transporting the hot mix to work site, laying the mixed materials at specified laying temperature with a hydrostatic paver finisher with sensor control to the required grade, level and alignment over prepared surface coated with tack coat, rolling with smooth wheeled, vibratory and tandem rollers for break down, inter-mediate and finished rolling to achieve the desired density of at least 98% of that of Laboratory Marshall specimen, including cost and carriage of bitumen, coarse and fine aggregates and filler materials and hire charges of machinery and equipment for construction and quality control, fuels and lubricants and wages of operational staff complete as per Clause 507 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	A. For Grading 1 (19 mm nominal size, **50 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1261.00	1336.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1221.00	1295.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1204.00	1277.00	
	B. For Grading 2 (13.2 mm nominal size, **30mm/40 mm thick.**)				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	cum	1244.00	1321.00	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	cum	1205.00	1280.00	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	cum	1187.00	1261.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.09	**Surface Dressing**				
	Providing and laying surface dressing as wearing course in single coat using approved quality crushed stone aggregates of specified size and hot bituminous binder laid on prepared surface including thorough cleaning of the surface, screening and cleaning of stone chips, applying uniformly requisite quantity of hot bitumen, spreading uniformly dry stone aggregates and rolling with 8-10 tonne smooth wheeled steel roller with necessary hand packing or				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	spreading of chips to obtain closed surface including the cost and carriage of bitumen and stone chips, heating the bitumen and all other cost and charges of fuel, lubricants in this connection including hire and operational charges of machinery and equipment for construction and quality control complete as per Clause 509 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). **(By Mechanical Means)**				
	A. Single coat or 1st coat over granular surface using bitumen @ 12 kg per 10 m2 and stone chips / bajree (100% passing through 22.4 mm sieve and 100% retained on 11.2 mm sieve) @ 0.15 m3 per 10 m2 surface.	sqm	5.70	5.90	
	B. Second coat or renewal coat on black topped surface using bitumen @ 10 kg per 10 m2 and stone chips / bajree (100% passing through 13.2 mm sieve and 100% retained on 5.6 mm sieve) @ 0.10 m3 per 10 m2 surface.	sqm	5.70	6.20	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.10	**Open-Graded Premix Surfacing using Viscosity grade Paving Bitumen and HMP**				
	Providing, laying and rolling of Open - graded premix surfacing of 20 mm thickness composed of 13.2 mm (@ 0.018 m^3 per m^2) and 11.2 mm (@ 0.009 m^3 per m^2) size stone aggregates, including thoroughly cleaning of the surface, screening, cleaning and pre-heating stone chips and fully pre-coating the same either using viscosity grade paving bitumen or cut-back or emulsion, carrying the mixture by tipper trucks or by any other suitable arrangements, laying the mixture uniformly over the surface with paver finisher, including manual operations as and when required for proper line, grade and level to serve as wearing course on a previously prepared base, including mixing in Hot Mix Plant and thoroughly rolling with a smooth wheeled roller 8-10 tonne capacity, finished to required level and grades including the cost and carriage of stone chips and matrix, heating the matrix, preheating the aggregates to required temperature and including the hire charges of Hot Mix Plant and other machinery, pay of operators, cost of fuel and lubricants etc. complete as per Clause 510 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) Using Batch Type HMP of minimum capacity 100-120 TPH.	sqm	24.10	25.40	
	(ii) Using Drum mix Type HMP of minimum capacity 60-90 TPH.	sqm	22.00	23.30	
	(iii) Using Drum mix Type HMP of minimum capacity 40-60 TPH.	sqm	21.20	22.40	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
5.11	**Open-Graded Premix Surfacing using Bituminous (Viscosity grade Paving Bitumen / Modified bitumen) Binder and Mobile Hot Mix Plant (Light Duty)**				
	Providing, laying and rolling of Open - graded premix surfacing of 20 mm thickness composed of 13.2 mm (@ 0.018 m^3 per m^2) and 11.2 mm (@ 0.009 m^3 per m^2) size stone aggregates, including thoroughly cleaning of the surface, screening, cleaning and pre-heating stone chips and fully pre-coating the same either using viscosity grade paving bitumen or cut-back or emulsion, carrying the mixture by any suitable arrangements, laying the mixture uniformly over the surface, including line, grade and level to serve as wearing course on a previously prepared base, including mixing in Mobile Hot Mix Plant (Light Duty) and thoroughly rolling with a smooth wheeled roller 8-10 tonne capacity, finished to required level and grades including the cost and carriage of stone chips and matrix, heating the matrix, preheating the aggregates to required temperature and including the hire charges of Mobile Hot Mix Plant (Light Duty) and other machinery, pay of operators, cost of fuel and lubricants etc. complete to be followed by seal coat of either Type A or Type B as per Technical Specification Clause 508 for Rural Roads of MORD.	sqm	14.10	14.70	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.12	**Open Graded Premix Surfacing** with **Cationic Bitumen Emulsion** using 13.2 mm (@ 0.018 m3/m2) and 11.2 mm (@ 0.009 m3/m2) size stone aggregates, premixed with Cationic Bituminous Emulsion (M.S. grade) conforming to IS : 8887-1970 @ 21.5 kg per 10 m^2 of surface, including cleaning, moistening the surface, applying tack coat with cationic bitumen emulsion, screening, cleaning and washing the stone chips, intimately mixing with emulsion using Concrete Mixer, laying the mixture uniformly over the surface and rolling with power roller after hand packing and pinning adequately to ensure a compact surface all complete as per specification and direction of the Engineer-in-charge including cost and carriage of stone materials and emulsion, including cost of labour, hire and running charges of road roller and other tools and plants and cost of all other incidental charges including hire charges and cost of fuel and lubricants of machineries and equipment for construction and quality control as per Technical Specification Clause 508.2 for Rural Roads of MORD.	sqm	11.60	12.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
5.13	**Seal Coat**				
A.	Providing and laying **Liquid Seal Coat (Type A)** with approved quality stone chips and bitumen binder on thoroughly cleaned black top surface, spreading screened & cleaned stone aggregates (100 % passing through 11.2 mm sieve and retained on 2.36 mm sieve) uniformly @ 0.09 m3 of dry aggregate per 10 m2 of area using suitable means, brushing the chips, if necessary, to ensure uniformity, followed by rolling with power roller including the cost and carriage of binder and stone chips, cost of heating the binder and all other incidental charges, cost of fuel and lubricants, including hire charges of machineries, tools & plants required for construction and quality control complete as per Clause 511 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	I By Mechanical Means				
	(i) With Hot Bitumen Binder (@ 9.80 kg / 10 sqm.)	sqm	4.60	5.00	
	(ii) With Cationic Bitumen Emulsion (@ 15.00 kg / 10 sqm.)	sqm	4.60	5.00	
	II By Manual Means **With Hot Bitumen Binder** (@ 9.80 kg / 10 sqm.)	sqm	9.70	9.90	
B.	Providing and laying **Premixed Seal Coat (Type B)** with approved quality sand/grit @ 0.6 m3/ 100 m2 and bitumen binder on thoroughly cleaned black top surface coated with tack coat, including heating and mixing cleaned sand/grit (100 % passing through 2.36 mm sieve and retained on 180 micron sieve) uniformly with bitumen binder, laying and spreading the mix at an uniform rate using suitable means, brushing the surface, if necessary, to ensure uniformity, followed by rolling with power roller including the cost and carriage of binder and aggregates, cost of heating the binder and aggregates and all other incidental charges, cost of fuel and lubricants, including hire charges of machineries, tools & plants required for construction and quality control complete as per Clause 511 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	I By Mechanical Means				
	(i) With Hot Bitumen Binder (@ 6.80 kg / 10 sqm.)	sqm	7.00	7.30	
	(ii) With Cationic Bitumen Emulsion (@ 10.50 kg / 10 sqm.)	sqm	7.00	7.30	
	II By Manual Means **With Hot Bitumen Binder** (@ 6.80 kg / 10 sqm.)	sqm	7.80	8.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate(₹)	Remarks
5.14	**Mastic Asphalt** Providing and laying Mastic asphalt wearing course with paving grade bitumen meeting the requirements given in table 500-29 using approved coarse aggregate, fine aggregate, filler material and bitumen, prepared by using Mastic cooker including cost and carriage of all ingredients, cost of heating aggregates and binder, mixing in specified proportions conforming to approved Job Mix Formula and laid to required level and slope after cleaning the surface, compacting, sealing the construction joints and surface finishing conforming to specifications including providing antiskid surface with bitumen pre-coated fine-grained hard stone chipping of 13.2 mm nominal size at the rate of 0.005 cum per 10 sqm and at an approximate spacing of 10 cm center to center 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, including the hire charges of all tools and plants and machinery, pay of operators, cost of fuel and lubricants and all other incidental charges and quality control all complete as per Clause 516 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) 25 mm thickness	sqm	172.00	178.00	
	(ii) 50 mm thickness	sqm	235.00	244.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.15	**Slurry Seal**				
	Providing and laying Slurry seal consisting of a mixture of approved quality fine aggregates of proper grading, Portland cement filler, bituminous emulsion and water on a road surface including cleaning of surface, mixing of slurry seal in a suitable mobile plant, laying and compacting with pneumatic-tyred roller, if required, to provide even riding surface including cost and carriage of all ingredients, hire and operational charges of roller and other tools and plants including cost of fuel, lubricants and all other incidental charges, quality control as per Clause 512 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) 5 mm thickness	sqm	2.30	2.40	
	(ii) 3 mm thickness	sqm	1.70	2.20	
	(iii) 1.5 mm thickness	sqm	1.20	1.40	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
5.16	**Fog Spray**				
	Providing and applying Fog Spray using low viscosity (SS Type) Cationic bitumen emulsion for sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing including thoroughly cleaning of surface using scrubber and compressed air jets, applying SS type Bituminous Emulsion using bitumen pressure distributor, including cost and carriage of all ingredients and hire and operational charges of all machinery, tools and plants including fuel, lubricants and cost of quality control as per Clause 513 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	1.10	1.20	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.17	**Bituminous Cold Mix (Including Gravel Emulsion)**				
	Providing, laying and rolling of Bituminous cold mix on prepared base consisting of a mixture of unheated mineral aggregate and emulsified, including mixing in a Plant of suitable type and capacity, transporting, laying, compacting and finishing to specified grades and levels as per Clause 518 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	(i) Using 9.5mm or 13.2 mm nominal size aggregate	cum	428.00	464.00	
	(ii) Using 19mm or 26.5 mm nominal size aggregate	cum	453.00	501.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.18	**Crack Prevention Courses**				
	(i) Stress Absorbing Membrane (SAM) crack width less than 6 mm				
	Providing and laying of a Stress Absorbing Membrane over a cracked road surface, with crack width below 6 mm after cleaning with a mechanical broom, using modified binder complying with clause 517, sprayed at the rate of 9 kg per 10 sqm and spreading 5.6 mm crushed stone aggregates @ 0.11 cum per 10 sqm with hydraulic chip spreader, sweeping the surface for uniform spread of aggregates and surface finished to conform to clause 902 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	3.30	3.60	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(ii) Stress Absorbing Membrane (SAM) with crack width 6 mm to 9 mm				
	Providing and laying of a Stress Absorbing Membrane over a cracked road surface, with crack width 6 to 9 mm after cleaning with a mechanical broom, using modified binder complying with clause 517, sprayed at the rate of 11 kg per 10 sqm and spreading 11.2 mm crushed stone aggregates @ 0.12 cum per 10 sqm, sweeping the surface for uniform spread of aggregates and surface finished to conform to clause 902 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	3.70	4.10	
	(iii) Stress Absorbing Membrane (SAM) crack width above 9 mm and cracked area above 50 per cent				
	Providing and laying a single coat of a Stress Absorbing Membrane over a cracked road surface, with crack width above 9 mm and cracked area above 50 per cent after cleaning with a mechanical broom, using modified binder complying with clause 517, sprayed at the rate of 15 kg per 10 sqm and spreading 11.2 mm crushed stone aggregates @ 0.12 cum per 10 sqm, sweeping the surface for uniform spread of aggregates and surface finished to conform to clause 902 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	3.90	4.40	
	(iv) Bitumen Impregnated Geotextile				
	Providing and laying a Bitumen Impregnated Geotextile layer after cleaning the road surface, geotextile conforming to requirements of clause 703.2, laid over a tack coat with 1.05 kg per sqm of paving grade bitumen 80 - 100 penetration and constructed to the requirement of clause 703.3 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	14.90	15.00	
Note:	Add cost & carriages of materials as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
5.19	Providing and laying **Bituminous Profile Corrective Course** using Mobile Hot Mix Plant (Light Duty) and using aggregates of Grading-2 of Table-33 premixed with 75kg of bitumen per cum, transported to site laid over a previously prepared surface at specified laying temperature to the required grade, level and alignment, as per specification to achieve the desired compaction including cost and carriage of stone materials and bitumen, hire charges of machinery and equipment, cost of fuel and lubricants and wages of operational staff, quality control complete as per direction of Engineer-in-charge.	cum	940.00	978.00	
Note:	Add cost & carriages of materials to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
5.20	**Recycling of Bituminous Pavement with Central Recycling Plant** Recycling pavement by cold milling of existing bituminous layers, planning the surface after cold milling, reclaiming excavated material to the extent of 30 per cent of the required quantity, hauling and stockpiling the reclaimed material near the central recycling plant after carrying out necessary checks and evaluation, adding fresh material including rejuvenators as required, mixing in a hot mix plant, transporting and laying at site and compacting to the required grade, level and thickness, all as specified in Clause 519.	cum	723.00	768.00	
5.21	**Providing & Laying 20 mm thick Mix Seal Surfacing (MSS)** Providing, laying and rolling of close graded premix surfacing using materials of 20 mm thickness composed of 11.2mm to 0.09mm (For Type – A) or 13.2mm to 0.09mm (For Type – B) aggregates using penetration grade bitumen to the required line, grade and level to serve as wearing course on a previously prepared base, including mixing in a suitable plant, laying and rolling with a smooth wheeled roller 8 – 10 tonne capacity and finishing to required level and grade etc. including all other incidental charges, quality control as per clause 508 of specifications for Road & Bridge Works of MoRT&H (5th Revision) complete.				
	(a) Type – A : Using 2.2 kg bitumen per square meter surface area : **i) Using Hot Mix Plant not less than 75 T / Hr.**	Sqm	22.80	23.50	
	(b) Type – B : Using 1.9 kg bitumen per square meter surface area : **i) Using Hot Mix Plant not less than 75 T / Hr.**	Sqm	21.90	22.60	
Note :	Add cost and carriages of materials as per requirement vide Table 3.3-1 of section 3 to get the final consolidated rate.				
5.22	**Micro Surfacing** Providing and laying **Micro surfacing** with micro paver equipment (mounted on truck), meeting the requirement as par table 500-33 & 500-34 of MoRT&H by using coarse aggregate, mineral filler & modified bitumen emulsion of required specification including screening, cleaning of chips and preparing a uniform and homogeneous mix and laying the mix with a micro surfacing paver finisher as per clause 514 of MoRT&H (5th revision) complete in all respect.				
	i) Type - II (4 to 6 mm thick)	Sqm	21.40	22.80	
	(ii) Type - III (6 to 8 mm thick)	Sqm	23.80	24.50	
Note :	Add cost & Carriage of materials as per requirement vide Table 3.3-1 of section-3 under item no. 5.22.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
5.23	**Stone Matrix Asphalt** Providing and laying **Stone Matrix Asphalt** with Hot Mix Plant meeting the requirement as par table 500-37 & 500-38 of MoRT&H by using coarse aggregates ,fine aggregates, mineral filler, Pelletized cellulose fiber & bituminous binder of required specification including screening, cleaning of chips and preparing a uniform and homogeneous mix and transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per clause 515 of specifications for Roads & Bridge works of MoRT&H (5th Revision) complete in all respect.				
	(i) 13 mm SMA with layer thickness 40-50 mm	cum	2560.00	2600.00	
	(ii)19 mm SMA with layer thickness 45-75 mm	cum	2570.00	2610.00	
Note :	Add cost & carriage of materials as per requirement vide Table 3.3-1 of section-3 under item no. 5.23				

CHAPTER - 6
CEMENT CONCRETE PAVEMENT

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
6.01	**Dry Lean Cement Concrete Sub- base**				
	Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing. (As per clause 601 of specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	852.00	1270.00	
Note:	Construction Wing will add the cost & carriage of 0.90 cum/m³ crushed stone & Cement @ 150 kg/cum of concrete only to arrive at consolidated rate.				
6.02	**Cement Concrete Pavement** **(laying with fixed form / slip form paver)**				
	Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with cement content as per IRC: 15-2011, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, **mixed in a batch mix plant** as per approved mix design **(as per IRC:44 2008)**, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint polysulphide sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing and clause 602 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	985.00	995.00	
Note:	**1.** Construction Wing will add the cost & carriage of 0.9 cum/m³ crushed stone aggregates, cement, dowel bar & tie rod and cost of sand (vide Table II-1 of Page 14, excl. 10% Contractor's Profit) as per design and drawing only to arrive at consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	2. Construction Wing will also add 5% for Overhead charges & 10% Contractor's Profit separately over the cost of materials of Sl. 1 above.				
	3. The characteristic flexural strength of concrete shall not be less than 4.5 MPa.				
6.02 A	**Cement Concrete Pavement (laying manually)**				
(New)	Construction of un-reinforced, dowel jointed at expansion and construction joint only, plain cement concrete pavement, thickness as per design, over a prepared sub base, with cement content **as per IRC: 15-2011**, coarse and fine aggregates conforming to IS:383, maximum size of coarse aggregate not exceeding 25 mm, **mixed in a batch mix plant / RMC** and appropriate weigh batcher using approved mix design **(as per IRC:44 2008)**, laid in approved fixed side formwork (steel channel, laying and fixing of 125 micron thick polythene film, wedges, steel plates including levelling the formwork as per drawing, spreading the concrete with shovels, rakes, compacted using needle, screed and plate vibrators and finished in continuous operation including provision of contraction and expansion, construction joints, applying debonding strips, primer, polysulphide sealant, dowel bars, near approaches to bridge/ culvert and construction joints, admixtures as approved, curing of concrete slabs for 14-days, using curing compound (where specified) and water finishing to lines and grade as per drawing and Technical Specification Clause 1501 for Rural Roads of MORD.				
	(i) With Batch Mix Plant	cum	1615.00	1637.00	
	(ii) With RMC	cum	1724.00	1752.00	
Note:	**1.** Construction Wing will add the cost & carriage of 0.9 cum/m³ crushed stone aggregates, cement, dowel bar & tie rod and cost of sand (vide Table II-1 of Page 14, excl. 10% Contractor's Profit) as per design and drawing only to arrive at consolidated rate. **2.** Construction Wing will also add 3% for formwork, 5% for Overhead charges & 10% Contractor's Profit separately over the cost of materials of Sl. 1 above. **3.** The characteristic flexural strength of concrete shall not be less than 4.5 MPa.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
6.03	**Roller Compacted Concrete Pavement**				
	Construction of Roller Compacted Concrete Pavement (RCCP) with coarse and fine aggregates conforming to IS:383, the size of coarse aggregate not exceeding 25 mm with minimum aggregate cement ratio of 5:1 mm and with minimum cement content of 310 kg per cum, aggregate gradation to be as per Table 602.2 after blending, mixing in concrete mixer at optimum moisture content, transporting to site, laying with wheel barrows or steel pans or with mechanical paver, compacting with 80-100 kN smooth wheel, tandem vibratory roller, to achieve, the designed flexural strength, finishing and curing as per drawings and Technical Specification Clause 1502 for Rural Roads of MORD.	cum	2066.00	2503.00	
Note:	Construction Wing will add the cost & carriage of 0.90 cum/m³ crushed stone & cost of cement only to arrive at consolidated rate.				
6.04	**Rectangular Concrete Block Pavement**				
	Manufacturing, laying of cement concrete blocks of size 0.450 m x 0.300 m x 0.15 m of Cement Concrete (C.C.) M30 grade and spreading 25 mm thick sand underneath and filling joints with sand on existing W.B.M. base as per Technical Specification Clause 1503 for Rural Roads of MORD.	sqm	932.00	1052.00	
6.05	**DELETED**				

CHAPTER - 7
GEOSYNTHETICS AND REINFORCED EARTH

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
7.01	**Narrow Filter Sub-Surface Drain**				
	Construction of a narrow filter sub- surface drain consisting of porous or perforated geotextile pipe of 150 mm dia. laid in narrow trench surrounded by a geotextile filter fabric, with a minimum of 450 mm overlap of fabric and installed as per clause 702.3 and 309.3.5 of Specifications for Road & Bridge Works of MoRT&H (5th Revision) including excavation and backfilling.	metre	404.00	404.00	
7.02	**Laying Paving Fabric Beneath a Pavement Overlay**				
	Providing and laying paving fabric with physical requirements as per table 704-2 of MoRT&H Specification over a tack coat of paving grade Bitumen 80-100 penetration, laid at the rate of 1 kg per sqm over thoroughly cleaned and repaired surface to provide a water resistant membrane and crack retarding layer. Paving fabric to be free of wrinkling and folding and to be laid before cooling of tack coat, brooming and rolling of surface with pneumatic roller to maximise paving fabric contact with pavement surface.	sqm	92.00	93.00	
7.03	**Laying Boulder Apron in Crates of Synthetic Geogrids**				
	Providing, preparing and laying of Geogrid crated apron 1 m x 5 m, 600 mm thick including excavation and backfilling with baffles at 1 metre interval, made with geogrids having characteristics as per clause 704.2, joining sides with connectors/ring staples, top corners to be tie tensioned, placing of suitable cross interval ties in layers of 300 mm connecting opposite side with lateral braces and tied with polymer braids to avoid bulging, constructed as per clause 704.3. filled with stone with minimum size of 200 mm and specific gravity not less than 2.65, packed with stone spalls, keyed to the foundation recess in case of sloping ground and laid over a layer of geotextile to prevent migration of fines, all as per clause 704 of MoRT&H Specification and laid as per clause 2503.3 and approved design.	cum	1525.00	1770.00	
Note:	Construction wing is to add cost and carriage of 1.15 cu.m. of stone with minimum size of 200 mm & 0.15 cu.m of stone spalls only to arrive at consolidated rate.				
7.04	**Reinforced Earth Structures**				
	Reinforced earth Structures have four main components as under:				
	a) Excavation for foundation (to be executed as per Item 12.01 of Ch. 12).	cum	98.00	98.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	b) Foundation concrete and cement concrete grooved seating in the foundation for facing elements (to be executed as per Item 12.05 (A) to (E) of Ch. 12).	cum			
	c) Providing, carriage, hoisting and placement of Facia element (180 mm thick) of RCC (M35) with dimension and reinforcement as per provision of clause 703.4 of MORT&H Specifications for Road & Bridge Works inclusive of reinforcement, shuttering, curing, transporting, placing, fixing all complete.	sqm	1390.00	1611.00	
	d) Providing assembling, joining with facing elements and laying of the reinforcing elements as per provision of Clause 703.4 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	I. With reinforcing element of Galvanised carbon steel strips of 60 mm wide and 5 mm thick as per clause 3103 of Specifications for Road & Bridge Works of MoRT&H (5th Revision) and as per approved design and specifications.	metre	285.00	285.00	
	II. With reinforcing elements of synthetic geogrids as per clause 3102.8 and approved design and specifications.				
	(i) Height of the wall upto 5.0 m.	sqm of fascia wall	2000.00	2000.00	
	(ii) Height of the wall above 5.0 m & upto 10.0 m.		3000.00	3000.00	
	e) Back fill with granular material which is to be retained by the wall. Granular material will be as per Clause 3104 and placement & compaction as per clause 3106.5 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	cum	765.00	1359.00	

Notes :

1. *Construction wing should add the cost of Drainage arrangement including filter media as per approved design and drawings.*
2. *The specification and construction details to be adopted shall be as per section 3100 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).*
3. *Length of reinforcing strips will vary with the height of wall and will be as per approved design and drawings.*
4. *The type of reinforcing elements to be adopted shall be as per approved design and specifications.*
5. *Actual market rate for supply of reinforcing elements and their accessories are to be obtained from reputed firms in the field of earth reinforcement.*
6. *The back fill material shall be clean, free draining, granular with high friction and low cohesion, non-corrosive, coarse grained with not 10 per cent of particles passing 75 micron sieve, free of any deleterious matter, chlorides, salts, acids, alkalies, mineral oil, fungus and microbes and shall be of specified pH value.*
7. *Capping beam is to be priced separately as per approved design. The rate for cement concrete shall be taken from Chapter 12 of Departmental Schedule of Rates.*

CHAPTER - 8
TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
8.01	**Cast in Situ Cement Concrete M20 Kerb**				
	Construction of cement concrete kerb with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M-10 grade foundation 150 mm thick, foundation having 50 mm projection beyond kerb stone, kerb stone laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 409 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (The rate is inclusive of cost of all materials, labour, hire and usage charges of machinery and all incidental charges in this connection.)				
	A) Using Concrete Mixer	metre	280.00	348.00	
	B) Using Concrete Batching and Mixing Plant	metre	274.00	342.00	
8.02	**Cast in Situ Cement Concrete M 20 Kerb with Channel**				
	Construction of cement concrete kerb with channel with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M10 grade foundation 150 mm thick, kerb channel 300 mm wide, 50 mm thick in PCC M20 grade, sloped towards the kerb, kerb stone with channel laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 409 of Specifications for Road & Bridge Works of MoRT&H (5th Revision). (The rate is inclusive of cost of all materials, labour, hire and usage charges of machinery and all incidental charges in this connection.)				
	A) Using Concrete Mixer	metre	530.00	666.00	
	B) Using Concrete Batching and Mixing Plant	metre	525.00	661.00	
8.03	**Printing New Letters and Figures of any Shade**				
	Printing new letter and figures of any shade with synthetic enamel paint black or any other approved colour to give an even shade as per drawings and Technical Specification Clause 801 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	i) Hindi (Matras commas and the like not to be measured and paid for. Half letters shall be counted as half only)	per cm per letter	0.80	0.80	
	ii) English and Roman		0.50	0.50	
8.04	**Retro-Reflectorised Traffic Signs**				
	Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of high intensity grade sheeting vide clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)`	Remarks
	cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing and Clause 801 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).				
	i) 90 cm equilateral triangle	each	4246.00	4355.00	
	ii) 60 cm equilateral triangle	each	2811.00	2920.00	
	iii) 60 cm circular	each	3750.00	3859.00	
	iv) 80 mm x 60 mm rectangular	each	5208.00	5317.00	
	v) 60 cm x 45 cm rectangular	each	3654.00	3763.00	
	vi) 60 cm x 60 cm square	each	4320.00	4429.00	
	vii) 90 cm high octagon	each	6629.00	6738.00	
8.05	**Direction and Place Identification Signs upto 0.9 sqm Size Board.**				
	Providing and erecting direction and place identification retro-reflectorised sign as per IRC:67 made of high intensity grade sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area not exceeding 0.9 sqm supported on a mild steel single angle iron post 75 x 75 x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 x 45 x 60 cm, 60 cm below ground level as per approved drawing and Clause 801 of Specifications for Road & Bridge Works of MoRT&H (5th Revision)..	sqm	9230.00	9351.00	
8.06	**Direction and Place Identification Signs with size more than 0.9 sqm size Board.**				
	Providing and erecting direction and place identification retro- reflectorised sign as per IRC :67 made of high intensity grade sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area exceeding 0.9 sqm supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm, 2 Nos. firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing and Clause 801 of Specifications for Road & Bridge Works of MoRT&H (5th Revision)..	sqm	9568.00	9713.00	
8.07	Providing & fixing **Concrete Sign Board** as per IRC specification of size 900 x 750 x 37 mm. thick made with RCC 1:1½:3 with pakur variety stone chips reinforced with double layer IRC febric (75 x 75 mm. mesh) and fixed with necessary nuts & bolts on two RC precast posts 100 mm. x 150 mm. of height 2.65 m. of which top 750 mm. is of section 100 x 13 mm. and 1.90 metre above GL & 0.75 metre below GL including digging hole, repacking the same with cement concrete 1:3:6 with jhama khoa or with local stone chips etc. complete including painting two coats on both faces lettering sign marks etc. as per direction of the Engineer-in-Charge. (The rate is inclusive of cost of reinforcement, concrete, shuttering, nuts & bolts, washer etc. complete.)	each	2230.00	2669.00	
8.08	**Retro reflective Road Marking (Cold applied)**	sqm	349.00	349.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
8.09	**Road Marking with Hot Applied Thermoplastic Compound with Reflectorising Glass Beads on Bituminous Surface**				
	Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35. The finished surface to be level, uniform and free from streaks and holes complete as per Clause 803 of Specifications for Road & Bridge Works of MoRT&H (5th Revision).	sqm	584.00	584.00	
8.10	**Kilometre Stone**				
	Reinforced cement concrete M15 grade kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc.				
	(i) 5th kilometre stone (precast)	each	2687.00	2920.00	
	(ii) Ordinary kilometer stone (precast)	each	1577.00	1730.00	
	(iii) Hectometer stone (precast)	each	450.00	483.00	
8.11	**Road Delineators**				
	Supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide strips, fitted with 80 x 100 mm rectangular or 75 mm dia circular reflectorised panels at the top, buried or pressed into the ground and conforming to IRC-79 and the drawings.	each	386.00	386.00	
8.12	**Fencing With Welded Steel Wire Fabric 75 mm x 50 mm**				
	Providing 1.20 metre high fencing with angle iron posts 50 mm x 50 mm x 6 mm at 3 metre center to center with 0.40 metre embedded in M15 grade cement concrete, corner, end and every 10th post to be strutted, provided with welded steel wire fabric of 75 mm x 50 mm mesh or 75 mm x 25 mm mesh and fixed to iron posts by flat iron 50 x 5 mm and bolts etc. complete in all respects.	metre	477.00	485.00	
8.13	**Reinforced Cement Concrete Crash Barrier (For new Bridge construction)**				
	Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with reinforced cement concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer-in-Charge, all as specified.	metre	1539.00	1598.00	
Note:	Add cost of 0.30 cum/metre **concrete of desired grade** as per Fig. 4(a) of IRC: 5, to arrive at the complete rate. Rate for concrete may be taken from chapter on superstructure.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
8.14	**Metal Beam Crash Barrier**				
	A Type - A, "W" : Metal Beam Crash Barrier Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanized by hot dip process, all fittings to conform to IS:1367 andIS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per Clause 811.3 of Specifications for Road & Bridge Works of MoRT&H (5th Revision)..	metre	2518.00	2642.00	
	B Type - B, "THRIE" : Metal Beam Crash Barrier				
	Providing and erecting a "Thrie" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 85 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 2 m high with 1.15 m below ground level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a space of channel section 150 x 75 x 5 mm, 546 mm long complete as per Clause 811.3 of Specifications for Road & Bridge Works of MoRT&H (5th Revision)	metre	3136.00	3311.00	
8.15	**Supplying & fixing of Raised Pavement Markers / Road Studs / Cats Eye** made of polycarbonate moulded body and reflective panels with micro prismatic lens capable of providing total internal reflection of the light entering the lens face which shall support a load of 13635 kg tested in accordance to ASTM D 4280 Type H and complying to clause no 804 of MoRT&H's specification for Road &Bridge Works (Fifth Rev.). Marker height shall not be less than 10 mm and shall not exceed 20 mm, width shall not exceed 130mm and with minimum reflective area of 13 sq.cm. on each side and slope to the base shall be 35 ± 5 degree. Fixing will be without nails but by using epoxy resin based adhesive as per manufacturer's recommendation including site clearance etc. and complete as directed by the Engineer in Charge .The contractor will have to provide a test certificate from a reputable national/international laboratory conforming the above specifications.	each	255.00	255.00	
8.16	**R.C. Guard post** Supplying fitting and fixing R.C. guard post 1.37m long with C.C. 1:2:4 with graded stone chips of 13.2mm down casting , curing complete including cost of providing 4nos.of 12mm dia. rod of length 1.54m as main reinforcement and 6 nos. of round shaped 8mm dia rods used as binders; the placing of	each	773.00	853.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	the first binder should be at 75mm below the top finished surface and the other 5 nos of binders should be placed at 245mm c/c ; the guard post is of octagonal section with inscribed circle of dia 24cm at the base tapering to corresponding dimensions of 16cm at the top including two coats of painting with best quality synthetic enamel paint of approved make and grade to form 6 nos. horizontal alternate bands in white/tannery yellow and black to 90 cm length standing up above ground after mending good damages if any during striking off shuttering, making hole in ground of 47cm depth and 30cm. minimum dia, fixing the guard posts in the same holes and repacking the earth properly so as to keep the guard posts standing properly erect in correct position true to line and length including carriage of R. C. Guard Post with due care to the site including loading into the truck and unloading at site complete in all respect. **With Pakur variety stone chips**				
8.17	**Painting (one coat) guard posts** with 6nos. of 16cm wide horizontal alternate band in different colours after the scrapping the surface free from old paint etc. as directed with best quality synthetic enamel paint of approved make and brand after fixing old existing guard post in correct position true to line and level with repacking the ground at base properly and mending good damages if necessary complete in all respect.	each	120.00	120.00	
8.18	**Painting (one coat) K.M. post** with best quality synthetic enamel paint of approved make and brand of different shades as directed after cleaning and washing the surface including mending good damages as necessary complete in all respect.				
	a) 5th K.M. Post	each	104.00	104.00	
	b) Ordinary K.M. Post	each	67.00	67.00	
8.19	**Painting (one coat) 200 m post** with best quality synthetic enamel paint of approved make and brand of different shades as directed after cleaning and washing the surface including mending good damages as necessary, complete in all respect.	each	23.00	23.00	
8.20	**Painting the vertical end faces of posts, wheel guards or railing or parapet** with alternate bands of different colours as directed by the Engineer-in-charge with approved synthetic enamel paint.				
	a) One Coat	sqm	62.00	62.00	
	b) Two Coats	sqm	99.00	99.00	
8.21	**Supply fitting and fixing Boundary Pillars** as per type design IRC-25 1969 with cement concrete 1:2:4 with stone chips including cost of providing 2 nos. of 6 mm dia M.S. rods of length 1.84 m in the form of inverted U-Shape as main reinforcements placed crosswise to each other and 5 nos. of round shaped 6 mm dia M.S. rods used as binders; the placing of 1st binder should be at 75mm below the top finished surface and the other 4 nos. of binders should be placed at 1.85mm C/C and to be of 90 cm. long	each	1105.00	1340.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
	with 20cm dia at the base tapering to15cm dia at the top with head properly round and sunk inscriptions (as directed) at the side with 60cm embedment into the ground after making hole in the ground of size 50cm x 50cm x 75cm and repacking the hole properly with cement conc. 1:4:8 with stone chips and finishing the exposed portion of 30cm length with white wash & painting the inscription as directed including carriage of the post to the site with loading & unloading etc. complete in all respect. **With Pakur variety stone chips**				
8.22	**Overhead Signs** Providing and erecting overhead signs with a corrosion resistant 2mm thick aluminium alloy sheet reflectorized with high intensity retro-reflective sheeting of encapsulated lens type with vertical and lateral clearance given in clause 802.2 and 802.3 and installed as per clause 802.6 over a designed support system of aluminium alloy or galvanised steel trestles and trusses of sections and type as per structural design requirements and approved plans (Reference to MORT&H's specification 802).				
	a) Truss and Vertical Support	tonne	56870.00	56944.00	
	b) Aluminium Alloy Plate for Over Head Sign	sqm	374.00	374.00	
Note:	1. The cost of excavation and foundation concrete for fixing of vertical support system to be worked out separately as per the approved drawing/design and to be included in the estimate. 2. Lettering and arrow marks on sign board to be provided separately as per actual requirement. Rates for these items have been included separately in this chapter.				
8.23	**Painting Lines, Dashes, Arrows etc on Roads in Two Coats on New Work** Painting lines, dashes, arrows etc on roads in two coats on new work with ready mixed road marking paint conforming to IS:164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control (Reference to MORT&H's specification 803).				
	(i) Over 10 cm in width	sqm	89.00	89.00	
	(ii) Up to 10 cm in width	sqm	75.00	75.00	
8.24	**Painting Lines, Dashes, Arrows etc on Roads in Two Coats on Old Work** Painting lines, dashes, arrows etc on roads in two coats on old work with ready mixed road marking paint conforming to IS: 164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control (Reference to MORT&H's specification 803).				
	(i) Over 10 cm in width	sqm	62.00	62.00	
	(ii) Up to 10 cm in width	sqm	67.00	67.00	

CHAPTER - 9
HORTICULTURE

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
9.01	**Spreading of Sludge Farm Yard Manure or/and good Earth**				
	Spreading of sludge farm yard manure or/ and good earth in required thickness (cost of sludge, farm yard manure or/and good earth to be paid for separately)	cum	19.80	19.80	
9.02	**Making Lawns including Ploughing and Dragging with 'Swagha' Breaking of Clod**				
	Making lawns including ploughing and breaking of clod, removal of rubbish, dressing and supplying doobs grass roots and planting at 15 cm apart, including supplying and spreading of farm yard manure at rate of 0.18 cum per 100 sqm	sqm	20.20	20.20	
9.03	**Maintenance of Lawns or Turfing of Slopes**				
	Maintenance of lawns or Turfing of slopes (rough grassing) for a period of one year including watering etc.	sqm	60.30	61.60	
9.04	**Planting and Maintaining of Permanent Hedges**				
	(a) Planting permanent hedges including digging of trenches				
	Planting permanent hedges including digging of trenches, 60 cm wide and 45 cm deep, refilling the excavated earth mixed with farmyard manure, supplied at the rate of 4.65 cum per 100 metres and supplying and planting hedge plants at 30 cm apart.	metre	205.80	205.80	
	(b) Maintenance of hedge for one year	metre	122.30	122.70	
9.05	**Planting and Maintaining of Flowering Plants and Shrubs**				
	(a) Planting flowering plants and shrubs in central verge	km	22397.00	22449.00	
	(b) Maintenance of flowering plants and shrubs in central verge for one year	per km per year	133653.00	134433.00	
9.06	**Planting of Trees and their Maintenance for one Year**				
	Planting of trees by the road side (Avenue trees) in 0.60m dia holes, 1 m deep dug in the ground, mixing the soil with decayed farm yard/sludge manure, planting the saplings, backfilling the trench, watering, fixing the tree guard and maintaining the plants for one year.	each	688.00	690.00	
9.07	**Renovation Lawns including, Weeding, Forking the Ground, Top Dressing with Forked Soil**				
	Renovation lawns including, weeding, forking the ground, top dressing with forked soil, watering and maintenance the lawns, for 30 days or more, till the grass forms a thick lawn, free from weeds, and fit for moving and disposal of rubbish as directed, including supplying good earth, if needed but excluding the cost of well decayed farm yard manure.	sqm	9.80	9.80	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
9.08	**Half Brick Circular Tree Guard, in 2nd Class Brick, internal diameter 1.25 metres, and height 1.2 metres, above ground and 0.20 metre below ground**				
	Half brick circular tree guard, in 2nd class brick, internal diametre 1.25 metres, and height 1.2 metres, above ground and 0.20 metre below ground, bottom two courses laid dry, and top three courses in cement mortar 1:6 (1 cement 6 sand) and the intermediate courses being in dry honey comb masonry, as per design complete	each	1626.00	2202.00	
9.09	**Edging with 2nd Class Bricks, Laid Dry Lengthwise**				
	Edging with 2nd class bricks, laid dry lengthwise, including excavation, refilling, consolidation, with a hand packing and spreading nearly surplus earth within a lead of 50 metres	metre	32.90	44.70	
9.10	**Making Tree Guard 53 cm dia and 2 Metre High as per Design from Empty Bitumen Drums**				
	Making tree guard 53 cm dia and 2 metres high as per design from empty bitumen drums, slit suitably to permit sun and air, (supplied by the department at stock issue rate) including providing and fixing four legs 40 cm long of 30 x 3 mm MS riveted to tree guard and providing and fixing 2 nos MS sheet rings 50 x 0.5 mm with rivets complete in all respects.	each	480.00	484.00	
9.11	**Tree Guard with MS Angle Iron and Steel Wire**				
	Providing and fixing tree guard 0.60 metre square, 2.00 metre high fabricated with MS angle iron 30 x 30 x 3 mm, MS iron 25 x 3 mm and steel wire3 mm dia welded and fabricated as per design in two halves bolted together.	each	2383.00	2441.00	
9.12	**Compensatory Afforestation**				
	Planting trees as compensatory afforestation at the rate of 290 trees per hectare at a spacing of 6 m by grubbing and leveling the ground upto a depth of 150 mm, digging holes 0.9 m dia, 1 m deep, mixing farm yard/sludge manure with soil, planting of sapling 2 m high with 25 cm dia stem, backfilling the hole and watering.	hetare	90002.00	91921.00	

CHAPTER - 10
MAINTENANCE OF ROADS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
10.01	**Dressing and chilchalling** Road flanks including cutting and filling with earth up to 150 mm average thickness finished with outward cross-grade of 1 in 30.	sqm	12.20	12.20	
	(Extra quantity of earth for filling shall be obtained from road side borrow pits.)				
10.02	**Restoration of Rain Cuts**				
	Restoration of rain cuts with soil, moorum gravel or a mixture of these, clearing the loose soil, benching for 300mm width laying fresh material in layers not exceeding 250 mm and compaction with plate compactor or power rammer to restore the original alignment, level and slopes as per drawings and technical specifications Clause 1902 for Rural Roads of MORD.	cum	140.00	144.00	
10.03	**A. Maintenance of Earthen shoulder (filling with fres0h selected soil)**				
	Making up loss of material/irregularities on shoulders to the design level by adding fresh approved selected soil and compacting with appropriate equipment at OMC upto a lead of 1000 m as per technical specification Clause 1903 for Rural Roads of MORD. (Average thickness 150 mm)	sqm	26.20	26.80	
	B. Maintenance of Earthen shoulder (stripping of excess soil)				
	Stripping excess soil from the shoulder surface to achieve the approved level and compacting with plate compactor at OMC as per drawings and Technical Specification Clause 1903 for Rural Roads of MORD. (Average thickness 150 mm)	sqm	13.20	13.50	
10.04	**Maintenance of Non-bituminous Base and Sub-Base or WBM Road**				
	Patching of potholes by draining water, cutting the pothole area to rectangular shape with vertical edges, removing all loose materials, screening and stacking the same for reuse with new materials as per requirement, filling the pothole area with additional volume of crushed stone materials / laterite / Jhama / broken shingles / coated stones of Pakur variety etc. and screenings as applicable, and compacting the same with static roller as per Water Bound Macadam Specification, including cost of all materials and machineries.	cum	443.00	420.00	*Construction wing is to add the cost of 1.00 m3 of Grading-2 aggregates & 0.21 m3 of Type-B screening to arrive at the complete rate.*
Note:	1. The payment is to be done based on loose net volume of coarse aggregates only.				
	2. This item of work may be executed for temporary restoration of road and should be covered with bituminous overlay as soon as possible.				
	3. If filling is done using coated stone aggregates, a 75mm thick WBM (Grading- 2) layer shall overlay the fill using Pakur stone materials, before laying of bituminous course.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
10.05	**Maintenance of Bituminous surface road**				
	i) **Repair to pot holes** by removal of failed material, trimming the sides to vertical and leveling the bottom, cleaning the same with compressed air or any appropriate method filled with B.M (thickness not more than 75 mm in single layer) applying bitumen emulsion prime coat at the bottom and bitumen emulsion tack coat on sides and on bottom as per technical specifications Clauses 502 and 503 for Rural Roads of MORD.	cum	1562.00	1628.00	
	ii) **Patch repair** on already filled pot holes with BM with 20 mm premix carpet and seal coat Type B as per drawings and technical specification Clause 1904.2 for Rural Roads of MORD.	sqm	60.00	61.00	
	iii) **Patch repair** on already filled pot holes with BM with 12 mm premix carpet using premixed stone chips of approved quality with hot matrix using 1.00 m3 of 11.2 mm chips and 0.6m3 of 5.6 mm chips per 100 m2 of surface, including preheating the stone chips on suitable pans and intimately mixing the hot chips separately with hot matrix @ 56 kg per m3 of stone chips, laying the mixture uniformly over the surface and rolling with power roller, after hand packing and pinning adequately to ensure a compact surface.	sqm	10.50	11.20	
	iv) **Patch repair** on already filled pot holes with BM with 6 mm premix carpet using premixed stone chips of approved quality with hot matrix using 0.80 m3 of 11.2 mm chips and 0.25m3 of 5.6 mm chips per 100 m2 of surface, including preheating the stone chips on suitable pans and intimately mixing the hot chips separately with hot matrix @ 70 kg per m3 of stone chips, laying the mixture uniformly over the surface and rolling with power roller, after hand packing and pinning adequately to ensure a compact surface.	sqm	4.90	5.60	
Note:	Add cost and carriages of materials as specified to get the final consolidated rate.				
10.06	**A. Pre-coating Chips**				
	Pre-coating stone aggregates with hot matrix @ 56 kg/m3 of net volume of stone aggregate in concrete mixer including preheating the stone aggregate at a suitable temperature including the cost of carriage of the stone aggregate at the mixing yard and carriage of the pre-coated materials for dumping at a suitable place as directed including cost and carriage of bitumen and hire charges of machineries and all incidental charges complete as per direction of Engineer-in-charge.	cum	433.00	447.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
Note:	Add cost of materials and carriages as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
	B. Repairing pot holes by pre-coated Chips				
	Repairing pot holes with pre-coated stone materials including cutting, loading pre-coated stone materials at departmental stack-yard or any other approved pre-defined location, including carriage of pre-coated stone materials from source to different kilometers of road by truck and laying directly from truck and compacting with plate compactor / power roller including cutting the pot hole to regular shape clearing the pot holes of loose materials, drying the bed of pot holes, where necessary, by soaking with gunny bags and using lime, where necessary, before laying of pre-coated materials etc. complete as per direction of Engineer-in-charge.				
	(i) Within a distance up to 10 kms.	cum	1129.00	1171.00	
	(ii) Within a distance above 10 kms and up to 20 kms.	cum	1235.00	1282.00	
10.07	**Repairing pot-holes and making up small depressions** with ramming or power rolling including screening, cleaning chips or metals and washing, drying as necessary and heating the chips or metal where necessary, cutting pot holes to regular shapes with vertical edges, cleaning the disintegrated materials, heating matrix and applying tack coat (including sides), finishing the top of repaired surface levelled with adjoining area, including cost and carriage of stone aggregates and matrix, excluding cost of applying tack coat. [Tack coat is to be considered separately] i) **With premixed Chips or Bajrees** with 54 kg of bitumen per m3 of loose net volume of stone chips using concrete mixer machine. (The payment is to be made on the basis of loose net volume of stone materials consumed in the work)				*[Payment to the Contractor is to be made on the basis of loose net volume of coarse aggregate only excluding key aggregates]*
	(a) Using suitable pan	cum	691.00	720.00	
	(b) Using Mobile HMP (Light duty)	cum	384.00	418.00	
	ii) **By grouting method** using matrix @ 70 kg / m3 of loose net volume of course aggregate. Requirement of key aggregate may be taken as 10% of coarse aggregate and size 11.2 mm.	cum	608.00	620.00	
Note:	Add cost of materials and carriages as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
10.08	**Repairing pot-holes and making up small depressions using Cationic Bitumen Emulsion** conforming to IS 8887- 1978 with stone metals / chips premixed with emulsion in concrete mixer or any other method approved by the Engineer-in-Charge, including cutting the pot-hole area in regular shapes with vertical edges, thorough cleaning & moistening of surface, applying tack coat, filling up the pot-holes with pre-mixed metals/chips in layer/layers as per specification and direction of the Engineer-in-charge, compacting by power roller, finishing the top of repaired surface levelled with adjoining area including cost and carriage of stone aggregates, blinding material & bitumen emulsion, hire & running charges of rollers and other tools & plants, cost of fuel & lubricants and other incidental charges excluding cost of applying tack coat. [Using stone chips of size 22.4 mm and 11.2 mm in 60: 40 proportion, premixing with bitumen emulsion @ 70.7 kg per m3 of loose net volume of stone chips.]	cum	741.00	758.00	*(The payment is to be made on the basis of loose net volume of stone materials consumed in the work).*
Note:	Add cost of materials and carriages as per requirement vide Table 3.3-1 of Section 3 to get the final consolidated rate.				
10.09	**Mending Potholes and depressions by stitching picked jhama bricks** with one brick-on-edge laid in herring bone pattern and including necessary cushion of sand below the soling (and in between layers) including cutting the pothole area to rectangular shape with vertical edges, removing all loose materials, finishing the surface to match with adjacent areas complete as per direction.				
	(a) One brick-on-edge laid in herring bond pattern on a layer of brick flat (thickness 75 mm. plus 125 mm)	sqm	818.00	1079.00	
	(b) One brick-on-edge laid in herring bond pattern (thickness 125 mm)	sqm	518.00	681.00	
10.10	**Crack Filling**				
	Filling of crack using slow - curing bitumen emulsion and applying crusher dust in case crack are wider than 3mm.	metre	3.10	3.10	
10.11	**Spreading of sand over** the bituminous surface @ 0.003 m^3 per m^2 of surface from the road side stacks and carriage of the same up to a distance of 150 m from stack complete including cost of sand.	100 sqm	173.00	412.00	
10.12	**Maintenance of Drains**				
	The maintenance of drains include erosion, repair, clearing, cleaning, reshaping, regarding, deepening of side drains as well as catch water drains as per technical specification Clause 1907 for Rural Roads of MORD.	metre	2.40	2.40	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
10.13	**I) Maintenance of Culverts**				
	Maintenance of Hume pipe Culvert by way of Clearing, Cleaning, Erosion repair, repairs to cracks, parapet wall and protection work as per drawing and technical specification Clause 1908 for Rural Roads of MORD.	each (1000 mm dia)	1029.00	1029.00	
	II) Maintenance of Culverts Slab type				
	Maintenance of Slab type Culverts by way of clearing, Cleaning, Erosion repair, repairs to cracks, parapet walls and Protection works as per drawing and technical specification Clause 1908 for Rural Roads of MORD.	each (2 m span)	2121.00	2121.00	
10.14	**Maintenance of 200 metre and Km stones**				
	Maintenance of 200 metre km stone by way of refitting of tilted stones repairing with cement mortar, cleaning, repainting and lettering on 200 metre km stone and 5th km stone as per drawing and technical specification Clause 1912 for Rural Roads of MORD.	km	598.00	598.00	
10.15	**Cutting kutcha drain** of 600 mm wide and depth up to 300 mm, including disposal of excavated material in embankment slopes within a lead of 50 m.				
	(a) Through ordinary soil.	metre	14.40	14.40	
	(b) Through Mixed soil.	metre	16.20	16.20	
10.16	**Cutting of branches of trees shrubs and trimming of grass and weeds**				
	i) Cutting of branches of trees and shrubs from the road way or with in R.O.W including disposal of wood and leaves to suitable location as per technical specification Clause 1914 for Rural Roads of MORD.	per tree	95.00	95.00	
	ii) Cutting of shrubs from the road way or with in R.O.W and disposal of shrubs to suitable locations as per technical specifications Clause 1914 for Rural Roads of MORD.	each	5.90	5.90	
	iii) Trimming of grass and weeds from the shoulders/berms and disposing off the same to suitable locations as per technical specifications Clause 1914 for Rural Roads of MORD.	sqm	2.00	2.00	

BRIDGE AND CULVERT WORKS

CHAPTER - 11
PIPE CULVERTS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
11.01	**Excavation for Structures**				
	Earthwork in excavation for foundation of structures upto 3 m depth as per drawing and technical specification Clause 1104 for Rural Roads of MORD including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material.	cum	104.00	104.00	
11.02	**Bedding for Pipe**				
	i) Type A (Concrete Cradle) Bedding				
	Laying concrete cradle bedding with M15 Grade Cement Concrete as per Clause 1105 (i) for Rural Roads of MORD	cum	1563.00	2001.00	
	ii) Type B (First Class) Bedding				
	Laying (First Class) bedding on well compacted sand, moorum or approved granular material as per Clause 1105 (ii) for Rural Roads of MORD	cum	179.00	320.00	
Note:	Type A: Add the cost of cement and coarse aggregates to get the complete rate. Type B: Add the cost of required sand or moorum or granular material as the case may be.				
11.03	**Providing and Laying Reinforced Cement Concrete Pipe NP3 as per design in Single Row**				
	Providing and laying reinforced cement concrete pipe NP3 with spigot socket for culverts on first class bedding of granular material in single row including fixing with cement mortar 1:2 as per Technical Specification Clause 1106 for Rural Roads of MORD.				
	(A) 1800 mm dia	metre	2070.00	2085.00	
	(B) 1400 mm dia	metre	1383.00	1393.00	
	(C) 1200 mm dia	metre	1021.00	1029.00	
	(D) 1000 mm dia	metre	744.00	750.00	
	(E) 900 mm dia	metre	618.00	624.00	
	(F) 600 mm dia	metre	382.00	385.00	
Note:	Add cost and carriage of Pipe to get the final consolidated item rate.				
11.04	**Providing and Laying Reinforced Cement Concrete Pipe NP4 as per design in Single Row**				
	Providing and laying reinforced cement concrete pipe NP4 with spigot socket for culverts on first class bedding of granular material in single row including fixing with cement mortar 1:2 as per Technical Specification Clause 1106 for Rural Roads of MORD.				
	(A) 1800 mm dia	metre	2112.00	2124.00	
	(B) 1400 mm dia	metre	1436.00	1447.00	
	(C) 1200 mm dia	metre	1255.00	1263.00	
	(D) 1000 mm dia	metre	1012.00	1018.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(E) 900 mm dia	metre	848.00	854.00	
	(F) 600 mm dia	metre	432.00	436.00	
Note:	Add cost and carriage of Pipe to get the final consolidated item rate.				
11.05	**Providing and Laying Reinforced Cement Concrete Pipe NP3 as per Design in Double Row**				
	Providing and laying reinforced cement concrete pipe NP3 with spigot socket for culverts on first class bedding of granular material in double row including fixing with cement mortar 1:2 as per Technical Specification Clause 1106 for Rural Roads of MORD.				
	(A) 1800 mm dia	metre	4241.00	4453.00	
	(B) 1400 mm dia	metre	2844.00	3054.00	
	(C) 1200 mm dia	metre	2101.00	2311.00	
	(D) 1000 mm dia	metre	1526.00	1537.00	
	(E) 900 mm dia	metre	1269.00	1281.00	
	(F) 600 mm dia	metre	763.00	769.00	
Note:	Add cost and carriage of Pipe to get the final consolidated item rate.				
11.06	**Providing and Laying Reinforced Cement Concrete Pipe NP4 as per Design in Double Row**				
	Providing and laying reinforced cement concrete pipe NP4 with spigot socket for culverts on first class bedding of granular material in double row including fixing with cement mortar 1:2 as per Technical Specification Clause 1106 for Rural Roads of MORD.				
	(A) 1800 mm dia	metre	4329.00	4361.00	
	(B) 1400 mm dia	metre	2983.00	3007.00	
	(C) 1200 mm dia	metre	2569.00	2586.00	
	(D) 1000 mm dia	metre	2061.00	2073.00	
	(E) 900 mm dia	metre	1730.00	1742.00	
	(F) 600 mm dia	metre	864.00	870.00	
Note:	Add cost and carriage of Pipe to get the final consolidated item rate.				

CHAPTER - 12
FOUNDATIONS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
12.01	**Excavation for Structures** Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, removing, spreading or stacking of spoils within a lead of 150 m. as directed and including trimming the sides of the trenches, leveling, dressing and ramming the bottom, and backfilling with approved material complete as per direction of the Engineer-in-Charge .				
	I. In all sorts of soil excluding marshy soil & rocks (soft or hard) by manual means.				
	a) upto 3 m depth				
	(i) With pumping out water including shoring as required.	cum	124.00	124.00	
	(ii) With pumping out water excluding shoring	cum	123.00	123.00	
	(iii) Without pumping out water but including shoring as required	cum	115.00	115.00	
	(iv) Without pumping out water and shoring	cum	114.00	114.00	
	b) 3 m to 6 m depth				
	(i) With pumping out water including shoring as required.	cum	165.00	165.00	
	(ii) With pumping out water excluding shoring	cum	164.00	164.00	
	(iii) Without pumping out water but including shoring as required	cum	148.00	148.00	
	(iv) Without pumping out water and shoring	cum	146.00	146.00	
	c) Above 6 m depth				
	(i) With pumping out water including shoring as required.	cum	228.00	228.00	
	(ii) With pumping out water excluding shoring	cum	226.00	226.00	
	(iii) Without pumping out water but including shoring as required	cum	197.00	197.00	
	(iv) Without pumping out water and shoring	cum	195.00	195.00	
	II. In all sorts of soil excluding marshy soil & rocks (soft or hard) by mechanical means (using excavator of suitable capacity).				
	(i) Depth upto 3 m				
	(i) With pumping out water.	cum	47.00	49.00	
	(ii) Without pumping out water	cum	46.00	47.00	
	(ii) Depth 3 m to 6 m				
	(i) With pumping out water.	cum	55.00	57.00	
	(ii) Without pumping out water	cum	52.00	54.00	
	(iii) Depth above 6m				
	(i) With pumping out water.	cum	69.00	72.00	
	(ii) Without pumping out water	cum	64.00	67.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	III. In ordinary rock (not requiring blasting)				
	A By Manual Means				
	(i) With pumping out water.	cum	175.00	175.00	
	(ii) Without pumping out water	cum	162.00	162.00	
	B By mechanical means (using excavator of suitable capacity).				
	(i) With pumping out water.	cum	62.00	64.00	
	(ii) Without pumping out water	cum	57.00	59.00	
	IV In Hard rock (requiring blasting) including cost of hire & operational charges of air compressor with necessary accessories and cost of all necessary blasting materials.				
	(i) With pumping out water.	cum	408.00	410.00	
	(ii) Without pumping out water	cum	381.00	383.00	
	V In Hard rock (blasting prohibited)				
	(i) With pumping out water.	cum	441.00	455.00	
	(ii) Without pumping out water	cum	409.00	421.00	
	VI In Marshy soil for depth upto 3 m depth				
	A By Manual means				
	(i) With pumping out water including shoring as required.	cum	579.00	586.00	
	(ii) With pumping out water excluding shoring	cum	540.00	547.00	
	(iii) Without pumping out water but including shoring as required	cum	502.00	509.00	
	(iv) Without pumping out water and shoring	cum	463.00	470.00	
	B By Mechanical Means using excavator of suitable capacity and tipper trucks.				
	(i) With pumping out water including shoring as required.	cum	130.00	132.00	
	(ii) With pumping out water excluding shoring	cum	121.00	124.00	
	(iii) Without pumping out water but including shoring as required	cum	113.00	115.00	
	(iv) Without pumping out water and shoring	cum	105.00	107.00	
12.02	**Earthwork in filling in foundation trenches with good earth** in layers not exceeding 15cm. including watering and ramming layer by layer complete with earth obtained from excavation of foundation or from fresh excavation of land arranged by Department within a lead of 150 m.	cum	92.00	92.00	Applicable for foundation trenches in Rocky & Marshy soil.
12.03	**Earth in filling in foundation trenches and at the back of abutments with good earth (sandy soil)** in layers not exceeding 15 cm. including watering and ramming layer by layer complete with earth obtained by fresh excavation from land arranged by Department beyond 150 m. but within 300 m. including all lifts. Earth to be approved by the Engineer-in-charge.	cum	161.00	161.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
12.04	**Sand filling in foundation trenches and at the back of abutments, wing-walls etc. with good local sand** free from earth in layers not exceeding 15 cm. including inundating each layer by profuse water and poking and ramming layer by layer complete including supply of sand. Quality of sand is to be approved by the Engineer-in-charge.	cum	193.00	343.00	
Note :	1. Labour rate per m^3 is provided; Cost of sand is to be added to arrive at the complete item rate.				
	2. Compaction factor of dry clean sand is 0.835.				
12.05	**Plain / Reinforced Cement Concrete in Open foundation** with or without reinforcements, in any part of foundation of bridges / culverts with graded stone chips of appropriate nominal sizes, including screening and cleaning of coarse aggregates, fine aggregate (sand) conforming to proper grading zone, both of approved quality and cement, as necessary, cost of curing with water, including cost and carriage of all materials and including preparation of design mix, approval of the same by the Engineer-in-Charge, cost for quality control, sampling, testing etc. including cost of formwork but excluding reinforcement complete as per drawing and technical specifications.				
	A PCC Grade M20	cum	2043.00	2539.00	
	B RCC Grade M20				
	I) Using concrete mixer	cum	2042.00	2546.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1777.00	2290.00	
	C PCC Grade M25				
	I) Using concrete mixer	cum	2141.00	2638.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1878.00	2384.00	
	D RCC Grade M25				
	I) Using concrete mixer	cum	2140.00	2646.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1877.00	2391.00	
	E PCC Grade M30				
	I) Using concrete mixer	cum	2140.00	2636.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1877.00	2381.00	
	F RCC Grade M30				
	I) Using concrete mixer	cum	2135.00	2639.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1872.00	2384.00	
	G RCC Grade M35				
	I) Using concrete mixer	cum	2161.00	2666.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1899.00	2413.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
Note:	**(Applicable for all the item in Sl.12.05)**				
	1 Construction Wing will add the cost & carriage of 0.9 cum/m³ coarse aggregates and cement as per requirement vide Table 3.2-1 only to arrive at consolidated rate.				
	2 From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be mentioned in the items as per the direction of the Engineer-in-Charge.				
12.06	**Providing and constructing Temporary Island for construction of Well foundation.**				
	A Construction of **Temporary Island** assuming depth of water 1.0 m and height of island upto 1.25m. by sand / dry soil filled cement / polyethylene bags and removal of the same after main construction activity.				
	i) Area of Island between 100 m² to 120 m²	each	23448.00	24095.00	
	ii) Area of Island between 120 m² to 140 m²	each	27119.00	27902.00	
	iii) Area of Island between 140 m² to 160 m²	each	31049.00	31982.00	
	B Construction of **Temporary Island** by construction of outer annular layer with two rows of bullahs, suitable spaced, of dia. not less than 150 mm, driven at least half of the total length, properly tied, braced and supported and filling the annular space with sand / soil filled bags, protected by drum sheet walling on both side and filling the core portion with locally available materials including the dismantling, removing and cleaning the site of the construction of main component of the structure.				
	i) Area of Island between 100 m² to 120 m²				
	a) Height above bed level upto 2.25 m.	each	271429.00	272941.00	
	b) Height above bed level upto 3.25 m.	each	387866.00	390263.00	
	c) Height above bed level upto 4.25 m.	each	499557.00	501391.00	
	ii) Area of Island between 120 m² to 140 m²				
	a) Height above bed level upto 2.25 m.	each	302368.00	303348.00	
	b) Height above bed level upto 3.25 m.	each	426987.00	428402.00	
	c) Height above bed level upto 4.25 m.	each	551600.00	553449.00	
	iii) Area of Island between 140 m² to 160 m²				
	a) Height above bed level upto 2.25 m.	each	329235.00	330401.00	
	b) Height above bed level upto 3.25 m.	each	464886.00	466569.00	
	c) Height above bed level upto 4.25 m.	each	616441.00	619437.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
12.07	**A. Providing and constructing Service Road** of width 4.0 m to reach island location from one pier location to another pier location with height upto 1 m. by sand / dry soil filled cement / polyethylene bags and removal of the same after main construction activity.	metre	1365.00	1385.00	
	B. Providing and constructing Temporary Service Road of width not less than 3.75 m over river for movement of men, equipment and construction machineries from one pier / abutment location to another pier / abutment location considering necessary stability and safety aspects by providing and driving suitable piles, providing fitting, fixing suitable R.S. Joist, Channels, angles and wooden sleeper as per design requirement including dismantling and taking out the entire service road after construction.				
	i) With Eucalyptus bullah Pile: (Height of deck above bed level upto 2.25m)	metre	5170.00	5223.00	
	ii) With R. S. Joist Pile				
	a) Height of deck above bed level above 2.25 m & upto 3.25 m.	metre	11085.00	-	
	b) Height of deck above bed level above 3.25 m & upto 4.25 m.	metre	11246.00	-	
12.08	**Providing and laying Steel Cutting edge weighing not less than 40 kg per metre for Well foundation** including cost & carriage of all materials complete as per drawing and technical specification and direction of Engineer-in-charge.	kg	13.50	13.50	
Note:	Add cost and carriage of Structural steel in plates, angles, etc. to arrive at complete rate.				
12.09	**Plain / Reinforced Cement Concrete, in Well foundation** with coarse aggregates of appropriate nominal size and grading, fine aggregate (sand) conforming to proper grading zone, both of approved quality, cement and water reducing admixtures, as necessary, including labour, cost and carriage of all materials and including preparation of design mix, approval of the same by the Engineer-in-Charge and cost for quality control, sampling, testing etc. all complete as per drawing and technical specification including the cost of necessary form work and staging complete.				
	A In Well curb				
	(i) RCC M20 Grade				
	I) Using concrete mixer	cum	2763.00	3366.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2458.00	3072.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(ii) RCC M25 Grade				
	I) Using concrete mixer	cum	2946.00	3554.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2640.00	3259.00	
	(iii) RCC M35 Grade				
	I) Using concrete mixer	cum	3043.00	3661.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2739.00	3367.00	
	(iv) RCC M30 Grade				
	I) Using concrete mixer	cum	2957.00	3566.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2651.00	3270.00	
	B In Well steining				
	(i) PCC M20 Grade	cum	2316.00	2847.00	
	(ii) RCC M20 Grade				
	I) Using concrete mixer	cum	2313.00	2854.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2033.00	2583.00	
	(iii) PCC M25 Grade				
	I) Using concrete mixer	cum	2452.00	2986.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2173.00	2717.00	
	(iv) RCC M25 Grade				
	I) Using concrete mixer	cum	2451.00	2996.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2171.00	2725.00	
	(v) PCC M30 Grade				
	I) Using concrete mixer	cum	2466.00	3001.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2187.00	2731.00	
	(vi) RCC M30 Grade				
	I) Using concrete mixer	cum	2459.00	3005.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2179.00	2733.00	
	(vii) RCC M35 Grade				
	I) Using concrete mixer	cum	2524.00	3076.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2246.00	2806.00	
	(viii) RCC M40 Grade (With Batching Plant, Transit Mixer and Concrete Pump)	cum	2376.00	2937.00	
	C In Bottom Plug				
	(i) PCC Grade M20				
	I) Using concrete mixer	cum	2377.00	2886.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1923.00	2441.00	
	(ii) PCC Grade M25				
	I) Using concrete mixer	cum	2450.00	2961.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1995.00	2515.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate(₹)	Remarks
	(iii) PCC Grade M30				
	I) Using concrete mixer	cum	2462.00	2974.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	2008.00	2529.00	
	(iv) PCC Grade M35				
	I) Using concrete mixer	cum	2515.00	3031.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	2060.00	2585.00	
	D In Intermediate plug				
	(i) PCC Grade M20				
	I) Using concrete mixer	cum	2151.00	2631.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1719.00	2207.00	
	(ii) PCC Grade M25				
	I) Using concrete mixer	cum	2212.00	2693.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1779.00	2269.00	
	(iii) PCC Grade M30				
	I) Using concrete mixer	cum	2221.00	2703.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1790.00	2280.00	
	E In Top plug				
	(i) PCC Grade M20				
	Using Concrete Mixer	cum	2151.00	2631.00	
	(ii) PCC Grade M25				
	I) Using concrete mixer	cum	2212.00	2693.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1779.00	2269.00	
	(iii) PCC Grade M30				
	I) Using concrete mixer	cum	2221.00	2703.00	
	II) With Batching Plant, Transit Mixer and Crane / Concrete Pump	cum	1790.00	2280.00	
	F In Well cap				
	(i) RCC Grade M20				
	I) Using concrete mixer	cum	2030.00	2533.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1765.00	2277.00	
	(ii) RCC Grade M25				
	I) Using concrete mixer	cum	2140.00	2646.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1877.00	2391.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iii) RCC Grade M30				
	I) Using concrete mixer	cum	2135.00	2639.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1872.00	2384.00	
	(iv) RCC Grade M35				
	I) Using concrete mixer	cum	2161.00	2666.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	1899.00	2413.00	
	(v) RCC M40 Grade (With Batching Plant, Transit Mixer and Concrete Pump)	cum	2029.00	2543.00	
Note:	**(Applicable for all the items in Sl.12.09.)**				
	1 Construction Wing will add the cost & carriage of 0.9 cum/m³ coarse aggregates and cement as per requirement vide Table 3.2-1 only to arrive at consolidated rate.				
	2 From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be 400 kg/cu.m. and 0.4 respectively.				
12.10	**Sinking of Well** as per IRC specification through all types of strata namely sandy soil, clayey soil and rock as shown against each case, including drawing Foundation Wells true to position and plumb with dia under cutting edge as mentioned below, including hire charges of all tools and plants etc. and supplying power, dewatering etc, initial excavation of earth complete as per drawing and technical specifications and direction of the Engineer-in-charge including throwing the spoils clear off the well up to 150m. radius (Measurement to be taken in the following stages from the level of the bottom of capping slab on well up to the bottom of cutting edge) through any kind of soil including rocky soil and rock till 25% of cutting edge (linear) comes in contact with rock including testing of bottom plug by dewatering the well upto 5 meters and checking the rise in water level as per clause 1208 of IRC Specification. Depth of sinking is reckoned from bed level.				
	I. Sinking of 7 m external diameter Well				
	A. In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	10237.00	10673.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	11997.00	12507.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	14822.00	15467.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (7m dia well)				
	Depth in soft rock strata upto 3m	metre	18952.00	19614.00	
	C. In Hard Rock (7m dia well)				
	Depth in hard rock strata upto 3m	metre	25227.00	25934.00	
	II. Sinking of 8 m external diameter Well				
	A. In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	12530.00	13065.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	14167.00	14772.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	15806.00	16482.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (8m dia well)				
	Depth in soft rock strata upto 3m	metre	20998.00	21719.00	
	C. In Hard Rock (8m dia well)				
	Depth in hard rock strata upto 3m	metre	25615.00	26322.00	
	III. Sinking of 9 m external diameter Well				
	A. In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	11825.00	12317.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	14621.00	15239.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	17190.00	17927.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour). metre	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (9 m dia well)				
	Depth in soft rock strata upto 3m	metre	26768.00	27717.00	
	C. In Hard Rock (9m dia well)				
	Depth in hard rock strata upto 3m	metre	29591.00	30422.00	
	IV. Sinking of 10 m external diameter Well				
	A. In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	13094.00	13656.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	15403.00	16064.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	18601.00	19394.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (10m dia well)				
	Depth of soft rock strata upto 3m	metre	27356.00	28330.00	
	C. In Hard Rock (10m dia well)				
	Depth in hard rock strata upto 3m	metre	34962.00	36065.00	
	V. Sinking of 11 m external diameter Well				
	A In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	28923.00	30161.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	29339.00	30547.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	32286.00	33551.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (11m dia well)				
	Depth of soft rock strata upto 3m	metre	61487.00	63690.00	
	C. In Hard Rock (11m dia well)				
	Depth in hard rock strata upto 3m	metre	79393.00	81897.00	
	VI. Sinking of 12 m external diameter well				
	A In any kind of soil including Clayey soil				
	(i) Depth upto 3.0 M	metre	63768.00	66468.00	
	(ii) Depth beyond 3.0 m upto 6.0 m	metre	79125.00	82476.00	
	(iii) Depth beyond 6.0 m upto 10.0 m	metre	91312.00	95244.00	
	(iv) Depth beyond 10.0 m upto 20.0 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m :				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B. In Soft Rock (12m dia well)				
	Depth of soft rock strata upto 3m	metre	146255.00	151639.00	
	C. In Hard Rock (12m dia well)				
	Depth in hard rock strata upto 3m	metre	183117.00	189550.00	
12.11	**Sinking of Twin D Type well t**hrough all types of strata namely sandy soil, clayey soil and rock as shown against each case complete as per drawing and technical specifications. Depth of sinking is reckoned from bed level.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	A. In any kind of soil including Clayey soil (8m dia. Well)				
	(i) Depth below bed level upto 3.0 M	metre	15333.00	15994.00	
	(ii) Depth beyond 3.0 m upto 6.0 m depth	metre	17804.00	18571.00	
	(iii) Depth beyond 6.0 m upto 10.0 m depth	metre	19834.00	20689.00	
	(iv) Depth beyond 10 m upto 20 m :				
	Add 5% for every additional meter depth of sinking over the rate of sinking for the previous meter.	metre			
	(v) Depth beyond 20.0 m upto 30.0 m				
	a) Add 7.5% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 25% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	(vi) Depth beyond 30.0 m :				
	a) Add 10% for every additional meter depth of sinking over the rate of sinking for the previous meter	metre			
	b) Add 20% of cost for Kentledge including supports, loading arrangement and Labour).	metre			
	B In Soft Rock (Twin D Type well)				
	Depth of soft rock strata upto 3m	metre	31600.00	32792.00	
12.12	**Sand filling in Wells** in layers duly compacted by inundation with water including local carriages etc. complete as per drawing and technical specifications.	cum	170.00	343.00	
Note:	1. Labour rate per m^3 is provided; cost of sand is to be added to arrive at the complete item rate. 2. Compaction factor of dry clean sand is 0.835.				
12.13	**Providing Steel liner** for Curbs and 6 mm thick for Steining of Wells including fabricating and setting out as per detailed drawing.	tonne	9980.00	9980.00	
Note:	Add cost & carriage of materials only to arrive at the consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
12.14	**Providing Bored Cast-in-situ R.C.C. pile** in position as per specifications in all kinds of soil including cost of boring using drilling mud to stabilize the bore and flushing the bore of excess mud with freshly prepared drilling fluid by using pumps prior to placing concrete by tremie pipe in one continuous operation and including the cost of all materials and labour for placing of concrete and also including the cost of mobilization and hire charges of all equipment necessary for boring, welding of reinforcement cage as necessary and lowering of reinforcement cage, preparation and placing of concrete, including the cost of including the cost of concrete but excluding the cost of reinforcement and labour for bending binding etc. complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m. Work to be executed as per IS: 2911 (Part II Sec 2).				
	(a) Using hydraulic piling rig				
	i) Pile diameter - 750 mm.	metre	2700.00	-	
	ii) Pile diameter - 800 mm.	metre	2921.00	-	
	iii) Pile diameter - 900 mm.	metre	3489.00	-	
	iv) Pile diameter - 1000 mm.	metre	4278.00	-	
	v) Pile diameter - 1200 mm.	metre	5002.00	-	
	vi) Pile diameter - 1500 mm.	metre	5458.00	-	
	vii) Pile diameter - 1800 mm.	metre	5949.00		
	(b) Using tripod, winches				
	i) Pile diameter - 750 mm.	metre	1366.00	-	
	ii) Pile diameter - 800 mm.	metre	1409.00	-	
	iii) Pile diameter - 900 mm.	metre	1521.00	-	
	iv) Pile diameter - 1000 mm.	metre	1667.00	-	
	v) Pile diameter - 1200 mm.	metre	1943.00	-	
	vi) Pile diameter - 1500 mm.	metre	2409.00	-	
Note:	1. The rate provided is exclusive of cost of concrete. Construction wing is to add cost of concrete of desired grade for volume corresponding to 1.0m length of pile length, to arrive at the complete rate. Also the desired crushing strength is to be mentioned. The Rate of providing the temporary steel casing upto 3m depth is included.				
	2. Rate for concrete may be adopted same as for bottom plug vide item no. 12.09(C) (IV).				
	3. The rate is inclusive of cost of concrete for the length of pile above cut off level (dummy length) and cost of dismantling the same.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
12.15	**Driven Cast-in-place vertical R.C.C. pile** of required diameter and required length (length to be measured from the bottom of raft / Pile Cap to the bottom of shoe) including cost of all materials and labour for casting, hoisting, driving etc. and also including cost of dummy lengths of pile and of hire charges of all instruments as necessary but excluding reinforcement complete as per drawing and & Technical Specification.				
	(i) Pile diameter - 750 mm.	metre	1294.00	1338.00	
	(ii) Pile diameter - 1000 mm.	metre	1743.00	1803.00	
	(iii) Pile diameter - 1200 mm.	metre	2612.00	2701.00	
Note:	1. The rate provided is exclusive of cost of concrete. Construction wing is to add cost of concrete of desired grade for volume corresponding to 1.0m length of pile length, to arrive at the complete rate. Also the desired crushing strength is to be mentioned in the space provided in the description of item.				
	2. Rate for concrete may be adopted same as for bottom plug vide item no. 12.09 (C) (iv).				
	3. The quantity of concrete required to be removed above the designed top level of the concrete, if any, is to be added in the rate analysis.				
	4. The cost of dismantling the length of the pile above cut off level is to be added.				
	5. In case steel lining is included in the design for driven cast in situ pile and is planned to be retained, the same is to be included in the rate analysis. In case the temporary steel casing used during casting is planned to be removed an additional cost of 0.5% of the cost of concrete is to be provided to cover in usage.				
12.16	**Driven Precast vertical R.C.C. piles** of required diameter and required length (length to be measured from the bottom of raft / Pile Cap to the bottom of shoe) including cost of all materials and labour for casting, hoisting, driving etc. and also including cost of dummy lengths of pile and of hire charges of all instruments as necessary but excluding reinforcement complete as per drawing and & Technical Specification.				
	(i) Pile Diameter - 500 mm	metre	555.00	565.00	
	(ii) Pile Diameter - 750 mm.	metre	610.00	626.00	
	(iii) Pile Diameter - 1000 mm.	metre	786.00	809.00	
Note:	1. The rate provided is exclusive of cost of concrete. Construction wing is to add cost of concrete of desired grade for volume corresponding to 1.0m length of pile length, to arrive at the complete rate. Also the desired crushing strength is to be mentioned in the space provided in the description of item.				
	2. Rate for concrete may be adopted same as for bottom plug vide item no. 12.09 (C) (iv).				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
	3. The cost of dismantling the length of the pile above cut off level is to be added.				
12.17	**Driven vertical Steel piles** of required diameter and required length (length to be measured from the bottom of raft / Pile Cap to the bottom of shoe) including cost of all materials and labour for casting, hoisting, driving etc. and also including cost of dummy lengths of pile and of hire charges of all instruments as necessary but excluding reinforcement complete as per drawing and & Technical Specification.				
	(i) Section of the pile - H Section steel column 400 x 250 mm (ISHB Series)	metre	155.00	162.00	
	(ii) Section of the pile - H Section steel column 450 x 250 mm (ISHB Series)	metre	183.00	191.00	
Note	Add cost of structural steel only to arrive at complete rate.				
12.18	**Performing Lateral load test** on two piles or two groups of piles by introducing a hydraulic jack with gauge between two piles or pile groups under test by applying horizontal loads in increments of about 20% of the estimated safe load at each stage and applying the next increment after the rate of displacement is nearer to 0.1 mm. per 30 minutes till the total displacement becomes, 12 mm at the cut-off level including the cost of arranging the entire set-up, hire charges of all implements including at least two dial gauges, preparing the pile head if necessary, and removal of all arrangement after completion etc. complete in all respect including cost of carriage of all materials and as per IS specification and direction of Engineer-in-charge.	Each	27400.00	27400.00	
12.19	**Performing Vertical load test on single Pile** in accordance with IS:2911(Part-IV) by hydraulic jacks on pile/piles with 1.5 times the design load including preparation of the head of piles with concrete of required strength for receiving the jacks with all ancillary arrangements for setting up gauges, construction of suitable platforms, keeping the loads and dismantling and removing all arrangement etc. complete as per IS specification and direction of Engineer-in-charge				***N.B.*** *This item is applicable for both work pile and test pile. Test should be carried out as per IS 2911 part IV 1985.*
	i) Testing load up to 100 T.	Each	47500.00	47500.00	
	ii) Testing load between 100 T and 150 T.	Each	67200.00	67200.00	
	iii) Testing load between 150 T and 200 T.	Each	89600.00	89600.00	
	iv) Testing load between 200 T and 250 T.	Each	112000.00	112000.00	
	v) Testing load between 250 T and 300 T.	Each	134400.00	134400.00	
Note :	This test shall be done on working piles only in a pile group and should satisfy the provisions of routine test as given in IS-2911 (Part-4) 1985.				
12.20	**Cement Concrete for Reinforced Concrete in Pile Cap** complete as per drawing and Technical Specification.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
	A RCC Grade M20				
	i) Using Concrete Mixer	cum	2052.00	2556.00	
	(ii) Using Batching Plant, Transit Mixer and Concrete Pump	cum	1803.00	2315.00	
	B RCC Grade M25				
	(i) Using Concrete Mixer	cum	2167.00	2674.00	
	(ii) Using Batching Plant, Transit Mixer and Concrete Pump	cum	1923.00	2438.00	
	C RCC Grade M30				
	(i) Using Concrete Mixer	cum	2182.00	2689.00	
	(ii) Using Batching Plant, Transit Mixer and Concrete Pump	cum	1933.00	2449.00	
	D RCC Grade M35				
	(i) Using Concrete Mixer	cum	2235.00	2747.00	
	(ii) Using Batching Plant, Transit Mixer and Concrete Pump	cum	1990.00	2512.00	
Note:	**(Applicable for all the item in Sl.12.20)**				
	1. Construction wing is to add cost of cement, sand and cost & carriage of coarse aggregates as per requirement vide Table 3.2-1 of Section only to arrive at consolidated rate.				
	2. While actually providing the item in estimate or agreement of work, maximum nominal size of coarse aggregates intended to be used should be selected and mentioned in the item.				
	3. From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be as per the direction of the Engineer-in-Charge.				
12.21	**Supplying, fitting and placing un-coated HYSD bar reinforcement in Bridge Foundation** including initial straightening, straightening of coils bars, removal of loose rust (if any), cutting to requisite length bending, binding with annealed wire not less than 1 mm in size and conforming to IS 280 at every intersection hooked and bent to correct shape and placed on forms etc. including cost of black annealed wire and cost of loading, unloading, carriage of all steel materials complete as per drawing and technical specifications and direction of Engineer-in-charge.	tonne	3175.00	3175.00	
Note:	The rate provided is exclusive of cost of steel materials. Construction wing should add cost & carriage of 1.05 MT (considering 5% wastage) of steel materials to arrive at the final consolidated item rate.				
12.22	**Providing MS casing pipe** around RCC cast-in-situ bored piles of different diameters in position including cost of all materials, fabrication, handling etc. complete as per direction of Engineer-in-Charge.	MT	13395.00	-	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division	Darjeeling Hill Area	Remarks
Note:	The rate provided is exclusive of cost of steel materials. Construction wing should add cost of 1.02 MT (considering 2% wastage) of steel materials to arrive at the final consolidated item rate.				
12.23	**Cost of boring** using drilling mud to stabilized the bore and flushing the bore of excess mud with fresh drilling fluid for the portion of the pile **above cutoff level and up to the level of island** for providing RCC cast in situ bored pile in position including the cost of mobilization and hire charges of all equipment necessary for boring.				
(a)	**Using hydraulic piling rig** with power unit and complete accessories including cost of shifting of machinery from one bore location to other, removal of excavated earth with all lifts and lead up to 1 km by tipper trucks:				
	i) 750 mm. diameter pile.	metre	2549.00	-	
	ii) 800 mm. diameter pile.	metre	2737.00	-	
	iii) 900 mm. diameter pile.	metre	3217.00	-	
	iv) 1000 mm. diameter pile.	metre	3873.00	-	
	v) 1200 mm. diameter pile.	metre	4352.00	-	
	vi) 1500 mm. diameter pile.	metre	4439.00	-	
(b)	**Using tripod**, **winches** and other accessories including shifting of all machinery from one bore location to another and removal of excavated earth with all lifts and lead upto 150 m.				
	i) 750 mm. diameter pile.	metre	1080.00	-	
	ii) 800 mm. diameter pile.	metre	1084.00	-	
	iii) 900 mm. diameter pile.	metre	1108.00	-	
	iv) 1000 mm. diameter pile.	metre	1159.00	-	
	v) 1200 mm. diameter pile.	metre	1210.00	-	
	vi) 1500 mm. diameter pile.	metre	1261.00	-	
12.24	**Integrity testing of Pile** using Low Strain / Sonic Integrity Test / Sonic Echo Test method in accordance with IS 14893 including surface preparation of pile top by removing soil, mud, dust & chipping lean concrete lumps etc. and use of computerized equipment and high skill trained personal for conducting the test & submission of results, all complete as per direction of Engineer-in-charge.				
	a) Within 50 km. radius from Raj-Bhavan	Each	696.50	-	
	b) For Rest of South Zone & West Zone	Each	870.60	-	
	c) North Zone	Each	1160.80	1160.80	
Note:	The inclusion of the above item in the schedule of work shall be judiciously decided by the technical sanctioning authority, keeping in view the quality control, type of soil strata & importance of the project.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
12.25	**Performing High Strain Dynamic Pile Load testing** by using Pile Driving Analyzer as per IRC: 78-2014 standard procedure with a hammer of suitable weight (1-2% of the test load or 5-7% of the dead load on the pile or suitable energy as decided by Engineer-in charge). The rate is inclusive of construction of suitable platform, fixing of strain sensor & accelerometer, charges for hammer hoisting arrangement & removing etc. The rate is also inclusive of cost & carriage of all materials, completion of field test, CAPWAP analysis & submission of test results along with reports as per direction of Engineer-in-charge.				
	a) For Test load 0 to 100 MT				
	(i) Within 60 km from Rajbhaban	Each	66662.00	-	
	(ii) From 60-150 Km of Rajbhaban	Each	79305.00	-	
	(iii) Rest of South Bengal	Each	94247.00	-	
	(iv) For North Bengal	Each	108384.00	108384.00	
	b) For Test load 101 to 300 MT				
	(i) Within 60 km from Rajbhaban	Each	102292.00	-	
	(ii) From 60-150 Km of Rajbhaban	Each	118383.00	-	
	(iii) Rest of South Bengal	Each	140221.00	-	
	(iv) For North Bengal	Each	1161254.00	1161254.00	
	c) For Test load 301 to 500 MT				
	(i) Within 60 km from Rajbhaban	Each	126429.00	-	
	(ii) From 60-150 Km of Rajbhaban	Each	150565.00	-	
	(iii) Rest of South Bengal	Each	172977.00	-	
	(iv) For North Bengal	Each	198924.00	198924.00	

CHAPTER - 13
SUB-STRUCTURE

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
13.01	**Plain / Reinforced Cement Concrete in Sub-structure** with coarse aggregates of appropriate nominal size and grading, fine aggregate (sand) conforming to proper grading zone, both of approved quality, cement and water reducing admixtures, as necessary, including labour, cost and carriage of all materials and including preparation of design mix, approval of the same by the Engineer-in-Charge and cost for quality control, sampling, testing etc. all complete as per drawing and technical specification including the cost of necessary form work and staging complete as per drawing and technical specifications.				
	A PCC Grade M20				
	(i) Height upto 5m	cum	2316.00	2847.00	
	B PCC Grade M25				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2452.00	2986.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2173.00	2717.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2650.00	3208.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2361.00	2930.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2897.00	3486.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2596.00	3195.00	
	C PCC Grade M30				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2466.00	3001.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2187.00	2731.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2665.00	3226.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2376.00	2945.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2915.00	3506.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2613.00	3213.00	
	D RCC Grade M20				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2313.00	2854.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2033.00	2583.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2493.00	3059.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2203.00	2779.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2718.00	3315.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2415.00	3023.00	
	E RCC Grade M25				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2451.00	2996.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2171.00	2725.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2629.00	3197.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2340.00	2918.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2896.00	3498.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2593.00	3206.00	
	F RCC Grade M30				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2459.00	3005.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2179.00	2733.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2613.00	3179.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2326.00	2900.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2832.00	3426.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2533.00	3136.00	
	G RCC Grade M35				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2524.00	3076.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2246.00	2806.00	
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2649.00	3217.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2364.00	2941.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	2835.00	3427.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2542.00	3143.00	
	H RCC Grade M40				
	(i) Height upto 5m				
	I) Using concrete Mixer	cum	2728.00	3281.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2395.00	2956.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(ii) Height 5m to 10m				
	I) Using concrete Mixer	cum	2858.00	3426.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2518.00	3095.00	
	(iii) Height above 10m				
	I) Using concrete Mixer	cum	3054.00	3645.00	
	II) With Batching Plant, Transit Mixer and Concrete Pump	cum	2702.00	3303.00	
Note:	**(Applicable for all the item in Sl.13.01)**				
	1 Construction Wing will add the cost & carriage of 0.9 cum/m³ coarse aggregates and cement as per requirement vide Table 3.2-1 only to arrive at consolidated rate.				
	2 From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be as per the direction of the Engineer-in-Charge				
13.02	**Supplying, fitting and placing HYSD bar reinforcement in Sub-structure** including initial straightening, straightening of coils bars, removal of loose rust (if any), cutting to requisite length bending, binding with annealed wire not less than 1 mm in size and conforming to IS 280 at every intersection hooked and bent to correct shape and placed on forms etc. including cost of black annealed wire and cost of loading, unloading, carriage of all steel materials complete as per drawing and technical specifications and direction of Engineer-in-charge.	tonne	3308.00	3308.00	
Note:	The rate provided is exclusive of cost of steel materials. Construction wing should add cost & carriage of 1.05 MT (considering 5% wastage) of steel materials to arrive at the final consolidated item rate.				
13.03	**Providing weep holes** in Brick masonry / Plain / Reinforced concrete abutment, wing wall / return wall with 100 mm dia AC pipe, extending through the full width of the structure with slope of 1V:20H towards drawing face. Complete as per drawing and Technical specifications.	each	115.00	117.00	
13.04	**Back filling behind abutment, wing wall and return wall** complete as per drawing and Technical specification.				
	A) Granular material	cum	503.00	813.00	
Note:	Add cost at site of 1.20 m³ of granular materials (brick bats and fine sand in proportion of 60:40) to arrive at the consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	B) Sandy material	cum	423.00	666.00	
Note:	Add cost at site of 1.20 m³ of fine sand (dry loose volume) to arrive at the complete rate.				
13.05	**Providing and laying of Filter media** with granular materials/stone crushed aggregates/brick aggregates /river bed materials satisfying the requirements laid down in clause 2504.2.2 of MoRT&H Specifications to a thickness of not less than 600 mm with smaller size towards the soil and bigger size towards the wall and provided over the entire surface behind abutment, wing wall and return wall to the full height compacted to a firm condition complete as per drawing and technical specification.	cum	575.00	492.00	
Note:	Add cost at site of 0.72 m^3 of granular materials/stone crushed aggregates/brick aggregates/river bed materials and 0.48 m^3 of coarse sand (dry loose volume) to arrive at the consolidated rate.				
13.06	**Supplying, fitting and fixing in position true to line and level cast steel Rocker bearing** conforming to IRC: 83(Pt.-1) section IX and clause 2003 of MoRT&H specifications complete including all accessories as per drawing and Technical Specifications.	kg	212.00	212.00	
13.07	**Supplying, fitting and fixing in position true to line and level forged steel Roller bearing** conforming to IRC: 83(Pt.-1) section IX and clause 2003 of MoRT&H specifications complete including all accessories as per drawing and Technical Specifications.	kg	190.00	190.00	
13.08	**Supplying, fitting and fixing in position true to line and level Sliding Plate bearing with PTFE surface sliding** on stainless steel complete including all accessories as per drawing and Technical Specifications and BS: 5400, section 9.1 & 9.2 (for PTFE) and clause 2004 of MoRT&H Specifications.	kg	322.00	322.00	
13.09	**Supplying, fitting and fixing in position true to line and level Elastomeric bearing** conforming to IRC: 83 (Part-II) Section IX and Clause 2005 of MoRT&H specifications complete including all accessories as per drawing and Technical Specifications.	Cu.cm	1.00	1.00	
13.10	**Supplying, fitting and fixing in position true to line and level Sliding Plate bearing with Stainless steel Plate sliding** on stainless steel plate with mild steel matrix complete including all accessories as per drawing and Technical Specifications.	kg	280.00	280.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
13.11	**Supplying, fitting and fixing in position true to line and level POT-PTFE bearing** consisting of a metal piston supported by a disc or unreinforced elastomer confined within a metal cylinder, sealing rings, dust seals, PTFE surface sliding against stainless steel mating surface, complete assembly to be of cast steel/fabricated structural steel, metal and elastomer elements to be as per IRC: 83 part-I & II respectively and other parts conforming to BS: 5400, section 9.1 & 9.2 and clause 2006 of MoRT&H Specifications complete as per drawing and approved technical specifications.				
	a) For max. Horizontal force within 10% of the max. Vertical load.	Per tonne of vertical load	254.00	254.00	
	b) For max. Horizontal force within 25% of the max. Vertical load.	Per tonne of vertical load	339.00	339.00	
13.12	Supplying fitting and fixing in position true to line and level **cast steel spherical / cylindrical type bearing** with stainless steel plate **with PTFE slidingsurface** as per clause 2004 of Specification of Roads and bridge works of MORT&H complete with all accessories as per drawing and direction of E-in-C and including cost of all material installation and testing.				
	a) For max. Horizontal force within 10% of the max. Vertical load.	Per tonne of vertical load	339.00	339.00	
	b) For max. Horizontal force within 25% of the max. Vertical load.	Per tonne of vertical load	424.00	424.00	

CHAPTER - 14
SUPER-STRUCTURE

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.01	**Furnishing and Placing Reinforced / Pre-stressed Cement concrete in Super-structure** with coarse aggregates of appropriate nominal size and grading, fine aggregate (sand) conforming to proper grading zone, both of approved quality and cement and admixtures, as necessary, including labour, cost and carriage of all materials and including preparation of design mix, approval of the same by the Engineer-in-Charge and cost for quality control, sampling, testing etc. all complete as per drawing and technical specification including the cost of necessary form work and staging complete. as per drawing and technical specifications.				
Note:	1 Construction Wing is to add cost of cement and cost& carriage of coarse aggregates as per requirement vide Table 3.2-1 only to arrive at consolidated rate.				
	2 From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be as per the direction of the Engineer-in-Charge				
	A RCC Grade M20				
	I. Using Concrete Mixer				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2743.00	3346.00	
	b) Height 5m to 10m	cum	2966.00	3600.00	
	c) Height above 10m	cum	3188.00	3854.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	2966.00	3600.00	
	b) Height 5m to 10m	cum	3188.00	3854.00	
	c) Height above 10m	cum	3411.00	4108.00	
	II. Using Batching Plant, Transit Mixer and Concrete Pump				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2437.00	3050.00	
	b) Height 5m to 10m	cum	2647.00	3292.00	
	c) Height above 10m	cum	2857.00	3533.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	2647.00	3292.00	
	b) Height 5m to 10m	cum	2857.00	3533 .00	
	c) Height above 10m	cum	3067.00	3775.00	
	B RCC Grade M25				
	I. Using Concrete Mixer				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2932.00	3540.00	
	b) Height 5m to 10m	cum	3177.00	3818.00	
	c) Height above 10m	cum	3423.00	4096.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	3177.00	3818.00	
	b) Height 5m to 10m	cum	3423.00	4096.00	
	c) Height above 10m	cum	3669.00	4374.00	
	II. Using Batching Plant, Transit Mixer and Concrete Pump				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2630.00	3250.00	
	b) Height 5m to 10m	cum	2863.00	3516.00	
	c) Height above 10m	cum	3097.00	3782.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	2863.00	3516.00	
	b) Height 5m to 10m	cum	3097.00	3782.00	
	c) Height above 10m	cum	3330.00	4047.00	
	C RCC Grade M 30				
	I. Using Concrete Mixer				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2982.00	3591.00	
	b) Height 5m to 10m	cum	3231.00	3873.00	
	c) Height above 10m	cum	3481.00	4155.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	3231.00	3873.00	
	b) Height 5m to 10m	cum	3481.00	4155.00	
	c) Height above 10m	cum	3731.00	4436.00	
	II. Using Batching Plant, Transit Mixer and Concrete Pump.				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2660.00	3284.00	
	b) Height 5m to 10m	cum	2896.00	3553.00	
	c) Height above 10m	cum	3133.00	3822.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	2896.00	3553.00	
	b) Height 5m to 10m	cum	3133.00	3822.00	
	c) Height above 10m	cum	3369.00	4091.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	D RCC / PSC Grade M35				
	I. Using concrete mixer.				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2965.00	3569.00	
	b) Height 5m to 10m	cum	3225.00	3863.00	
	c) Height above 10m	cum	3486.00	4156.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	3225.00	3863.00	
	b) Height 5m to 10m	cum	3486.00	4156.00	
	c) Height above 10m	cum	3746.00	4449.00	
	(iii) For box girder and balanced cantilever,				
	a) Height upto 5m	cum	4007.00	4743.00	
	b) Height 5m to 10m	cum	4528.00	5330.00	
	c) Height above 10m	cum	5049.00	5917.00	
	II. Using Batching Plant, Transit Mixer and Concrete Pump				
	(i) For solid slab super-structure,				
	a) Height upto 5m	cum	2643.00	3257.00	
	b) Height 5m to 10m	cum	2890.00	3537.00	
	c) Height above 10m	cum	3137.00	3817.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	2890.00	3537.00	
	b) Height 5m to 10m	cum	3137.00	3817.00	
	c) Height above 10m	cum	3384.00	4097.00	
	(iii) For box girder and balanced cantilever,				
	a) Height upto 5m	cum	3630.00	4378.00	
	b) Height 5m to 10m	cum	4124.00	4938.00	
	c) Height above 10m	cum	4618.00	5498.00	
	E RCC/PSC Grade M-40				
	I. Using concrete mixer.				
	(i) For solid slab super-structure.				
	a) Height upto 5m	cum	3310.00	3928.00	
	b) Height 5m to 10m	cum	3582.00	4234.00	
	c) Height above 10m	cum	3855.00	4539.00	
	(ii) For T-beam & slab,				
	a) Height upto 5m	cum	3582.00	4234.00	
	b) Height 5m to 10m	cum	3855.00	4539.00	
	c) Height above 10m	cum	4128.00	4845.00	
	II. Using Batching Plant, Transit Mixer and Concrete Pump.				
	(i) For solid slab/voided slab super-structure,				
	a) Height upto 5m	cum	2843.00	3457.00	
	b) Height 5m to 10m	cum	3100.00	3748.00	
	c) Height above 10m	cum	3358.00	4039.00	
	(ii) For I-beam & slab including launching of precast girders by launching truss upto 40 m span.				*These rates are also applicable in case of casting on staging at site.*
	a) Height upto 5m	cum	3100.00	3748.00	
	b) Height 5m to 10m	cum	3358.00	4039.00	
	c) Height above 10m	cum	3616.00	4330.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iii) For cast-in-situ box girder, segmental construction and balanced cantilever.				
	a) Height upto 5m	cum	3873.00	4621.00	
	b) Height 5m to 10m	cum	4388.00	5203.00	
	c) Height above 10m	cum	4903.00	5785.00	
	F PSC Grade M-45				
	(i) For solid slab/voided slab super-structure				
	a) Height upto 5m	cum	2818.00	3423.00	
	b) Height 5m to 10m	cum	3089.00	3727.00	
	c) Height above 10m	cum	3360.00	4032.00	
	(ii) For I-beam & slab including launching of precast girders by launching truss upto 40 m span				These rates are also applicable in case of casting on staging at site.
	a) Height upto 5m	cum	3089.00	3727.00	
	b) Height 5m to 10m	cum	3360.00	4032.00	
	c) Height above 10m	cum	3630.00	4336.00	
	(iii) For cast-in-situ box girder, segmental construction and balanced cantilever				
	a) Height upto 5m	cum	3901.00	4641.00	
	b) Height 5m to 10m	cum	4442.00	5250.00	
	c) Height above 10m	cum	4984.00	5859.00	
	G PSC Grade M-50				
	(i) For cast-in-situ box girder, segmental construction and balanced cantilever				
	a) Height upto 5m	cum	3970.00	4707.00	
	b) Height 5m to 10m	cum	4532.00	5337.00	
	c) Height above 10m	cum	5095.00	5968.00	
	H PSC Grade M- 55				
	(i) For cast-in-situ box girder, segmental construction and balanced cantilever				
	a) Height upto 5m	cum	4163.00	4905.00	
	b) Height 5m to 10m	cum	4758.00	5570.00	
	c) Height above 10m	cum	5353.00	6235.00	
Note:	**(Applicable for all the item in Sl.14.01)**				
	1 Construction wing is to add cost and carriage of cement and coarse aggregates as per requirement vide Table 3.2-1 of Section 3 to arrive at consolidated rate.				
	2 From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be as per the direction of the Engineer-in-Charge				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate(₹)	Remarks
14.02	Providing **Sal-bullah / Eucalyptus bullah piles** of diameter not less than 150mm, driving upto desired depth but not less than 4 m and spacing as per approved design and joining each bullah piles with the staging props by proper arrangement capable to transmit the loads from superstructure, all complete.	sqm	2000.00	2000.00	
Note:	1. Diameter of bullah to be measured at 1.5 m from thicker end.				
	2. Projected area of the deck on river bed should be considered for arriving at the cost.				
14.03	**Supplying, fitting and placing HYSD bar reinforcement in Bridge Super-structure** including initial straightening, straightening of coils bars, removal of loose rust (if any), cutting to requisite length bending, binding with annealed wire not less than 1 mm in size and conforming to IS 280 at every intersection hooked and bent to correct shape and placed on forms etc. including cost of black annealed wire and cost of loading, unloading, carriage of all steel materials complete as per drawing and technical specifications.	tonne	4226.00	4226.00	
Note:	The rate provided is exclusive of cost of steel materials. Construction wing should add cost & carriage of 1.05 MT (considering 5% wastage) of steel materials to arrive at the final consolidated item rate.				
14.04	**Supplying & laying High Tensile Steel wires / Strands** including all accessories for stressing, stressing operations and grouting complete as per drawing and Technical Specifications.	tonne	38980.00	39320.00	
Note:	The rate provided is exclusive of cost of steel materials. Construction wing should add cost & carriage of 1.02MT (considering 2% wastage) of steel materials to arrive at the final consolidated item rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.05	**a) Supplying transporting & fabrication of welded steel girder** as per approved drawing duly made up built up sections of MS Plate, Angle, Channel of different thickness including metalizing priming coat followed by finish coat of paints of total thickness of 165µm. The rate shall be inclusive of supply of all the steels, labour consumables & machinery and all other materials & accessories required for fabrication to complete in all respect with all lead, lift etc. The rate is also includes(i) Cost of to and fro transportation between contractor's work shop & work site including all lead, lift, loading, unloading etc. (ii) Cost of inspection, testing of girders in stages by nominated inspection agency. Nomination of inspection agency for passing of fabricated members and trial assembly will be decided by Engineer-in-Charge. iii) Cost of supplying & fixing of HSFG*I* High strength bolts (not less than 8.8 grade). iv) Cost of blast-cleaning the steel surface including supplying & applying of zinc phosphate primer followed by finish coat of micaceous iron oxide pigmented drying oil type paint of total thickness of 165µm.	tonne	42000.00	44000.00	
Note:	Add cost & carriage of 1.05 MT Structural steel to arrive at consolidated item rate.				
	b) Assembling, erection *I* launching of fabricated steel girders in proper position, line, level, alignment including erection of staging and scaffolding, dismantling the same after completion of work. The rate shall be inclusive all complete in all respect with all materials, labour, tools & plants, lead and lift. This item pertains to erection of girders by contractor's own cranes *I* derricks staging, machineries, plants & equipment etc., wherever required to complete the job, as per approved drawing. The rate is inclusive of all stand by cranes, equipment, machineries etc. as directed by Engineer-in-charge to complete the work.	tonne	13000.00	13000.00	
14.06	**Providing and laying Cement concrete Wearing coat M-30 grade** with graded stone chips 19mm down including screening and cleaning approved stone chips and sand as necessary laying, finishing complete to camber and grade, curing with water, including cost and carriage of all materials and hire charges for form work including reinforcement complete as per drawing and Technical Specifications vide clause no. 2702 of MoRT&H's Specification for Road & Bridge Works.	cum	9688.00	10520.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.07	**Bituminous Wearing Coat** Providing and laying Bituminous Wearing coat with paving grade bitumen including screening and cleaning approved stone aggregates and filler materials as necessary laying, finishing complete to camber and grade, including cost and carriage of all materials complete as per drawing and Technical Specifications vide clause no. 2702 of MoRT&H's Specification for Road & Bridge Works.				***N.B.:*** *Before laying wearing coat the deck surface shall be thoroughly cleaned and tack coat shall be applied. The construction operations and bituminous mixes and tack coat shall conform to Section 500 of MoRT&H Specifications.*
	(i) Type 1: Bituminous Concrete 50 mm thick laid in single layer.	cum			
	(ii) Type 2: Bituminous Concrete 40 mm thick over-laid with **25 mm thick Mastic Asphalt**.	cum			
	(iii) Type 3: Mastic Asphalt 50mm thick laid in single layer.	cum			
Note:	Bituminous Concrete Rate as per item No. 5.08 & Mastic Asphalt Rate may be worked out on pro-rata basis as per item No. 5.14.				
14.08	**Construction of precast RCC railing of M30 Grade**, aggregate size not exceeding 12 rnm. true to line and grade, tolerance of vertical RCC post not to exceed 1 in 500, centre to centre spacing between vertical post not to exceed 2000 rnrn. leaving adequate space between vertical post for expansion, complete as per **MoRT&H standard drawing no SD/202** and technical specifications.	metre	1918.00	2058.00	
14.09	**Drainage Spouts in Superstructure i**ncluding providing drip mouldings and also including supplying, fitting and fixing approved type of materials complete as per drawing and Technical specification vide clause no. 2705 of MoRT&H's Specification for Road & Bridge Works.	each	783.00	791.00	
14.10	**Precast - Pretensioned Girders** Providing, precasting, transportation and placing in position precast pretensioned concrete girders as per drawing and technical specifications.	cum	7362.00	7918.00	
Note:	Construction Wing is to add the cost of concrete, HT strand and steel reinforcements to arrive at the final consolidated item rate.				
14.11	**Providing and fixing Helical pipes in voided concrete slabs**	metre	1318.00	1318.00	
14.12	Providing and laying a **burried expansion joint**, expansion gap being 20 mm, covered with 12 mm thick, 200 mm wide galvanised wieldable structural steel plate as per IS: 2062, placed symmetrical to centre line of the joint, resting freely over the top surface of the deck concrete, welding of 8 mm dia. 100 mm long galvanised nails spaced 300 mm c/c along the centre line of the plate, all as specified in clause 2604.	metre	860.00	860.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.13	**Filler joint**				
	(i) Providing & fixing **2 mm thick corrugated copper plate in expansion joint** complete as per drawing & Technical Specification.	metre	3840.00	3840.00	
	(ii) Providing & fixing **20 mm thick compressible fibre board in expansion joint** complete as per drawing & Technical Specification.	metre	259.00	259.00	
	(iii) Providing and fixing in position **20 mm thick pre-moulded joint filler in expansion joint** for fixed ends of simply supported spans not exceeding 10 m to cater for a horizontal movement upto 20 mm, covered with sealant complete as per drawing and technical specifications.	metre	189.00	189.00	
	(iv) Providing and filling **joint sealing compound** as per drawings and technical specifications with coarse sand and 6% bitumen by weight	metre	20.00	21.00	
14.14	**Asphaltic Plug joint** Providing and laying of asphaltic plug joint to provide for horizontal movement of 25 mm and vertical movement of 2 mm, depth of joint varying from 75 mm to 100 mm, width varying from 500 mm to 750 mm (in traffic direction), covered with a closure plate of 200mm x 6mm of wieldable structural steel conforming to IS: 2062, asphaltic plug to consist of polymer modified bitumen binder, carefully selected single size aggregate of 12.5 mm nominal size and a heat resistant foam caulking/backer rod, all as per approved drawings and specifications.	metre	9875.00	9875.00	
14.15	**Elastomeric Slab Seal Expansion Joint** Providing and laying of an elastomeric slab seal expansion joint, catering to right or skew (less than 20 deg., moderately curved with maximum horizontal movement upto 50 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation and as per Clause 2605 of Specifications for Road & Bridge works of MoRT&H (5th Revision).				
	(**a) For movement up to ± 10 mm** - Type : m 20	metre	15000.00	15000.00	
	(b) For movement up to ± 16 mm - Type : m 32	metre	22000.00	22000.00	
	(c) For movement up to ± 25 mm - Type : m 50	metre	30000.00	30000.00	
	(d) For movement up to ± 40 mm - Type : m 80	metre	46000.00	46000.00	
	(e) For movement up to ± 62.5 mm - Type : m 125	metre	71000.00	71000.00	
	(f) For movement up to ± 80 mm - Type : m 160	metre	104000.00	104000.00	
	(g) For movement up to ± 115 mm - Type : m 230	metre	140000.00	140000.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.16	**Compression Seal Joint** Providing and laying of compression seal joint consisting of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomer or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder to cater for a horizontal movement upto 40 mm and vertical movement of 3 mm.	metre	7500.00	7500.00	
14.17	**Strip Seal Expansion Joint** Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 80 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer / supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.	metre	10000.00	10000.00	
14.18	**Modular Strip / Box Seal Joint** Providing and laying of a modular strip Box steel expansion joint including anchorage catering to a horizontal movement beyond 80mm and upto 160mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/ supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.	metre	80000.00	80000.00	
14.19	**Modular Strip / Box Seal Joint** Providing and laying of a modular strip box seal expansion joint catering to a horizontal movement beyond 160mm and upto 240mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.	metre	120000.00	120000.00	
14.20	**Supply, testing, fitting, fixing and welding with stud guns** etc. of normal headed shear studs / shear connectors 25mm dia and 200 mm length conforming to IS: 3935-66 as per specifications of approved drawing along with ferrules to top flange of girder for deck slabs as per the direction / approval of Engineer in charge. (In case the shear connector of any other size is required then payment shall be made on pro-rata basis in proportion of the weight of the shear connectors).	each	338.00	338.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
14.21	**Providing and Painting of structural steel surfaces** of bridge members by grit blast cleaning or centrifugal blasting with a suitable abrasive materials like crushed slag in accordance with clause-III of IS 6586 : 1989 immediately before painting , to make the surface free from grease, oil, rust and other foreign materials. The rate includes supply of abrasivesand,fuel, cost of paint including all transportation, lead, lift and labour charges, consumables, tools & plants complete in all respect but exclusive of cost for staging/scaffolding. Painting of approved Zinc-phosphate primer of DFT 65 micron followed by finish coat of Micaceous iron oxide pigmented drying oil type paint of DFT 75 micron.	Sqm	593.00	593.00	

CHAPTER - 15
PROTECTION WORKS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
15.01	**Providing and laying boulders apron on river bed for protection against scour with stone boulders** weighing not less than 40 kg each complete as per drawing and Technical specification. **Boulder Laid Dry Without Wire Crates.**	cum	496.00	488.00	
Note:	Construction wing is to add cost and carriage of 1.00 cum. of stone with minimum size of 200 mm & 0.20 cum of stone spalls only to arrive at consolidated rate.				
15.02	**Boulder Apron Laid in Wire Crates**				
	Providing and laying of boulder apron laid in wire crates made with 4mm dia GI wire conforming to IS: 280 & IS:4826 in 100mm x 100mm mesh (weaved diagonally) including 10 per cent extra for laps and joints laid with stone boulders weighing not less than 40 kg each.	cum	1255.00	1247.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				
15.03	**Providing and laying Pitching on slopes** laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications.				
	I. Stone/Boulder	cum	496.00	488.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				
	II. Cement Concrete Blocks of size 0.3x0.3 x0.3 m cast in cement concrete of Grade M15	cum	1832.00	2309.00	
Note:	Construction wing is to add cost of cement and cost & carriage of coarse aggregates as per requirement vide Table 3.2·1 only to arrive at consolidated rate.				
15.04	**Providing and laying Filter material underneath pitching in slopes** complete as per drawing and Technical specification.	cum	730.00	647.00	
Note:	Add cost of 0.72 m3 of brick aggregates / river bed materials and 0.48 m3 of coarse sand (loose volume) to arrive at the consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
15.05	**Geotextile Filter**				
	Laying of a geotextile filter between pitching and embankment slopes on which pitching is laid to prevent escape of the embankment material through the voids of the stone pitching/cement concrete blocks as well as to allow free movement of water without creating any uplift head on the pitching.	sqm	109.00	109.00	
15.06	**Providing and laying Flooring** complete as per drawing and Technical specifications laid over cement concert bedding.				
	I. Rubble stone laid in cement mortar 1:3	cum	3894.00	4438.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				
	II. Cement Concrete blocks Grade M15	cum	2461.00	3102.00	
Note:	Construction wing is to add cost of cement and cost & carriage of coarse aggregates as per requirement vide Table 3.2·1 only to arrive at consolidated rate.				
15.07	**Dry Rubble Flooring**				
	Construction of dry rubble flooring at cross drainage works for relatively less important works.	cum	814.00	806.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				
15.08	**Curtain wall complete as per drawing and Technical specification**				
	I. Stone masonry in cement mortar (1:3)	cum	2980.00	3300.00	
Note:	Construction wing is to add cost & carriage of 1.1m³ of stone boulders weighing not less than 40 kg to arrive at the complete rate.				
	II. Cement concrete Grade M15	cum	1832.00	2309.00	
Note:	Construction wing is to add cost of cement and cost & carriage of coarse aggregates as per requirement vide Table 3.2·1 only to arrive at consolidated rate.				
15.09	**Flexible Apron** Construction of flexible apron 1 m thick comprising of loose stone boulders weighing not less than 40 kg beyond curtain wall.	cum	549.00	541.00	
Note:	Add cost & carriage of 1 cum of stone and 0.2 cum of stone spalls to arrive at the consolidated rate.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
15.10	**Gabion Structure for Retaining Earth**				
	Providing and construction of a gabion structure for retaining earth with segments of wire crates of size 7 m x 3 m x 0.6 m each divided into 1.5 m compartments by cross netting, made from 4 mm galvanised steel wire @ 32 kg per 10 sqm having minimum tensile strength of 300 Mpa conforming to IS:280 and galvanizing coating conforming to IS:4826, woven into mesh with double twist, mesh size not exceeding 100 x 100 mm, filled with boulders with least dimension of 200 mm, all loose ends to be tied with 4 mm galvanised steel wire.	cum	1374.00	1366.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				
15.11	**Gabion Structure for Erosion Control, River Training Works and Protection works**				
	Providing and constructing gabion structures for erosion control, river training works and protection works with wire crates of size 2 m x 1 m x 0.3 m each divided into 1m compartments by cross netting, made from 4 mm galvanised steel wire @ 32 kg per 10 sqm having minimum tensile strength of 300 MPa conforming to IS:280 and galvanizing coating conforming to IS:4826, woven into mesh with double twist, mesh size not exceeding 100 mm x 100 mm, filled with boulders with least dimension of 200 mm, all loose ends to be securely tied with 4 mm galvanised steel wire.	cum	2703.00	2695.00	
Note:	Construction wing is to add cost and carriage of 1.00 cu.m. of stone with minimum size of 200 mm & 0.20 cu.m of stone spalls only to arrive at consolidated rate.				

CHAPTER - 16
REPAIR AND REHABILITATION

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
16.01	**Removal of existing cement concrete wearing coat** including its disposal complete as per Technical specification without causing any detrimental effect to any part of the bridge structure and removal of dismantled material with all lifts and lead upto 1000m (Thickness 75 mm)	sqm	113.00	117.000	
16.02	**Removal of existing asphaltic wearing coat** comprising of 50 mm thick asphaltic concrete laid over 12 mm thick mastic asphalt including disposal with all lift and lead upto 1000m.	sqm	86.00	89.00	
16.03	**Guniting concrete surface** with cement mortar (25 mm nominal thick) applied with compressor after cleaning surface and spraying with epoxy complete as per Technical specification.	sqm	912.00	962.00	
16.04	**Providing and inserting nipples** with approved fixing compound after drilling holes for grouting as per Technical specifications including subsequent cutting/removal and sealing of the hole as necessary of nipples after completion of grouting with Cement/Epoxy.	each	102.00	102.00	
16.05	**Sealing of cracks / porous concrete** by injection process through nipples/Grouting complete as per Technical specification.				
	A Cement Grout	kg	59.00	60.00	
	B Cement mortar (1:1) Grouting	kg	139.00	141.00	
16.06	**Patching of damaged concrete surface** with polymer concrete (25 mm nominal thick) and curing compounds, initiator and promoter, available in present formulations, to be applied as per instructions of manufacturer and as approved by the Engineer.	sqm	1391.00	1393.00	
16.07	**Sealing of crack / porous concrete with Epoxy Grout** by injection through nipples complete as per clause 2803.1.	kg	882.00	883.00	
16.08	**Applying epoxy mortar** (10 mm nominal thick) over leached, honey combed and spalled concrete surface and exposed steel reinforcement complete as per Technical specification	sqm	665.00	665.00	
16.09	**Removal of defective concrete,** cleaning the surface thoroughly, applying the shotcrete mixture mechanically with compressed air under pressure, comprising of cement, sand, coarse aggregates, water and quick setting compound in the proportion as per clause 2807.1., sand and coarse aggregates conforming to IS: 383 and table 1 of IS: 9012 respectively, water cement ratio ranging from 0.35 to 0.50, density of gunite not less than 2000 kg/cum, strength not less than 25 MPa and workmanship conforming to clause 2807.6. (40 mm average thickness.)	sqm	261.00	286.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
16.10	**Applying pre-packed cement based polymer mortar** (10 mm nominal thick) of strength 45 MPa at 28 days for replacement of spalled concrete	sqm	115.00	115.00	
16.11	**Epoxy bonding of new concrete to old concrete**	sqm	517.00	517.00	
16.12	**Providing external prestressing with high tensile steel wires/strands** including drilling for passage of prestessing steel, all accessories for stressing and stressing operation and grouting complete as per drawing and Technical specification				
	(i) Span assumed: 25 m (12.7mm dia. Strand in 12T13 system. Weight-9.42 kg/m of cable.)	tonne	229385.00	234949.00	
	(ii) Span assumed: 50 m (12.7mm dia. Strand in 19T13 system. Weight-14.73 kg/m of cable.)	tonne	220028.00	225968.00	
	(iii) Span assumed: 100 m (12.7mm dia. Strand in 19T13 system. Weight-14.73 kg/m of cable.)	tonne	209296.00	214961.00	
Note:	The rate provided is exclusive of cost of H.T. Strand. Construction wing should add cost & carriage of 1.02 MT (considering 2% wastage) of H.T. Strand to arrive at the final consolidated item rate.				
16.13	**Replacement of bearings complete as per Technical specification**	each	8639.00	8647.00	
Note:	Add cost of bearing to arrive at the final consolidated item rate.				
16.14	**Rectification of bearings as per Technical specifications**	each	4508.00	4517.00	
16.15	**Replacement of Expansion Joints complete as per drawings**	metre	2442.00	2658.00	
Note:	The rate for the installation of new expansion joints may be taken from the chapter on superstructure. Broken concrete will have to be replaced which has been included in this analysis.				
16.16	**Replacement of damaged Concrete Railing.**	metre	242.00	245.00	
Note:	The rate for the provision of new railing may be adopted from the chapter on superstructure.				
16.17	**Replacement of Crash barrier.**	metre	426.00	429.00	
Note:	The rate for the construction of new crash barrier may be adopted from Chapter 8 on Traffic and Transportation.				
16.18	**Repair of Crash barrier** Repair of concrete crash barrier with cement concrete of M-30 grade by cutting and trimming the damaged portion to a regular shape, cleaning the area to be repaired thoroughly, applying cement concrete after erection of proper form work.	metre	206.00	228.00	
16.19	**Repair of RCC Railing** Carrying out repair of RCC M30 railing to bring it to the original shape.	metre	172.00	183.00	
16.20	**Repair of Steel Railing** Repair of steel railing to bring it to the original shape.	metre	292.00	301.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
16.21	**Providing anti-corrosive protective coating** to inhibit the corrosion to HYSD reinforcements including two coats of anti-corrosive coatings of consumption as per manufacturer's specification, cleaning etc. complete as per the direction of the Engineer-in-Charge.	sqm	506.00	506.00	
16.22	**Cleaning the exposed corroded Reinforcement** as well as worn out concrete by sand blasting with air compressor including all materials, hire charges of machineries and labour etc. all complete as per technical specification and direction of the Engineer-in-Charge.	sqm	604.00	680.00	
16.23	**Uplifting of Superstructure span by jacking up** from below by placing the jacks on pier /abutment caps for span weight as below:				
	(i) Span Wt. : Upto 240MT	each	44966.00	46572.00	
	(ii) Span Wt. : Upto 360MT	each	61274.00	63683.00	
	(iii) Span Wt. : Upto 800MT& above	each	66531.00	69191.00	
16.24	**Hire and labour charges for staging with sal bullah** for super structure of bridge (Major and Minor) including stripping off and removing clearing on completion of work as per design and drawing approved by the Engineer-in-charge.	cum	199.00	199.00	

CHAPTER - 17
SOIL BORING & TESTING WORKS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
17.01	**Mobilisation Charges** of all tools & Plants along with accessories, material, labour, supervision etc. at site of work required in connection with boring and testing work, including setting up boring rigs and shifting to different Bore-hole points etc. and also including withdrawal of same from the site after completion of work, complete as per direction of Engineer-in-Charge.				
	a) Preliminary Investigation	L.S	8000.00	8500.00	
	b) Detailed Investigation	L.S	25000.00	27000.00	
Note	Payment will be made after successful completion of work.				
	Preliminary Investigation is mainly for collection of disturbed samples where deployment of heavy machineries is not involved.				
17.02	**Carriage of all Disturbed & Undisturbed Samples** from site of work to the Divisional office or elsewhere including loading and unloading as per direction of Engineer-in-Charge. **Detailed Investigation.**	L.S	1600.00	1700.00	
Note:	Some samples are to be kept at Sub-Division Office for Additional testing By the Engineer-in-Charge.				
17.03	Labour for **boring by sinking and finally withdrawing** 50mm to 100mm dia. (internal) pipe by a standard method to any depth below ground level / bed level in all types of soil like clay, silt, sand, stiff clay, mixed soils etc. except rocks, including collection of disturbed soil samples and including preparation and submission of bore-log as per standard proforma and also including hire charges of tool and plants complete as per direction of Engineer-in-Charge.				
	a) Depth 0m to 30m	metre	150.00	160.00	
	b) Depth greater than 30m upto 60m	metre	200.00	220.00	
	c) Extra for boring in water (with depth of Water upto 3.0 m)	L.S	9500.00	10000.00	
17.04	Labour for **making Bore-Holes** of 150mm to 250mm dia. by any standard method to any depth below ground level / bed level in all kinds of soil like clay, , silt, sand, stiff clay, mixed soils etc. except rocks (for the purpose of collecting Disturbed & Un disturbed soil samples, conducting Standard Penetration Test at suitable intervals etc.) including preparation and submission of bore-log as per IRC : 75 and 78 and Clause 2400 of Specifications for Road & Bridge Works (5th Revision), Published by IRC, and also including hire charges of tools and plants complete as per the direction of Engineer-in-Charge.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	a) When Casing pipe is used to prevent collapse of bore hole (casing pipe to be finally withdrawn)				
	(i) Depth 0m to 10m	metre	340.00	360.00	
	(ii) Depth greater than 10m and upto 20m	metre	400.00	430.00	
	(iii) Depth greater than 20m and upto 30m	metre	470.00	500.00	
	(iv) Depth greater than 30m. and upto 40m	metre	550.00	590.00	
	(v) Depth greater than 40m and upto 50m	metre	650.00	700.00	
	(vi) Depth greater than 50m and upto 60m	metre	750.00	810.00	
	b) When drilling mud "Bentonite of suitable consistency" is used to prevent collapse of bore hole.				
	(i) Depth 0m to 10m	metre	290.00	310.00	
	(ii) Depth greater than 10m and upto 20m	metre	350.00	380.00	
	(iii) Depth greater than 20m and upto 30m	metre	420.00	450.00	
	(iv) Depth greater than 30m. and upto 40m	metre	470.00	500.00	
	(v) Depth greater than 40m and upto 50m	metre	520.00	560.00	
	(vi) Depth greater than 50m and upto 60m	metre	690.00	740.00	
	c) Extra for boring in water (1.2m and higher depths).	each	10670.00	11420.00	
17.05	**A. Laboratory Investigation:**				
	i) Liquid Limit as per IS 2720 (Part – V).	each	350.00	380.00	
	ii) Plastic Limit as per IS 2720 (Part – V)	each	350.00	380.00	
	iii) Grain size analysis by Sieving as per IS 2720 (Part – IV).	each	530.00	570.00	
	iv) Grain size analysis by Hydrometer Method as per IS 2720 (Part – IV).	each	690.00	750.00	
	v) Determination of Water Content as per IS 2720 (Part – II).	each	140.00	150.00	
	vi) Determination of Specific Gravity as per IS 2720 (Part – III).	each	460.00	500.00	
	vii) Direct Shear Test as per IS 2720 (Part – XIII).	each	570.00	620.00	
	viii) Determination of Unconfined Compression Strength as per IS 2720 (Part – X).				
	a) Undisturbed.	each	690.00	750.00	
	b) Remoulded.	each	920.00	990.00	
	ix) Determination of Sand Content as per IS 2720 (Part – IV).	each	410.00	440.00	
	x) Determination of Shrinkage Factor as per IS 2720 (Part – VI).	each	510.00	550.00	
	xi) Determination of Water ContentDry Density relation usinglight compaction as per IS 2720 (Part – VII).	each	1150.00	1240.00	
	xii) Determination of Water ContentDry Density relation usingheavy compaction as per IS 2720 (Part – VIII).	each	1590.00	1720.00	
	xiii) Determination of Density Index (Relative Density of cohesion less soil) as per IS 2720 (Part – XIV).	each	920.00	990.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	xiv) Determination of Consolidation Properties as per IS 2720 (Part – XIV).	each	920.00	990.00	
	xv) Laboratory Determination of **California Bearing Ratio** on Disturbed / Remoulded samples as per IS: 2720, Part XVIII.				
	a) Un soaked	each	920.00	990.00	
	b) Soaked	each	1150.00	1240.00	
	xvi) **Tri-Axial Shear Test.**				
	a) Determination of Shear strength Parameters of a specimen tested in Unconsolidated Undrained Tri-axial compression without measurement of pore water pressure as per IS 2720 (Part – XI).	each	920.00	990.00	
	b) Determination of Shear strength Parameters of a specimen tested in Consolidated Undrained Tri-axial compression Test with measurement of pore water pressure as per IS 2720 (Part – XII).	each	1150.00	1240.00	
	c) Determination of Shear strength Parameters of a soil from Consolidated Drained Test as per IS 2720 (Part – X).	each	1380.00	1490.00	
	xvii) Laboratory Determination of Permeability as per IS 2720 (Part– XVII).	each	690.00	750.00	
	xviii) Determination of Field Moisture Equivalent as per IS 2720 (Part– XVIII).	each	460.00	500.00	
	xix) Determination of Centrifuge Moisture Equivalent as per IS 2720 (Part– XIX).	each	460.00	500.00	
	xx) Determination of Linear Shrinkage as per IS 2720 (Part– XX).	each	800.00	860.00	
	xxi) Laboratory Total Soluble Solid as per IS 2720 (Part– XXI).	each	690.00	750.00	
	xxii) Determination of Organic Matter as per IS 2720 (Part– XXII).	each	460.00	500.00	
	xxiii) Determination of Calcium Carbonate as per IS 2720 (Part– VIII).	each	510.00	550.00	
	xxiv) Determination of pH Value as per IS 2720 (Part– VIII).	each	460.00	500.00	
	xxv) Determination of Total Soluble Sulphate as per IS 2720 (Part– VIII).	each	460.00	500.00	
	xxvi) Laboratory **Vane Shear Test** as per IS 2720 (Part-XVIII).	each	690.00	750.00	
	xxvii) Determination of Free Swell Index of Soil as per IS 2720 (Part– VIII).	each	460.00	500.00	
	xxviii) Determination of Swelling Pressure of Soil as per IS 2720 (Part– VIII).	each	690.00	750.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	B Field Investigation:				
	i) Shallow boring by auger and collection of disturbed sample upto 10m. Depth (In Clayey Silty soil)				
	a) 0m.-6.0m.	Per m	350.00	380.00	
	b) 6.0m.-10.0m.	Per m	460.00	500.00	
	ii) Collection of Undisturbed Samples from the open pits (Pits to be dug by client)	Per sample	460.00	500.00	
	iii) Collection of Samples from the bore hole made as per B-a				
	(a)Undisturbed	Per sample	350.00	380.00	
	(b) Disturbed	Per sample	120.00	130.00	
	iv) Collection of Undisturbed Samples by core cutter method	Per sample	1150.00	1240.00	
	v) Collection of Undisturbed soil sample from the bore hole to be made by the concerned Division / Party at their cost.				
	(i)0.0m - 10.0m	each	230.00	250.00	
	(ii)10.0m-20.0m	each	350.00	380.00	
	(iii)20.0m-30.0m	each	460.00	500.00	
	(iv)30.0m-40.0m	each	570.00	610.00	
	(v)40.0m-50.0m	each	680.00	730.00	
	vi) **Standard Penetration Tests (S.P.T.)** by Split Spoon Sampler in the bore hole as per IS 2131.				
	(i)0.0m - 10.0m	each	350.00	380.00	
	(ii)10.0m-20.0m	each	460.00	500.00	
	(iii)20.0m-30.0m	each	570.00	620.00	
	vii) **Static Cone-Penetration Test** as per IS 4968 (Part - III).	each	460.00	500.00	
	viii) **Dynamic Cone-Penetration Test** using 50mm cone without using Bentonite slurry as per IS 4968 (Part – I).	each	460.00	500.00	
	ix) Conduction of Benkelman Beam Test (Standard Loaded Truck to be arranged)	Per Point	270.00	290.00	
	x) **Collection of Undisturbed sample by C.B.R. Mould upto 1.5 m depth.**	Per sample	690.00	750.00	
	xi) Determination of **Density** of soil in place by Sand-replacement Method as per IS 2720 (Part – XXIII).	Per test	570.00	620.00	
	xii) Field determination of **California Bearing Ratio** as per IS 2720 (Part XXXI)	Per test	2300.00	2480.00	
	xiii) Load Tests of Soils (Loading arrangement shallbe done by the client) as per IS 1888.				
	a) For evaluation of Bearing Capacity & Settlement	Per test	5670.00	6120.00	
	b) For evaluation of sub-grade modulus	Per test	6910.00	7460.00	
	xiv) Observation of Water Table	Per test	6910.00	7460.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
17.06	**TEST OF MATERIAL:**				
	A. Blast Furnace Slag, Cinder, Stone, Jhama, Laterite, etc.				
	(i) Grading by Sieve Analysis as per IS: 2386 (Part – I)	Per sample	350.00	380.00	
	(ii) Flakiness Index & Elongation Index Combined	Per sample	460.00	500.00	
	(iii) Estimation of Deleterious Materials as per IS: 2386 (Part – II)	Per sample	920.00	990.00	
	(iv) Determination of Specific Gravity as per IS: 2386 (Part – III)	Per sample	460.00	500.00	
	(v) Determination of Bulk Density as per IS: 2386 (Part – III)	Per sample	230.00	250.00	
	(vi) Determination of Void Ratio as per IS: 2386 (Part – III)	Per sample	230.00	250.00	
	(vii) Determination of Water Absorption as per IS: 2386 (Part – III)	Per sample	230.00	250.00	
	(viii) Determination of Aggregate Crushing Value as per IS: 2386 (Part – IV)	Per sample	690.00	750.00	
	(ix) Determination of the 10% Fines Value per IS: 2386 (Part – IV)	Per sample	690.00	750.00	
	(x) Determination of Aggregate Impact Value as per IS: 2386 (Part – IV)	Per sample	690.00	750.00	
	(xi) Determination of Aggregate Abration Value (Los Angles) as per IS: 2386 (Part – IV)	Per sample	920.00	990.00	
	(xii) Soundness Test as per IS: 2386 (Part – V)	Per sample	460.00	500.00	
	(xiii) Determination of Compressive Strength a) For Prepared Sample b) For Sample to be Prepared	Per sample	 460.00 690.00	 500.00 750.00	
	(xiv) Determination of Stripping Value of Road Aggregate (Bitumen to be supplied and determination of specification will be charged) as per IS: 6241	Per sample	690.00	750.00	
	B. (I) FIELD TEST ON ROCKS :				
	Boring and drilling of rocks and collection / recovery of rock core including supplying information on the physical condition and type of rock, length of pieces of core, joints, colour, weathering changes and other effects in the drilling logs as per IS 4464 and IS 5313 complete.				
	a) By Diamond Drills	each	1850.00	1980.00	
	b) By Tungsten Cutters	each	950.00	1020.00	
	(II) LABORATORY TEST ON ROCKS				
	(i) Compressive Strength of Rock as per IS 1121 (Part-I)	Per sample	580.00	630.00	
	(ii) Transverse Strength of Rock as per IS 1121 (Part-II)	Per sample	680.00	730.00	
	(iii) Tensile Strength of Rock as per IS 1121 (Part – III).	Per sample	580.00	630.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iv) Shear Strength of Rock as per IS 1121 (Part - IV).	Per sample	530.00	570.00	
	(v) Determination of True Specific Gravity as per IS 1122	Per sample	460.00	500.00	
	(vi) Determination of Water Absorption as per IS: 1124	Per sample	230.00	250.00	
	(vii) Determination of Toughness of rock.	Per sample	570.00	620.00	
	C. BRICKS				
	(i) Determination of Compressive Strength as per IS: 3405 (Part I-IV)	Per sample	920.00	990.00	
	(ii) Determination of Water Absorption as per IS: 3405 (Part I-IV)	Per sample	230.00	250.00	
	(iii) Determination of Efflorence as per IS: 3405 (Part I-IV)	Per sample	580.00	630.00	
	D. SAND				
	(i) Grading by Sieve Analysis as per IS: 2386 (Part – I)	Per sample	460.00	500.00	
	(ii) Estimation of Deleterious Materials as per IS: 2386 (Part – II)	Per sample	580.00	630.00	
	(iii) Estimation of Organic Impurities as per IS: 2116 & 383	Per test	580.00	630.00	
	(iv) Determination of Specific Gravity as per IS: 2386 (Part III)	Per test	460.00	500.00	
	(v) Determination of Bulk Density as per IS: 2386 (Part III)	Per test	180.00	190.00	
	(vi) Determination of Bulking of Sand	Per test	320.00	350.00	
	(vii) Determination of Lecy's Silt Factor	Per test	920.00	990.00	
	E. LIME				
	(i) Determination of Fineness of Hydrated Lime as per IS: 712	Per test	280.00	300.00	
	(ii) Determination of Setting Time (Initial & Final as per IS: 712	Per test	280.00	300.00	
	(iii) Determination of Workability as per IS: 712	Per test	430.00	460.00	
	(iv) Test of Soundness as per IS: 712	Per test	230.00	250.00	
	(v) Determination of Compressive Strength (14 days & 28 days) as per IS: 712	Per test	920.00	990.00	
	(vi) Determination of Calcium Oxide Content as per IS: 712	Per sample	320.00	350.00	
	(vii) Determination of Free Lime Content as per IS: 15514	Per sample	690.00	750.00	
	(viii) Determination of Calcium Carbonate as per IS: 712	Per sample	510.00	550.00	
	F. BITUMEN				
	(i) Determination of Specific Gravity as per IS: 1202	Per sample	430.00	460.00	
	(ii) Determination of Penetration as per IS: 1203	Per sample	460.00	500.00	
	(iii) Determination of Softening Point as per IS: 1205	Per sample	430.00	460.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iv) Determination of Kinematic Viscosity as per IS: 1206 (Part-III)	Per sample	460.00	500.00	
	(v) Determination of Ductility as per IS: 1206	Per sample	460.00	500.00	
	(vi) Determination of Flash Point & Fire Point as per IS: 1209	Per sample	350.00	380.00	
	(vii) Float Test as per IS: 1210	Per sample	580.00	630.00	
	(viii) Determination of Water Content as per IS: 1211	Per sample	350.00	380.00	
	(ix) Determination of Loss on Heating as per IS: 1212	Per sample	350.00	380.00	
	(x) Determination of Solubility on Carbon Dy Sulphide or Trichloroethylene as per IS: 1216	Per sample	580.00	630.00	
	(xi) Marshal Stability & Flow Test: a) Supply Sample b) Sample to be prepared	Per sample	 1150.00 1840.00	 1240.00 1990.00	
	(xii) Determination of Stripping Value	Per sample	690.00	750.00	
	(xiii) Design of Asphaltic Concrete including necessary Test	L.S.	17710.00	19130.00	
	(xiv) Determination of Hardness of Mastic Asphalt as per IS: 1195	Per sample	690.00	750.00	
	(xv) Determination of Bitumen Content	Per sample	710.00	770.00	
	(xvi) Miscibility in Water of Bituminous Emulsion as per IS: 3117	Per sample	230.00	250.00	
	(xvii) Coating Test of Bituminous Emulsion as per IS: 3117	Per sample	460.00	500.00	
	G. MODIFIED BITUMEN				
	(i) Determination of Flash Point as per IS: 1209	Per sample	350.00	380.00	
	(ii) Elastic Recovery of half tread in Ductilometer as per ASTM D5976	Per sample	710.00	770.00	
	(iii) Determination of Loss in weight on Heating as per IS: 9382	Per sample	530.00	570.00	
	H. STEEL				
	(i) Tensile Strength of Steel as per IS: 1608 &2026	Per sample	460.00	500.00	
	(ii) Determination of 2% Proof Stress as per IS: 1608 &2026	Per sample	460.00	500.00	
	(iii) Elongation Test as per IS: 1608 &2026	Per sample	390.00	420.00	
	(iv) Bend Test as per IS: 1599 &2060	Per sample	350.00	380.00	
	I. CEMENT				
	(i) Fineness by dry sieving as per IS: 4031 (Part-I)	Per sample	280.00	300.00	
	(ii) Fineness by Specific Surface by blown air permeability method as per IS: 4031 (Part-II)	Per sample	580.00	630.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(iii) Determination of Soundness by Leechatelier method as per IS: 4031 (Part-III)	Per sample	230.00	250.00	
	(iv) Determination of Consistency of Standard Cement Paste as per IS: 4031 (Part-IV)	Per sample	280.00	300.00	
	(v) Determination of Initial & Final Setting Time as per IS: 4031 (Part-V)	Per sample	300.00	320.00	
	(vi) Determination of Compressive Strength of Hydraulic Cement as per IS: 4031 (Part-VI) (3 days, 7 days & 28 days)	Per sample	1660.00	1790.00	
	(vii) Determination of Heat Hydration of Cement as per IS: 4031 (Part-IX)	Per sample	1770.00	1910.00	
	(viii) Determination of Drying Shrinkage of Cement as per IS: 4031 (Part-X)	Per sample	580.00	630.00	
	(ix) Determination of Specific Gravity of Cement as per IS: 4031 (Part-XI)	Per sample	340.00	370.00	
17.07	**CONCRETE**				
	(i) Slump Test as per IS: 1199	Per sample	230.00	250.00	
	(ii) Compacting Factor Test as per IS: 1199	Per sample	460.00	500.00	
	(iii) Determination of Consistency of Concrete by Vee - Bee Consistometer as per IS: 1199	Per sample	1150.00	1240.00	
	(iv) Flexural Strength of Concrete Beam as per IS: 1199 & 516 a) Supply Specimen b) Specimen to be prepared	 Per sample	 1040.00 2000.00	 1120.00 2160.00	
	(v) Compressive Strength Test of Concrete Specimen as per IS: 516	Per sample	280.00	300.00	
	(vi) Preparation of Concrete Specimen & Compressive Strength Test as per IS: 1199 & 516	Per sample	1040.00	1120.00	
	(vii) Bulk Density, Water absorption & Void Ratio of Concrete Specimen	Per sample	810.00	870.00	
	(viii) Determination of Compressive Strength of Cored Sample (Sample to be supplied) as per IS: 1199 & 516	Per sample	460.00	500.00	
	(ix) Test of Permeability of Concrete as per IS: 3085	Per sample	1150.00	1240.00	
	(x) Test for Sulphate & Chloride in Water	Per sample	1180.00	1270.00	
17.08	Preparation and submission of report in 6 (Six) copies, giving all relevant information data like site plan, Bore log and water table, test results, calculations, discussions, suggestions and recommendations in respect of suitable foundation etc. including determination of silt factor calculation of waterways and complete design of foundation including analysis of Bearing Capacities and settlements in bound and presentable form complete as per direction of Engineer-in-Charge.				
	a) Preliminary Investigation	L.S	5000.00	5500.00	
	b) Detailed Investigation	L.S	12500.00	13500.00	

MISCELLANEOUS WORKS

CHAPTER - 18
MISCELLANEOUS WORKS

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
18.01	Labour for **picking up existing metalled road surface** to a specified average depth, including screening and stacking the pavement materials.				
	(a) For average depth up to 40 mm by manual means:				
	(i) Stone-metal surface.	sqm	12.90	12.90	
	(ii) Brick / Jhama metal surface.	sqm	9.50	9.50	
	(b) For average depth above 40 mm but not exceeding 75 mm by manual means:				
	(i) Stone-metal surface.	sqm	19.00	19.00	
	(ii) Brick / Jhama metal surface.	sqm	12.90	12.90	
	(c) For average depth above 75 mm but not exceeding 150 mm by manual means:				
	(i) Stone-metal surface.	sqm	25.50	25.50	
	(ii) Brick / Jhama metal surface.	sqm	19.00	19.00	
18.02	**Picking up and removing** old bituminous layer or sand sealing coat from old black topped surface and cleaning the exposed surface by scraping and stacking the material as directed.				
	(a) By manual means :				
	(i) From 25 mm to 50 mm thick.	sqm	22.60	22.60	
	(ii) From 50 mm to 100 mm thick.	sqm	30.40	30.40	
	(iii) Above 100 mm thick.	sqm	45.20	45.20	
	(b) By mechanical means (without milling machine) :				
	(i) From 25 mm to 50 mm thick.	sqm	3.80	3.90	
	(ii) From 50 mm to 100 mm thick.	sqm	7.50	7.80	
	(iii) Above 100 mm thick.	sqm	15.00	15.60	
	(c) By mechanical means (without milling machine) : Cold milling of Bituminous Pavement surface upto the required depth by mechanical means using milling machine, without disturbing the under laying layers, to proper line and level, cleaning the surface properly after milling and removing the loose materials, stacking the milled materials for re-use, necessary guarding, barricading & lighting, including hire charges of machinery, cost of fuel and labour and other incidental charges all complete and as per direction of Engineer-in-charge.				
	(i) For depth upto 100mm	Sqm	46.00	48.30	
	(ii) For depth upto 100mm to 150mm	Sqm	66.50	69.80	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
18.03	Labour for **mixing stable anti-stripping agent** of approved quality conforming to Table - A4-1 of Appendix–4 of Specification for Road & Bridge Works of MoRT&H (5th Revision) to the binder @ 0.5% to 1% by weight of binder (depending up on size & stripping value of the aggregates) and allowing 15 to 30 minutes of circulation or stirring in the hot bitumen tank to ensure a homogeneous mix of binder and anti-stripping agent for different bituminous works as per Technical Specifications given in Appendix – 4 of Specification for Road & Bridge Works of MoRT&H (5th Revision) and direction of Engineer-in-Charge complete including cost and carriage of all materials, labours, hire charges of T&P but excluding the cost but including carriage of anti-stripping agent to site of works.	kg	4.50	4.50	
18.04	Labour charges for **transferring Bulk Bitumen** from departmental vats in to empty bitumen drums by cutting or other suitable means, including hire charges of bitumen drums, carriage & handling up to a lead of 30 m, including all incidental charges, T&P, fuel, lubricants etc. complete.	MT	445.00	445.00	
18.05	**Hire and labour charges for Shuttering** with or without staging upto 4.0 m height using approved stout props with wooden planks/ply wood/steel sheet plate with required bracing for any kind of plain or reinforced concrete works in all sorts of minor structure including culvert, box culvert, cross-drain etc. The rate is inclusive of fitting, fixing and striking out after completion of work as per specification and direction.				
	(a) Where staging is required.	sqm	354.00	354.00	
	(b) Where staging is not required.	sqm	214.00	214.00	
18.06	**First class Brick work** in cement sand mortar in steining of well, pier, abutment, wing wall, parapets cross drain. H.P. culverts, guard wall etc. including curing, scaffolding, raking out joints etc. complete including cost and carriage of all materials.				
	(a) In 1:4 proportion.	cum	2394.00	2863.00	
	(b) In 1:6 proportion	cum	2235.00	2746.00	
Note:	Construction wing is to add cost and carriage of bricks as per Consumption chart vide Section 3 of Vol. I for Building Works only to arrive at consolidated rate.				
18.07	**Providing and laying Design Mix concrete for plain / reinforced concrete work** in any part of bridge (excluding bottom plugging) with coarse aggregates of appropriate nominal size and grading, fine aggregate (sand) conforming to proper grading zone, both of approved quality and cement, as necessary, including labour, cost and carriage of all materials and including preparation of design mix, approval of the same by the Engineer-in-Charge and cost for quality control, sampling, testing etc. all complete but excluding				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	cost of labour and materials for formwork & reinforcement works.				
	(a) M-15 Grade				
	Using concrete mixer.	cum	1406.00	1823.00	
	(b) M-20 Grade				
	Using concrete mixer.	cum	1470.00	1894.00	
	(c) M-25 Grade:				
	Using concrete mixer.	cum	1524.00	1950.00	
	(d) M-30 Grade:				
	(i) Using concrete mixer.	cum	1528.00	1954.00	
	(ii) Using Batching Plant, Transit Mixer & Concrete Pump	cum	1296.00	1729.00	
	(e) M-35 Grade:				
	(i) Using concrete mixer.	cum	1554.00	1982.00	
	(ii) Using Batching Plant, Transit Mixer & Concrete Pump	cum	1322.00	1758.00	
Note:	**(Applicable for all the item in Sl.18.07)**				
	1. Construction wing is to add cost and carriage of coarse aggregates and cost of cement as per requirement vide Table 3.2-1 only to arrive at consolidated rate.				
	2. From durability consideration, the value of minimum cement content and maximum water cement ratio to be considered in the mix design shall be as per the direction of the Engineer-in-Charge.				
18.08	**Mixing Superplastisizer** in concrete as per manufacturer's specification and direction of Engineer-in-Charge. The rate is inclusive of cost of superplastisizer.				
	(a) Carboxylate based	kg	176.00	176.00	
	(b) Naptha based	kg	73.10	73.10	
18.09	Providing **Steel anchor dowels** at the base of the well including **drilling holes** upto 2.5 m. depth in rock, placing the dowels in position and effectively grouting the holes (32 mm. diameter steel rod of 4.0 m length grouted upto 2.5 m. depth) etc. Complete as directed by Engineer in charge.	each	3081.00	3081.00	
18.10	**Welding by gas / electric plant** including transportation of welding plant at site including cutting, forging & drilling to required shape.	cm	1.80	1.80	
18.11	**A)** Supplying and fitting fixing **M.S. Iron pile shoe** as per approved drawing.	kg	75.10	76.80	
	B) Supplying and fitting fixing **M.S. Iron ring** with 50mmx6mm flat over head of pile for driving including cutting of pile head.	kg	75.90	77.60	
18.12	**M.S. Works in bolts and nuts** of different sizes fitted and fixed in position including drilling holes and welding including cost of labour and materials.	kg	68.40	68.50	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
18.13	**Labour for M.S. work in Rolled steel joists**, channels, angles. Tees, plates etc. including hoisting, placing in position including providing staging and removing after completion of works and cutting to sizes as required.	kg	7.30	7.30	
Note:	The item is exclusive of the cost of steel materials, necessary nuts & bolts and cost of welding.				
18.14	**Re- fitting** R.S. Joist, Angles, Tees, Plates, and other steel materials by sawing.	MT	397.00	397.00	
18.15	**Re- fitting the railing** with old and new bolts as required.	m	62.80	62.80	
Note:	Cost of new bolts, if required, is to be added.				
18.16	**Straightening** curved or twisted steel elements.				
	(a) R.S. joists and Channel	kg	4.40	4.40	
	(b) Angles, Tees	kg	3.30	3.30	
18.17	Labour for **driving Sal-bullah / Eucalyptus bullah piles** by monkey in sorts of soil including hoisting and placing piles in position, protecting the pile head with iron ring and cutting and shaping heads before and after driving and including hire and labour for necessary driving appliances and all tackles.				
	(i) 100mm diameter	m	83.00	83.00	
	(ii) 125mm diameter	m	92.00	92.00	
	(iii) 150mm diameter	m	105.00	105.00	
	(iv) 175mm diameter	m	112.00	112.00	
	(v) 200mm diameter	m	119.00	119.00	
	(vi) 225mm diameter	m	126.00	126.00	
Note:	1) Payment to be made on the length driven into the ground, diameter of the measured at 1.5m. from the thicker end.				
	2) For string staging under specific instruction of Engineer-in-charge or for driving from pontoon or boats the rate will be enhanced by ` 4.00 per meter.				
	3) For driving done by pile engine set (without staging) under specific instruction of Engineer-in-charge, the rates will be enhanced by ` 4.00 per meter.				
	4) For driving done by pile engine set (with heavy staging or from specially made pontoon) under specific instruction of Engineer-in-charge. The rates will be enhanced by ` 7.00 per m.				
18.18	**Supplying Eucalyptus-bullah piles** at work site, including dressing and making one end pointed.				
	(i) 100mm diameter	m	96.00	-	
	(ii) 125mm diameter	m	145.00	-	
	(iii) 150mm diameter	m	217.00	-	
	(iv) 175mm diameter	m	267.00	-	
	(v) 200mm diameter	m	305.00	-	
	(vi) 225mm diameter	m	460.00	-	
Note:	Diameter of pile to be measured at a distance of 1.5m from the thicker end.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
18.19	**Supplying Sal-bullah piles** at work site, including dressing and making one end pointed				
	(i) 100mm diameter	m	142.00	142.00	
	(ii) 125mm diameter	m	214.00	214.00	
	(iii) 150mm diameter	m	263.00	263.00	
	(iv) 175mm diameter	m	313.00	313.00	
	(v) 200mm diameter	m	386.00	386.00	
	(vi) 225mm diameter	m	575.00	575.00	
Note:	Diameter of pile to be measured at a distance of 1.5m from the thicker end.				
18.20	**Joining Sal-bullah / Eucalyptus bullah** pile of 20 cm. to 30 cm. diameter with half lap joints (lap length at least 90 cm long) with 3 nos. of collars made of 50 mm. x 6 mm. M.S. Flat, clamps, bolts and nuts and washers as per approved drawing and design.	each	528.00	538.00	
18.21	**Butt joining Sal-bullah / Eucalyptus bullah** piles of diameter from 20 cm. to 30 cm. inserting 25 mm. dia and 45 cm long M.S. Rod as dowel bar 22 cm. minimum at the centre of each bullah and fastened with 4 nos. 75 cm. long 65 mm. x 65 mm. x 10 mm. M.S. angles placed diametrically opposite to each other and fixed by nuts and bolts (16 mm. dia.)-8 nos. and washers being tied with 4 Nos. 50 mm. x 6 mm. M.S. Flat suitably profiled to grip the M.S. angle at upper and lower ends of M.S. angles fitted and fixed with nuts, bolts and washers etc. including coal-tarring two coats complete etc. as per, drawing and direction of the Engineer-in- Charge.	each	1625.00	1648.00	
18.22	**Sal-wood work rough dressed** including necessary hoisting and fitting, and fixing in position including cost of nails but excluding cost of bolts, nuts and washer in Bridge Work excluding Bridge Floor.	cum	55160.00	55160.00	
18.23	**Sal-wood work rough dressed in bridge floor** fitted and fixed with patent or round headed nails including cost of materials and fittings.	cum	62150.00	62150.00	
18.24	**Labour for Sal-wood work undressed** in scantling in bridge floor, railing post, wheel guard including cost of supply of bolts, nuts, washers etc. as directed.	cum	2544.00	2544.00	
18.25	**Labour for Sal-wood** work in bridge members **with old timber** including cutting out rotten portion sizing, dressing, cutting to sizes, taking out nails etc. complete with supply of new snap headed country nails.	cum	2324.00	2324.00	
18.26	**Taking out Sal-bullah / Eucalyptus piles** from river bed or from elsewhere including carrying stacking materials in the nearest stack yard.				
	(a) Up to 17.5 cm. diameter.	m	11.80	11.80	
	(b) Above 17.5 cm. and up to 25 cm. diameter	m	14.10	14.10	
18.27	**Coal tarring** on wooden surfaces including cost of materials				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(a) Double coat.	sqm	36.00	38.00	
	(b) Single coat	sqm	22.00	23.00	
18.28	**Supplying empty Cement bags** in good condition.	100 Nos.	330.00	330.00	
18.29	**Filling empty Cement bags** with dry earth or sand, stitching the bag (cost of thread included) and carrying and placing them in position and all incidental charges complete but excluding cost of sand and gunny bags.	100 bags	350.00	350.00	
18.30	**Weaving wire mattress** as directed with wire of 4mm dia. and making sausage crate of required shape after tying all intersections including joining longitudinal ends, closing ends of sausage, carriage of wire to site of work complete in all respect as per direction of the Engineer-in-charge **including cost of supply of G.I. wire.** (With 100mm x 100mm mesh.)	sqm	201.00	201.00	
18.31	**Filling properly the empty sausage crates** with boulders of any size & shape with hand packing after preparation of bed of placement, placing the crate in position, carriage of boulders from road stacks with a lead upto 150m etc. complete in all respect including stitching the rest of the crate with wire (passage for filling boulders) after filling up the crate with boulders and launching the crate in position if necessary and as directed by the Engineer-in charge. [Rate provided is **exclusive** of the cost of stone boulders and sausage crate]	cum	431.00	426.00	
18.32	**Masonry work** with rough dressed **Stones** of size as directed with cement mortar, true to line, level and shape, including dressing and shaping boulders to size as required, curing complete including cost and carriage of all materials complete.				
	(a) With cement-sand mortar 1 : 6				
	(i) In Road &Jhora Work	cum	1591.00	-	
	(ii) In Bridge & Culvert Work	cum	1639.00	-	
	(b) With cement-sand mortar 1 : 4				
	(i) In Road &Jhora Work	cum	1833.00	-	
	(ii) In Bridge & Culvert Work				
	1) Upto height 4.0 m	cum	1904.00	-	
	2) Height above 4.0 m	cum	2010.00	-	
Note:	Construction wing is to add cost and carriage of 1.25 cu.m. of laterite / stone only to arrive at consolidated rate.				
18.33	**Brick pavement** with 1st class / picked jhama bricks (as per direction of Engineer in charge) with joints set closed in cement mortar 1:6 including preparation of bed by cutting or filling with ramming the filled up earth to the same profile as that of the finished pavement. Rate is inclusive of cost of supply of all materials, labour and all incidental charges in this connection.				

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
	(a) When laid with a cushion of sand below including cost thereof:				
	(i) One brick flat pavement.	sqm	377.00	501.00	
	(ii) One brick on edge pavement.	sqm	567.00	746.00	
	(iii) One brick on edge pavement laid in herring bone bond pattern	sqm	591.00	770.00	
	(b) When laid in cement mortar (1:6) on the underside as well.				
	(i) One brick flat pavement.	sqm	427.00	554.00	
	(ii) One brick on edge pavement.	sqm	620.00	801.00	
	(iii) One brick on edge pavement laid in herring bone bond pattern	sqm	651.00	833.00	
18.34	**Painting with approved quality Curing compound** on the vertical or inclined surfaces of concrete, where water curing is not possible. Painting is to be done with a brush on new surfaces, immediately after removal of shuttering, including supply of all materials and other incidental charges complete as per direction of the Engineer-in-charge.	sqm	38.50	38.50	
18.35	**Painting** with approved synthetic enamel paint **Circular panel** (upto 30cm dia.) or **Rectangular panel** (size 38cm to 30cm x 25cm to 20cm) including the Load classification number or the number of bridge or culvert painted thereon in a different colour, complete as directed by Engineer-in-charge.	sqm	55.00	55.00	
18.36	**Painting (one coat) to Sal bullah Guard post** with 6 nos. of 16cm wide horizontal alternate band with white/Tannery yellow and black with best quality synthetic enamel paint of approved make and brand after fixing old existing guard post in correct position true to line and level with repacking the ground at base properly complete in all respect.	each	54.30	54.30	
18.37	**Close Bamboo Walling** made of 65mm to 75mm dia. bamboos (in single line) driven about half-length into the ground side by side, with stout stays at an interval of 1m, 3nos. of half split bamboo runner of same dia fitted and fixed with nails etc. complete as per direction. (Measurement to be taken along the length of piling after finishing the works).				
	(i) With bamboos of length upto 2.00m	metre	448.00	448.00	
	(ii) With bamboos of length above 2.00m and upto 2.50m	metre	517.00	517.00	
	(iii) With bamboos of length above 2.50m and upto 3.00m	metre	587.00	587.00	

Item No.	Description of Items	Unit	All districts of West Bengal and Darjeeling Plain of Siliguri Sub-Division Rate (₹)	Darjeeling Hill Area Rate (₹)	Remarks
18.38	**Bamboo Pile Walling** made of 6.5cm to 7.5cm dia bamboo (in single line) driven about half-length into ground at very close spacing of 30cm c/c side by side, with stout stays at an interval of 90cm fixed with bamboo post of length 1.25m driven 1m below G.L., 3 nos. of half split bamboo runner of same dia fitted and fixed with nails etc. and lining exposed portion with sheets made from cut drums (empty bitumen drums) fitted and fixed with a lap width of 100 mm at each joint, complete as per direction including the cost of drum sheets and including the cost of nails, wires etc.				
	(i) With bamboos of length upto 2.00m	metre	526.00	526.00	
	(ii) With bamboos of length above 2.00m and upto 2.50m	metre	626.00	626.00	
	(iii) With bamboos of length above 2.50m and upto 3.00m	metre	735.00	735.00	
18.39	**Drum Sheet Walling 1.40m (av.) high on Sal-bullah / Eucalyptus bullah piling** 10 cm dia. and 3.25m long driven 1.75m (av.) below G.L. and 75cm centre to centre including fitting fixing 3 nos. of half bullah pieces (from 10 cm dia) and drum(empty bitumen) sheet (approved condition) of height 1.5m , cutting and straightening drum sheet (each joint must have lap length of min.50mm) including cost of necessary nails, bolts, nuts etc. and providing 2 to 3m long half bullah ties of 10cm dia. @ 2.25 m centre to centre fixed with 10 cm dia. bullah posts driven 1.5m below G.L. including cost of all materials and one coat of coal tarring to all bullah etc. complete as per direction.				
	(i) Using Eucalyptus bullah	metre	1244.00	-	
	(ii) Using Sal-bullah	metre	1569.00	1569.00	
18.40	**Painting on concrete surface** Providing and applying 2 coats of cement washing with admixture of pigment if necessary as directed by Engineer-in-charge to unplastered concrete surface after cleaning the surface of dirt, dust, oil, grease, efflorescence and using cement @ 2.50 kg per 10 sqm. of surface.	sqm	18.30	18.30	
18.41	Labour for fitting and fixing 10 cm. to 13 cm. diameter Sal-bullah/Eucalyptus-bullah as ties and runners including necessary nails, bolts and nuts.	metre	20.60	20.60	

APPENDIX – I

DISTANCES FROM HALDIA REFINERY TO DIFFERENT DEPARTMENTAL GODOWN / STACKYARD UNDER P. W. (ROADS) DIRECTORATE

Sl. No.	Divisions / Departmental godowns	Distances (km) by road from Haldia
1.	**Barasat Highway Division No. – I**	
	a) Baguihati	*129*
	b) Basirhat	*186*
	c) Barasat	*143*
2.	**Barasat Highway Division No. – II**	
	a) Barasat	*143*
	b) Habra	*167*
	c) Bongaon	*196*
	d) Gaighata	*179*
3.	**Diamond Harbour Highway Division**	
	a) Diamond Harbour	*161*
	b) Kakdwip	*204*
	c) Lakshmikantapur / Karbala	*171*
	d) Chakdah	*163*
	e) Falta (EPZ)	*163*
	f) Namkhana	*218*
4.	**24 Parganas Highway Division**	
	g) Canning	*166*
	h) Baruipur	*140*
5.	**Howrah Highway Division & NH Division No. - I**	
	a) Amta	*80*
	b) Kona	*100*
	c) Eksara	*109*
	d) Jagatpur	*83*
	e) Mahisrekha	*72*
	f) Ankurhati	*103*
	g) Mrigola	*117*
6.	**Hooghly Highway Division No. – I**	
	a) Hooghly / Kidalia stackyard	*147*
	b) Srirampore	*128*
	c) Kalachara	*142*
	d) Sheakhala	*134*
	e) Jangipara	*146*
	f) Arambag	*147*
	g) Khanakul	*173*
	h) Ramjibanpur	*124*
	i) Kuntighat / Mogra	*153*
	j) Gurap	*177*
	k) Pandua	*167*
7.	**Hooghly Highway Division No. – II**	
	a) Bansberia / Borapara	*156*
	b) Bera	*138*
8.	**Nadia Highway Division No. – I**	
	a) Krishnanagar	*228*
	b) Majdia	*249*
	c) Palasi	*284*
	d) Chakdah	*184*
	e) Devagram	*273*

Sl. No.	Divisions / Departmental godowns	Distances (km) by road from Haldia
9.	**Nadia Highway Division No. – II**	
	a) Kalyani	*161*
	b) Ranaghat	*194*
10.	**Murshidabad Highway Division No. – I**	
	a) Berhampore	*323*
	b) Beldanga	*302*
11.	**Murshidabad Highway Division No. – II**	
	a) Berhampore	*323*
	b) Kandi	*352*
	c) Kuli	*359*
	d) Salar	*380*
	e) Palsunda	*340*
12.	**Malda Highway Division & NH Division - VII**	
	a) Malda	*458*
	b) Narayanpur (NH-VII)	*466*
	c) Mangalbari	*461*
	d) Gajole	*487*
	e) Chanchol	*524*
	f) Kaliachak	*435*
	g) Manikchak Ghat	*494*
	h) Samsi	*511*
	i) Farrakka (NH-VII)	*426*
	j) Umerpore More	*373*
	k) Raghunathgunj	*377*
13.	**Birbhum Highway Division**	
	a) Suri	*302*
	b) Bolpur	*276*
	c) Rampurhat	*348*
	d) Nalhati	*364*
	e) Kirnahar	*277*
14.	**Bankura Highway Division**	
	a) Bishnupur	*175*
	b) Bankura / Natunchati	*209*
15.	**Purulia Highway Division & NH Division - III**	
	a) Purulia	*290*
	b) Hura	*259*
	c) Balarampore	*320*
	d) Manbazar	*250*
16.	**North Dinajpur Highway Division**	
	a) Raigunj	*534*
	b) Kaliagunj	*549*
	c) Islampore	*643*
17.	**South Dinajpur Highway Division**	
	a) Balurghat	*570*
	b) Buniadpore	*518*
	c) Dalkhola	*583*
	d) Kushmandi	*529*
	e) Karnajhora	*539*
18.	**Darjeeling Highway Division**	
	a) Siliguri	*716*
	b) Matigara	*712*
	c) Saktigarh	*716*
19.	**Coochbehar Highway Division & NH Division - X**	
	a) Coochbehar	*855*
	b) Mathabhanga	*825*
	c) Silbari (Coochbehar NH Sub-Division)	*863*
	d) Moratorsha	*855*

Sl. No.	Divisions / Departmental godowns	Distances (km) by road from Haldia
20.	**Jalpaiguri Highway Division & NH Division - XI, X**	
	a) Jalpaiguri	*760*
	b) Moynaguri	*771*
	c) Lataguri	*789*
	d) Dhupguri	*791*
	e) Falakata (NH-XI)	*814*
	f) Gayerkata	*864*
	g) Hasimara (NH-X)	*843*
	h) Madarihat (NH-X)	*831*
	i) Malbajar	*770*
21.	**Burdwan Highway Division No. – I**	
	a) Burdwan (Sadarghat)	*193*
	b) Nabadwip	*217*
	c) Kalna	*193*
	d) Jamuria	*285*
	e) Memary	*189*
	f) Guskara	*223*
22.	**Burdwan Highway Division No. – II & NH Division –III**	
	a) Durgapur (NH)	*254*
	b) Asansole	*294*
	c) Rayna	*192*
	d) Khandaghosh	*194*
	e) Samudragarh	*206*
23.	**Burdwan Highway Division No. – III & NH Division –III**	
	a) Bhatar	*209*
	b) Katwa	*247*
	c) Ramjibanpore	*274*
	d) Ketugram	*265*
	e) Nandan Ghat	*219*
	f) Panagarh (NH-III)	*240*
	g) Shaktigarh (NH-III)	*179*
24.	**Tamluk Highway Division**	
	a) Tamluk	*45*
	b) Contai (Kanthi)	*80*
	c) Norghat	*35*
25.	**Midnapore Highway Division No. – I**	
	a) Midnapore	*112*
	b) Baliachak	*84*
	c) Bagnan	*67*
	d) Chaitanyapur	*18*
	e) Chandrakona Road	*135*
	f) Kharagpur	*108*
	g) Krishnanagar (Kharagpur)	*100*
	h) Mahisrekha	*72*
	i) Panskura	*62*
26.	**Midnapore Highway Division No. – II**	
	a) Midnapore	*112*
	b) Jhargram	*155*
	c) Garbeta	*147*
	d) Debra	*82*
	e) Lodha Suli	*140*
	f) Belda	*136*
	g) Egra	*109*

APPENDIX – II

DISTANCES FROM QUARRIES OF STONE AGGREGATES AND RIVER BED LOCATIONS OF SAND

(A) QUARRY LOCATIONS :		
Name of Quarries	Initial leads (km) by road	
	From quarry to	Lead
Rampurhat (Birbhum)	Rampurhat Railway Station	14
	Moregram Junction (232 kmp of NH-34)	50
	Panagarh (513 kmp of NH-2)	129
Nalhati (Birbhum)	Nalhati Railway Station	6
Panchami (Birbhum)	Panchami More (Suri-Rampurhat Road)	12
	Moregram Junction (232 kmp of NH-34)	81
	Panagarh (513 kmp of NH-2)	98
Dhadka (Burdwan)	Asansol Town (462 kmp of NH - 2)	2
Hura (Lalpur More) (Purulia)	Purulia Town (90 kmp of NH-32)	30
Puncha / Laulara (Purulia)	Purulia Town (90 kmp of NH-32)	50
Barabazar	Purulia Town (90 kmp of NH-32)	30
Malti / Balarampur (Purulia)	Purulia Town (90 kmp of NH-32)	32
	Balarampur (126 kmp of NH-32)	4
(B) RIVER BED LOCATIONS :		
Name of Sources	**Initial leads (km) by road**	
	From source to	**Lead**
Dudhia River Bed	69 kmp of NH - 55	23
Jaldhaka River bed	115 kmp of NH - 31C	6
Upper Basra River bed	182 kmp of NH - 31D	30
Bhutanghat River bed	226 kmp of NH-31C	43
Balason River bed	570 kmp of NH-31	6
Pagli River bed	718 kmp of NH - 31	12
Shilbari River bed	718 kmp of NH - 31	16
Kajli River bed	202 kmp of NH-31C	10

APPENDIX - III

SIGN OF DISTRESS, PROBABLE CAUSES AND SUGGESTED MEASURE IN BITUMINOUS PAVEMENT

Sl.	Type of Distress	Sign of distress	Probable causes	Suggested treatment
A.	**Surface Defects –**			
	1. Fatty surface	Collection of binder on the surface.	Excessive binder in premix, spray or tack coat, loss of cover to aggregates; excessively heavy axle loads.	Sand blinding; open-graded premix; liquid seal coat.
	2. Smooth surface	Slippery	Polishing of aggregates under traffic, or excessive binder.	Resurfacing with surface dressing or premix carpet.
	3. Streaking	Presence of alternate lean and heavy lines of bitumen.	Non-uniform application of bitumen or at a low temperature.	Application of a new surface.
	4. Hungry surface	Loss of aggregates or presence of fine cracks.	Use of less bitumen or absorptive aggregates.	Slurry seal or fog seal.
B.	**Cracks –**			
	1. Hair-line cracks	Short and fine cracks at close intervals on the surface.	Insufficient bitumen, excessive filler or improper compaction.	The treatment will depend on whether pavement is structurally sound, or unsound. Where the pavement is structurally sound, the cracks should be filled with a low viscosity binder or a slurry seal or fog seal depending on the width of cracks. Unsound cracked pavements will need strengthening or rehabilitation treatment.
	2. Alligator cracks	Inter-connected cracks forming a series of small blocks.	Weak pavement, unstable conditions of subgrade or lower layers, excessive over loads or brittleness of binder.	
	3. Longitudinal crack	Crack on a straight line along the road.	Poor drainage, shoulder settlement, weak joint between adjoining spreads of pavement layers or differential frost heave.	
	4. Edge crack	Crack near and parallel to pavement edge.	Lack of support from shoulder, poor drainage, frost heave, or inadequate pavement width.	
	5. Shrinkage cracks	Cracks in transverse direction or inter-connected cracks forming a series of large blocks	Shrinkage of bituminous layer with age.	
	6. Reflection cracks	Symmetrical cracks over joints and cracks in the pavement underneath.	Due to joints and cracks in the pavement underneath.	
C.	**Deformation –**			
	1. Slippage	Formation of crescent-shaped cracks pointing in the direction of the thrust of wheels.	Usual thrust of wheel in a direction, lack or failure of bond between surface and lower pavement courses	Removal of the surface layer in the affected area and replacement with fresh material.
	2. Rutting	Longitudinal depression in the wheel tracks.	Heavy channalised traffic inadequate compaction of pavement layers, poor stability of pavement material, or heavy bullock-cart traffic.	Filling the depressions with premix material.
	3. Corrugations	Formation of regular undulations	Lack of stability in mix, oscillations set up by vehicles, springs, or faulty laying of surface course.	Scarification and relaying of surfacing, of cutting of high spots and filling of low spots.

Sl.	Type of Distress	Sign of distress	Probable causes	Suggested treatment
	4. Shoving	Localized bulging of pavement surface along the crescent-shaped cracks.	Unstable mix, lack of bond between layers, or stop type movements and those involving negotiation of curves and gradients.	Removing the material to firm base and relaying a stable mix.
	5. Shallow depression	Localized shallow depressions	Presence of inadequately compacted pockets.	Filling with premix materials.
	6. Settlement and upheaval	Large deformation of pavement	Poor compaction of fills, poor drainage, inadequate pavement or frost heave.	Where fill is weak the defective fill should be excavation and re-done. Where inadequate pavement is the cause, the pavement should be strengthened.
D.	**Disintegration –**			
	1. Stripping	Separation of bitumen from aggregate in the presence of moisture	Use of hydrophilic aggregate, inadequate mix composition, continuous contact with water, poor bond between binder and aggregate, poor compaction, etc.	Spreading and compacting heated sand over the affected area in the case of surface dressing; replacement with fresh bituminous mix with added anti-stripping agent in other cases.
	2. Loss of aggregate	Rough surface with loss of aggregate in some portions	Ageing and hardening of binder, stripping poor bond between binder and aggregate insufficient binder, brittleness of binder, etc.	Application of liquid seal, fog seal, or slurry seal depending on the extent of damage.
	3. Raveling	Failure of binder to hold the aggregate shown up by pock marks or eroded areas on the surface.	Poor compaction, poor bond between binder and or aggregate insufficient binder, brittleness of binder, etc.	Application of cutback covered with coarse sand, or slurry seal, or a premix renewal coat.
	4. Pothole	Appearance of bowl-shaped holes, usually after rain.	Ingress of water into the pavement, lack of bond between the surfacing and WBM base, insufficient bitumen content, etc.	Filling potholes with premix material or penetration patching.
	5. Edge breaking	Irregular breaker of pavement edges	Water infiltration poor lateral support from shoulders, inadequate strength of pavement edges, etc.	Cutting the affected area to regular sections and re-building with simultaneous attention paid to the proper construction of shoulders.

Appendix - IV
(Refer Clause 2.26.2.4)

Table A.1-1 Specification for Antistripping Compound

S.No.	Test	Method	Limit
1.	Appearance	Visual	Liquid/Solid
2.	Odour	Smelling	Agreeable
3.	Specific gravity 27°C	15:1202-1978	0.860-1.03
4.	Pour point °C Maximum	IS:1448	42
5.	Flash Point °(COC) Minimum	IS:1448	150
6.	Water Content percent Vol. Maximum	IS:1448	1.0
7.	Solubility in diesel oil (HDO or LDO) in the ratio of 2:98 at 50°C	As given at the end of Appendix	Complete
8.	Total base value mg KOH/g minimum	ASTM D 664	200
9.	Nitrogen content percent Wt. minimum	Elemental Analyser	7.0
10.	Stripping value with bitumen containing 1 percent Wt. antistripping compound at 40°C 24 hours	IS:6241 As given at the end of Appendix	No stripping
11.	Under water coating test	-do-	Complete Coating
12.	Thermal stability at 163°C 5 hours	-do-	Should not lose its efficiency
13.	Boiling water test percent minimum coating	ASTM D 3625	95
14.	Retained Marshall Stability percent minimum	As given at the end of appendix	75

Table A.1-2 Tentative Recommended Minimum Dose of Antistripping Agent for Sprayed Work

Aggregate stripping value	Dose of antistripping agent in percent by weight of			
	Surface dressing with precoated aggregate	Pentration Macadam/Built up spray grout	Surface Dressing with uncoated aggregate	Liquid seal coat
0-25	0.5	0.6	0.7	0.8
25-50	0.6	0.7	0.8	1.0
50-100	0.75	1.0	1.0	1.0

Table A.1-3 Tentative Recommended Minimum Dose of Antistripping Compound in Bitumen Premix Works

Stripping value of aggregate	Dose of antistripping agent in percent by weight of bitumen		
	Voids content 3-5 percent	Voids content 5-10 percent	Voids content 10-15 percent
0-25	0.3	0.4	0.5
25-50	0.4	0.5	0.6
50-100	0.6	0.8	1.0

Appendix - V
(Refer Clause 2.49.8)

GROUTING RECORD

Job Name:

Span No. Cable No.

Date of Cable Installation: Date of Grouting:

Type of Cement: OPC/II ISOPC Week and Year of Manufacture of OPC/II ISOPC

W/C Ratio: Name and amount of admixture used, if any

Temperature: Mixing water : Grout

Time: Start : Finish

Equipment: Grout mixture : Grout pump = _____

Cable duct: Diameter _____ Length

Volume of grout in litres _____ Regrouting

Grouting pressure:

Cement consumption: Theoretical : Actual

Pre-grouting checks:

Free of blockage	Inlet:	Yes/No	:	Outlet:	Yes/No
	Vents:	Yes/No	:	Cable duct:	Yes/No

Leakage observed: Yes/No Sealed: Yes/No

If cable duct blocked: Remedial Measures

Grouting observations:

Passage of grout through vents : Yes/No

Passage of grout through outlet : Yes/No

Any equipment failure

Post grouting checks :

Probbing by stiffwire :

Remarks

Signatures of officers present during grouting :

Client Collector System supplier

Appendix - VI
(Refer Clause 2.45.7.1)

HISTORY OF SINKING Of WELL NO. _____

LOWEST BED LEVEL _____ LOWEST WATER LEVEL _____ HIGHEST FLOOD LEVEL _____ FOUNDING LEVEL _____

HEIGHT OF CURB _____ HEIGHT OF CUTTING EDGE _____

DATE	STEINING					SINKING					DEPTH OF SUMP BELOW CUTTING EDGE (METRE)	STRATA MET WITH	KENTLEDGE			QUANTITY OF DREDGED MATERIAL (CUBIC METRE)	REPORT REGARDING OBSTACLES OR SAND BELOW DURING SINKING	REPORT ANY SPECIAL METHOD OF SINKING EMPLOYED	REMARKS	SIGNATURE OF SUPERVISING OFFICER
	REDUCED LEVEL (RL) OF BOTTOM OF CUTTING EDGE	RL OF TOP OF STEINING BEFORE CASTING	RL OF TOP OF STEINING AFTER CASTING	HEIGHT OF STEINING CAST (COL.4-COL.3) (METRE)	TOTAL HEIGHT OF STEINING (INCLUDING) CURB AND CUTTING EDGE (COL.4-COL.3) METRE	RL.OF REFERENCE LEVEL (AT WHICH CUTTING EDGE IS PLACED)	INITIAL GAUGE READING (METRE)	FINAL GAUGE READING (METRE)	SINKING DURING THE DAY (COL9-COL.8) METRE	RL OF BOTTOM OF CUTTING EDGE (CO1.7-COL.8) METRE			WEIGHT (TONNES)	ECCENTRICITY ALONG X AXIS (METRE)	ECCENTRICITY ALONG Y-AXIS (METRE)					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Appendix - VII
(Refer Clause 2.45.7.10)

TILT AND SIIIFT IN WELL NO.:

DATE	TOTAL STE1NING (METRE)	TOTAL SINKING (METRE)	REDUCED LEVELS (RL'S) OF GAUGE MARKS						TILT ALONG X-AXIS COLUMN 6 DIVIDED BY WELL DIA	TILT ALONG Y - AXIS COLUMN 9 DIVIDED BY WELL DIA	RESULTANT TILT $\sqrt{(COL.10^2 + COL.11^2)}$	SHIFT			ACTION TAKEN FOR RECTIFICATION	REMARKS	SIGNATURE OF SUPERVISING OFFICER	
			ALONG X - AXIS				ALONG Y - AXIS					ALONG X-AXIS WITH DIRECTION (METRE)	ALONG Y AXIS WITH DIRECTION (METRE)	RESULTANT $\sqrt{S (COL.13^2) + \{(COL\ 14^2)\}^{1/2}}$ (METRE)				
			(PLACE) END	(PLACE) END	DEFERENCE (COL.5-COL-4) (METRE)	(U/S)	(D/S)	DEFERENCE (COL.8-COL.7) (METRE)										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

Appendix - VIII
(Refer Clause 2.49.3.2)

PRESTRESSING REPORT:

NUMBER OR NAME OF THE BRIDGE: SPAN No. _____ Stressing Sequence Drg. No. Left end of Cable = A

Right end of Cable = B

Ave. Cube Strength at the time of stressing : _____kg/cm² ELEMENT / GIRDER No. _____ Marks of Plant Used Jacks : Specified Gauge Pressure During Jacking

High Tensile Steel (UTS) _____kg/cm² LAST DATE OF CONCRETING _____ Pumps :

Cube Strength : at 28 days _____ kg/cm² DATE OF PRESTRESSING _____ Gauges :

Max-Jack Pressure not to exceed under any circumstances _____ kg/cm²

COLUMNS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Cable Stressing Sequence		Calculated Elongation mm		Gauge Mark Readings of extension in mm at the pressure of 100 kg/cm²			Gauge Mark Readings of extension in mm at the pressure of 200 kg/cm²			Reading at Instant of Locking					INITIAL ELONGATION upto 100 kg/cm² e6 = (e4 – e3) mm	TOTAL ELONGATION e7 = e5 – e3 + e6 mm	DEVIATION e1 – e7 MM	SLIP (Draw-in) mm					NET ELONGATION e8 = e7 – S mm	DEVIATION After Draw-in e2 – e8 mm	% Excess or shortfall in deviation after draw in $\frac{e2-e8 \times 100}{e2}$	Remarks
																	Immediately after locking		After 24 Hrs.		Total Draw-in				
Sequence	Cable MKD	Before Draw-in e1	Before Draw-in e2	Δ Ao	Δ Bo	e3 - Δ Ao + Δ Bo	Δ A1	Δ B1	e4 = Δ A1 + Δ B1	Δ A2 mm	PA kg/cm²	Δ B2 mm	PB kg/cm²	e5 = Δ A2 + Δ B2 mm				SAo	SBo	SA_{24}	SB_{24}	S = SAo + SBo + SA_{24} + SB_{24}				

Signature of Officers present during prestressing :

Client Collector System supplier

APPENDIX – IX

Table - XII.1 Area & linear weights of common reinforcement bars:

Diameter of bar (mm)	Cross sectional area (cm^2)		Weight per meter length (kg / m)	
	M.S. Bars	H.Y.S.D. Bars	M.S. Bars	H.Y.S.D. Bars
6	28.27	28.30	0.222	0.222
8	50.26	50.30	0.390	0.395
10	78.54	78.50	0.616	0.617
12	113.10	113.10	0.888	0.888
16	201.06	201.10	1.578	1.579
20	314.16	314.20	2.466	2.467
22	380.13	380.10	2.984	2.985
25	490.87	490.90	3.853	3.855
28	615.75	615.70	4.834	4.836
32	804.24	804.20	6.313	6.316
36	1017.88	1017.90	7.990	7.994
40	1256.64	1256.60	9.865	9.869

Table - XII.2 Conversion factors for Linear Measurements:

To convert	To	Conversion factor	To convert	To	Conversion factor
millimeter	inch	0.03937	mile	kilometer	1.60934
Inch	millimeter	25.4000	kilometer	mile	0.62137
meter	foot	3.28084	centimeter	inch	0.39370
foot	meter	0.30480	meter	yard	1.09361
yard	meter	0.91440	mile	yard	1760.00

Table - XII.3 Conversion factors for Weight:

To convert	To	Conversion factor	To convert	To	Conversion factor
kilogram	pound	2.20459	ton	metric ton	1.01606
pound	kilogram	0.45360	metric ton	ton	0.98419
Metric ton (tonne)	kip (kilo pound)	2.20459	ton	pound	2240.00
kip	Metric ton	0.45360	ton	kilogram	1016.06

Table - XII.4 Conversion factors for Area:

To convert	To	Conversion factor	To convert	To	Conversion factor
centimeter ^{2}	inch ^{2}	0.15500	acre	hectare	0.40467
inch ^{2}	centimeter ^{2}	6.45160	hectare	acre	2.47113
meter ^{2}	foot ^{2}	10.76391	meter ^{2}	hectare	0.00010
foot ^{2}	meter ^{2}	0.09290	sq. mile	sq. kilometer	2.58998

Table - XII.5 Conversion factors for volume:

To convert	To	Conversion factor	To convert	To	Conversion factor
Imperial gallon	litre	4.54610	inch ^{3}	centimeter ^{3}	16.38706
US gallon	litre	3.76902	foot ^{3} (cft)	meter ^{3}	0.02832
foot ^{3} (cft)	litre	28.31685			

Table - XII.6 Conversion factors for density:

To convert	To	Conversion factor	To convert	To	Conversion factor
pound / cft	tonne / meter ^{3}	0.01602	gram / centimeter ^{3}	pound / cft	62.42691
pound / inch ^{3}	gram / centimeter ^{3}	27.6804	kilogram / meter ^{3}	pound / cft	0.06243

Appendix - X

LIST OF SOME INDIAN AND FOREIGN STANDARDS REFERRED IN THE SPECIFICATION

Number Designation	Title
(A) INDIAN STANDARDS	
IS: 73-1992	Paving Bitumen Specification (Second Revision)
IS: 226-1975	Structural Steel (Standard Quality) (Fifth Revision)
IS: 269-1989	Specification for 33 Grade Ordinary Portland Cement (Fourth Revision)
IS: 383-1970	Specification for Coarse and Fine aggregates from Natural Sources for Concrete (Second Revision)
IS: 460-1985 (Part 3)	Specification for Test Sieves: Part III Methods of Examination of Apertures of Test Sieves (Third Revision)
IS: 516-1959	Methods of Test for Strength of Concrete
IS: 961-1975	Structural Steel (High Tensile) (Second Revision)
IS: 1199-1959	Method of Sampling and Analysis of Concrete
IS: 1785-1983 (Part-1)	Specification for Plain, Hard Drawn Steel Wire for Prestressed Concrete: Part 1 Cold Drawn Stress Relieved Wire (Second Revision)
IS: 1785-1983 (Part-II)	Specification for Plain, Hard Drawn Steel Wire for Prestressed Concrete: Part 2 As Drawn Wire (First Revision)
IS: 1786-1985	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement (Third Revision)
IS: 1888-1982	Method of Load Test on Soils (Second Revision)
IS: 1892-1979	Code of Practice for Sub Surface Investigation for Foundations (First Revision)
IS: 2062-2006	Hot Rolled Low, Medium and High Tensile Structural Steel (Sixth Revision)
IS: 2090-1983	Specifications for High Tensile Steel Bars used in Prestressed Concrete(First Revision)
IS: 2131-1981	Method for Standard Penetration Test for Soils (First Revision)
IS: 2386-1963	Methods of Test for Aggregates for Concrete
(Part 1)	Particle size and shape
(Part 2)	Estimation of Deleterious Materials and Organic Impurities
(Part 3)	Specific Gravity, Density, Voids, Absorption and Bulking
(Part 4)	Mechanical Properties
(Part 5)	Soundness
(Part 6)	Measuring Mortar Making Properties of Fine Aggregates
(Part 7)	Alkali Aggregate Reactivity Test
(Part 8)	Petro graphic examination
IS: 2502-1963	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS: 3138-1966	Specifications for Hexagonal Bolts and Nuts
IS: 3812:1981	Specification for Fly Ash for Use as Pozzolana and Admixture (First Revision)
IS: 4826-1979	Hot Dipped Galvanised Coating on Round Steel Wires (First Revision)
IS: 5640-1970	Method for Determining the Aggregate Impact Value of Soft Coarse Aggregate
IS: 6003-1983	Specification for indented Wire for Prestressed Concrete (First Revision)
IS: 6006-1983	Specification for Uncoated Stress Relieved Strand for Prestressed Concrete (First Revision)

Number Designation	Title
IS: 9012-1978	Recommended Practice for Shotcreting
IS: 11587-1986	Structural Weather Resistant Steels
1S: 12269-1987	Specification for 53 Grade Ordinary Portland Cement
IS: 12330-1988	Specification for Sulphate Resisting Portland Cement
IS: 12594-1988	Hot Dip Zinc Coating on Structural Steel Bars for Concrete Reinforcement-Specification
IS: 13162 (Part-4)-1992	Geotextiles- Methods of Test-Part 4: Determination of Puncture Resistance by Falling Cone Method
IS: 13162 (Part-5)-1992	Geotextiles- Methods of Test-Part 5: Determination of Tensile Properties using a Wide Width Strip
IS: 15462-2004	Polymer and Rubber Modified Bitumen-Specification

(B) FOREIGN STANDARDS

ASTM 36	Standard Specifications for Carbon Structural Steel
ASTM E 810	Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting Utilizing the Coplanar Geometry
ASTM D: 2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM 2172	Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM 4280	Standard Specification for Extended Life Type, Non-plowable, Raised Retro-reflective Pavement Markers
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D-4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D: 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
ASTM D: 5581	Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen)
BS: 873-4:1973	Specification for the Construction of Road Traffic Signs and Internally Illuminated Bollards & Road Studs
BS1047	Specification for Air-cooled Blast Furnace Slag Aggregate for Use in Construction
BS1377	Methods of Test for Soils for Civil Engineering Purposes
BS 4483	Specification for Steel Fabric for the Reinforcement of Concrete.
BS 6088:1981	Specification for Solid Glass Beads for Use with Road Marking Compounds and for other Industrial Uses
BS: 7542	Method of Test for Curing Compounds for Concrete
BS EN ISO 9863-1:2005	Geosynthetics. Determination of Thickness at Specified Pressures. Single Layers
BS EN ISO 9864:2005	Geosynthetics. Test Method for the Determination of Mass per Unit Area of Geotextiles and Geotextile-Related Products.
BS 8006-1: 2010	Code of Practice for Strengthened / Reinforced Soil and other Fills.

Appendix - XI

Sample Abstract sheet to prepare Project cost Estimate

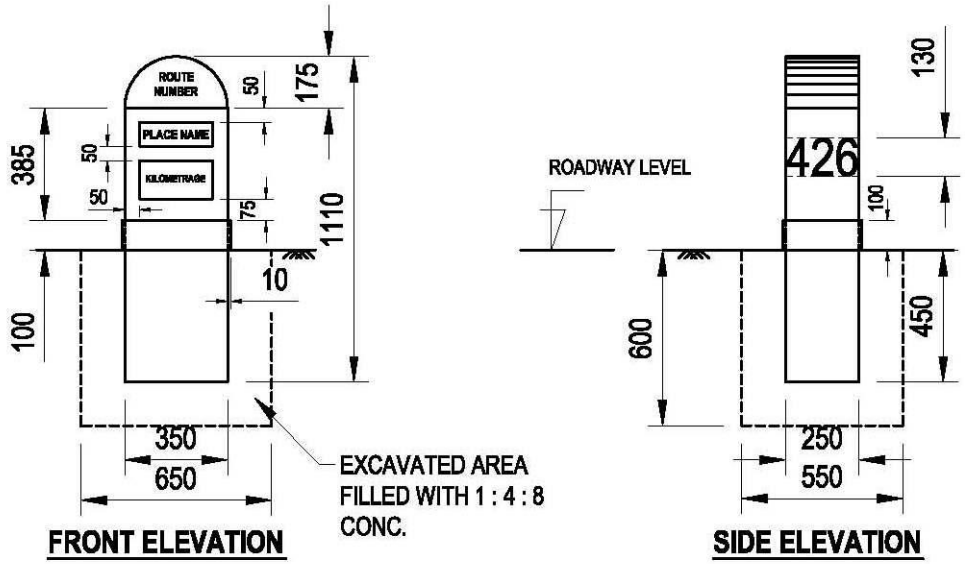
GENERAL ABSTRACT OF COST

Project Title: CONSTRUCTION OF PROPOSED .....

.....

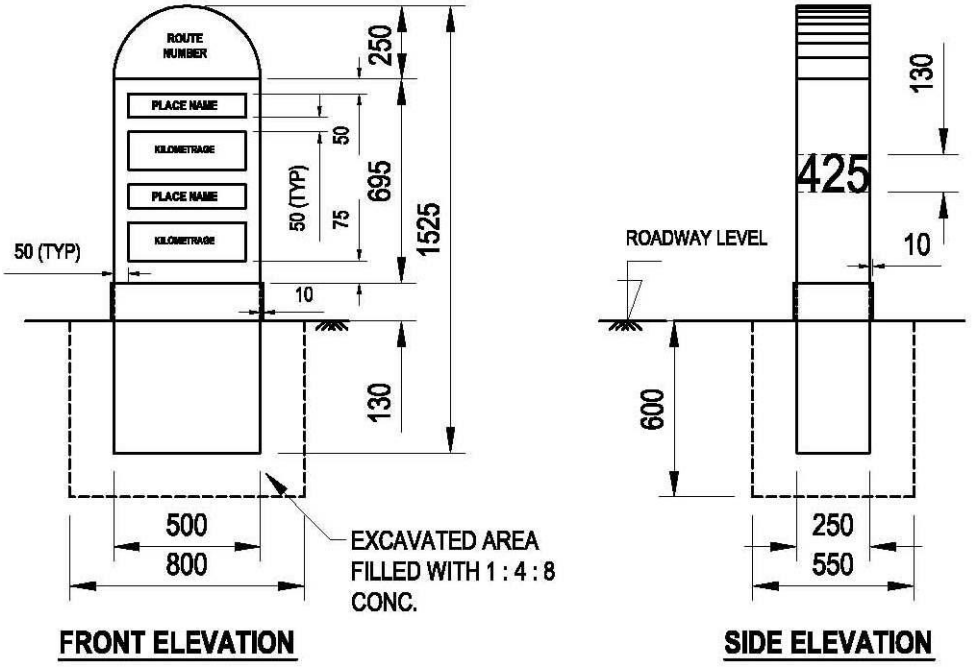
Sl. No.	Description	Amount (₹)
1	Cost for Bridge proper, Approach Viaduct & Retaining wall	X
2	Cost for Road Works	Y
3	Cost for Protective Work	Z
4	Sub-total Cost (1+2+3)	A = (X+Y+Z)
5	GST, as applicable on Sl. No. 4	B
6	Cost of civil works *excluding* labour welfare cess (4+5)	C = (A+B)
7	Labour welfare cess @1% on Sl. No. 6	D
8	Cost of civil works *including* labour welfare cess (6+7)	E = (C+D)

Note: Contingency charge (@ 3.00%) & Quality Control charge (@1.00%) / Supervision Consultancy charge (@ 2.50%) are to be considered on Sl. No. 6.



DETAIL OF ORDINARY KILOMETRE POST

(CONCRETE GRADE 1 : 2 : 4)

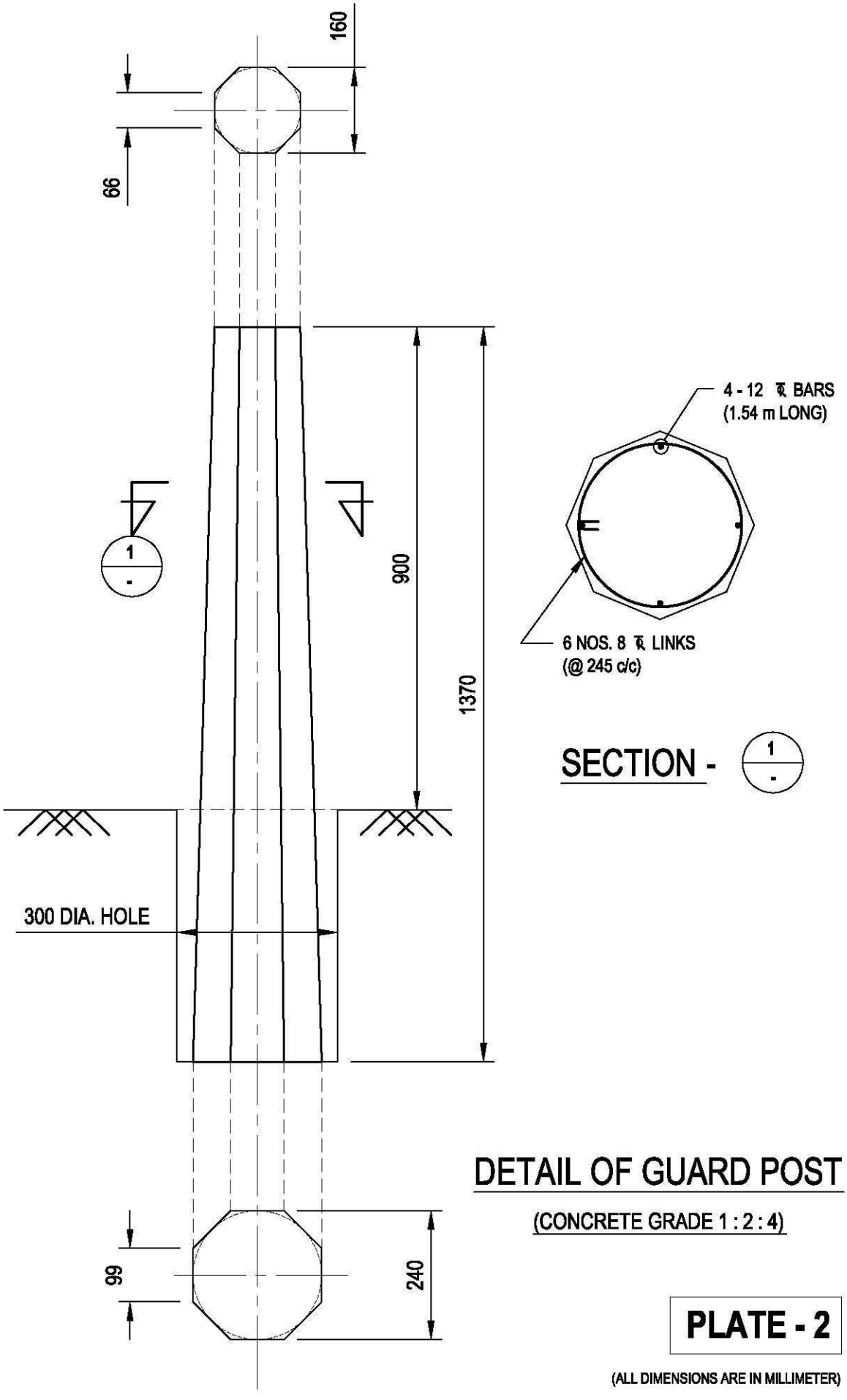


DETAIL OF 5TH KILOMETRE POST

(CONCRETE GRADE 1 : 2 : 4)

PLATE - 1

(ALL DIMENSIONS ARE IN MILLIMETER)



DETAIL OF GUARD POST

(CONCRETE GRADE 1 : 2 : 4)

PLATE - 2

(ALL DIMENSIONS ARE IN MILLIMETER)

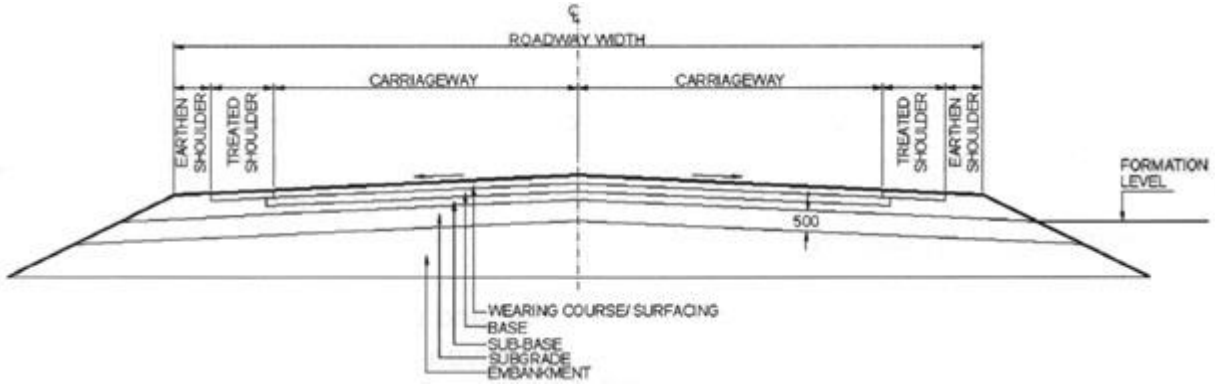


FIG. 1 TERMS USED IN THE SPECIFICATIONS TO DESCRIBE ROAD CROSS-SECTION ELEMENTS WITH A FLEXIBLE PAVEMENT

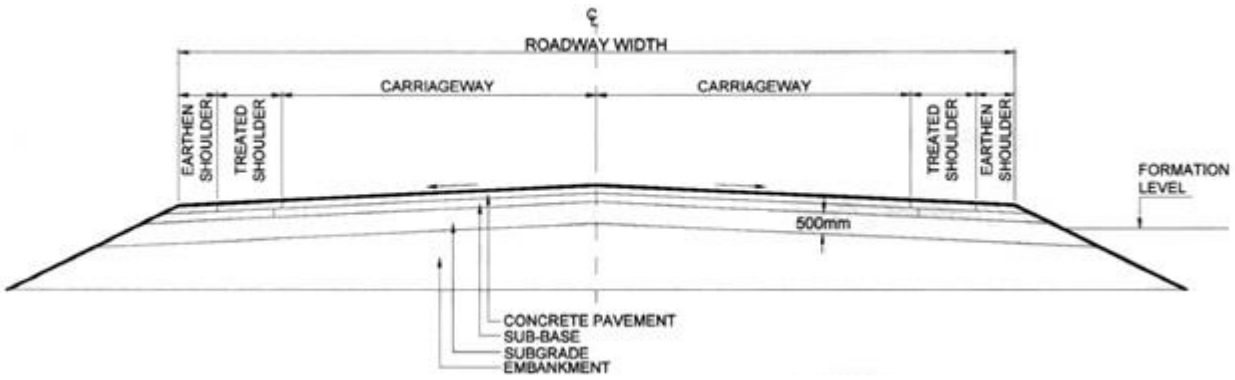


FIG. 2 TERMS USED IN THE SPECIFICATIONS TO DESCRIBE ROAD CROSS-SECTION ELEMENTS WITH A CONCRETE PAVEMENT

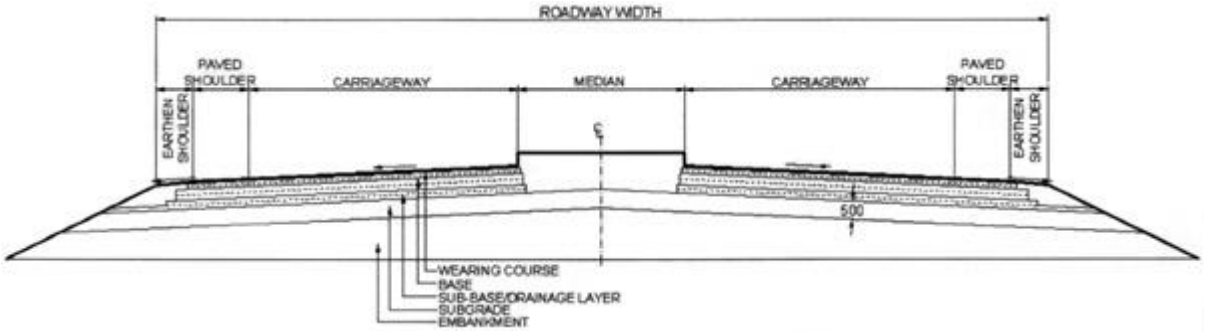


FIG. 3 TERMS USED IN THE SPECIFICATIONS TO DESCRIBE ROAD CROSS-SECTION ELEMENTS OF A DUAL CARRIAGEWAY