Ministry of Road Transport and Highways

SPECIFICATIONS FOR ROAD AND BRIDGE WORKS

(Up-gradation of Third Revision)

UPGRADED SECTION 500 AND ITS RELATED ASPECTS IN SECTIONS 900 AND 3000
(Addendum to Third Revision)

Published by the Indian Roads Congress on behalf of the Govt. of India, Ministry of Road Transport and Highways

Copies can be had from the Secretary, Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110 011.

NEW DELHI 2000 Price Rs. 200/-
Plus packing & postage charges

published : November, 2000

Printed at Dee Kay Printers, New Delhi-110015
2000 Copies

PREFACE TO THE THIRD REVISION

"Specifications for Road and Bridge Works" first published in 1973 has, already undergone two revisions in the past. With the advent of the externally aided projects based on international contract documents and modernisation of Highway Construction, it became necessary to revise the Specifications to be consistent with equipment based construction techniques. Many of these revised specifications were included in the bidding documents of individual projects. The specifications have now been completely revised incorporating all the changes required to take into account the latest construction practices and the suggestions received from various users, A few additional chapters on topics not covered earlier have also been added.

Revision of these specifications could be carried out in a short time only due to the concerted efforts of officers of the Roads Wing and the consultants who were intimately connected with this work, 1 wish to record my appreciation of the efforts put in by all concerned.

As with all specifications, the Third Revision of the Specifications will also no doubt need further updating in course of time. Feed back and suggestions for improvement would be welcome from all users of the document.

New Delhi
November, 1994.

M. V, SASTRY
Director General (Road Development)

CONTENTS

100

General

101. INTRODUCTION

These Specifications shall apply to all such road and bridge works As are required to be executed under the Contract or otherwise directed by the Engineer-in-charge (hereinafter referred to as the Engineer). In every case, the work shall be carried out to the satisfaction of the Engineer and conform to the location, lines, dimensions, grades and cross-sections shown on the drawings or as indicated by the Engineer. The quality of materials, processing of materials as may be needed at the site, salient features of the construction work and quality of finished work shall comply with the requirements set forth in succeeding sections. Where the drawings and Specifications describe a portion of the work in only general terms, and not in complete detail, it shall be understood that only the best general practice is to prevail, materials and workmanship of the best quality or to be employed and instructions of the Engineer are to be fully complied with.

A list of Indian roads Congress Specifications and Recommended Codes of Practice which have been made use of in the preparations of these Specifications is given at *Appendix-1*. The latest edition of all Specifications/Standards till 30 (thirty) days before the final date of submission of the tender, shall be adopted.

102. DEFINITIONS

The words like Contract, Contractor, Engineer (synonymous with Engineer-in-charge), Drawings, Employer, Government, Works and Work Site used in these Specifications shall be considered to have meaning as understood from the definitions of these terms given in the General Conditions of Contract.

The following abbreviations shall have the meaning as set forth below:

AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing and Material
BS	:	British Standard published by the British Standards Institution
CBR	:	California Bearing Ratio
IRC	:	Indian Roads Congress
IS	:	Indian Standard published by the Bureau of Indian Standards

The various elements in the cross-section of a road referred to in these Specifications are shown in the cross-sections in Figs. 100-1 and 100-2.

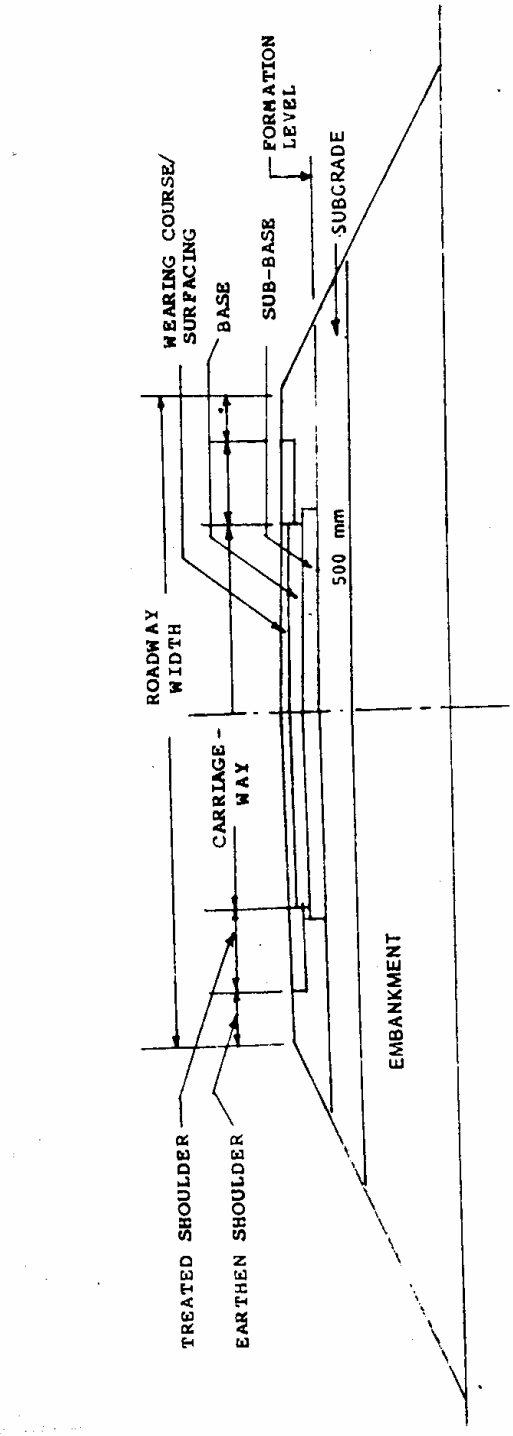


Fig.100.1: Terms used in the specifications to describe road cross-section elements with a flexible pavement.

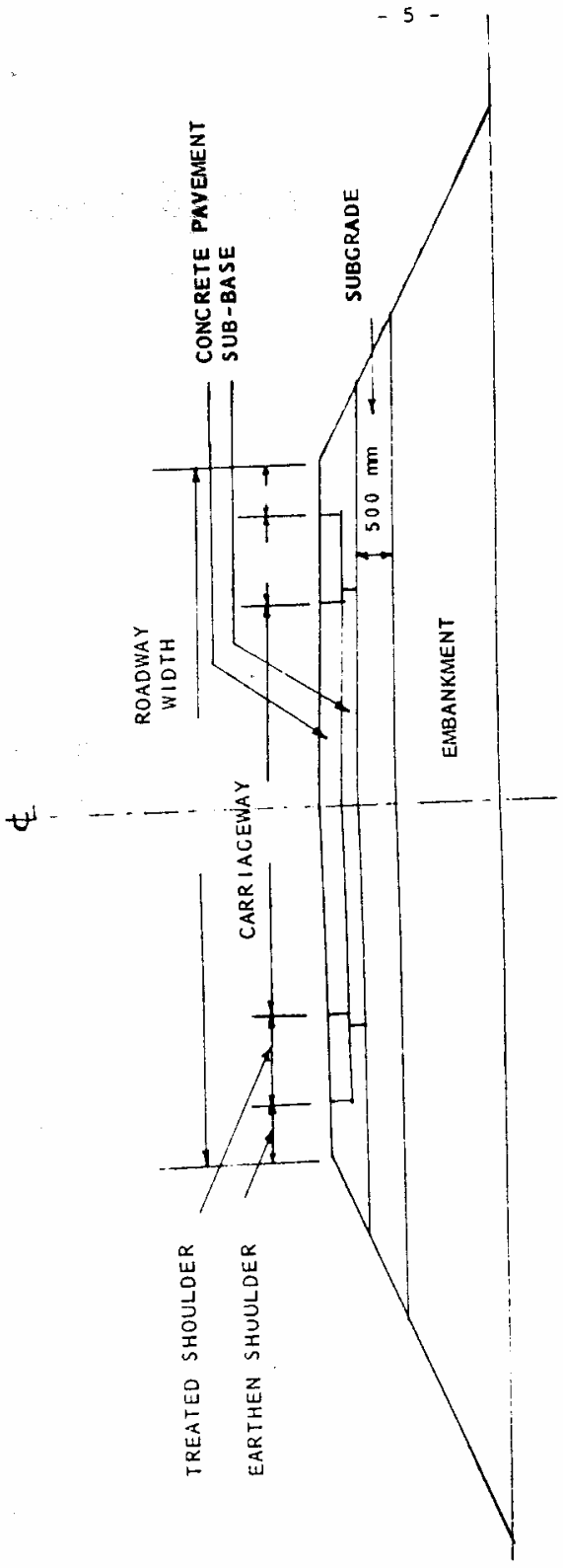


Fig.100.2: Terms used in the specifications to describe road cross-section elements with a concrete pavement

Treated shoulders shown in the cross-section shall be of two types:-

(i) "Head" shoulders which have select gravel/moorum, any other compacted granular layer of bricks.

(ii) "Paved" Shoulders which have a bituminous surfacing over granular layers

103. MATERIALS AND TEST STANDARDS

The relevant standards for materials, as well as the testing procedures, have been indicated at appropriate places in the Specifications. A list of these standards with their full title and the years of publication applicable is included at *Appendix-2*.

104. SIEVE DESIGNATIONS

The sieve designations referred to in the Specifications correspond to those specified by Bureau of Indian Standards in IS: 460. Table 100.1 gives the list of the commonly used IS sieves.

TABLE 100.1 DESIGNATIONS OF TEST SIEVES

(in mm)	(in micron)
* 128	850
106	
	* 710
* 90	600
75	
	* 500
* 63	425
53	355
	300
* 45	
37.5	* 250
	212
* 31.5	
26.5	* 180
	150
* 22.4	
19.0	* 125
	106
* 16.0	
13.2	* 90
	75
* 11.2	
9.50	* 63
	53
* 8.00	
6.70	* 45

*	5.60
	4.75
*	4.00
	3.35
*	2.80
	2.36
*	2.00
	1.70
*	1.40
	1.18
*	1.00

Note: 1. '*' are the principal sizes stated in ISO-565 and are preferred.
2. Sieve sizes given in BS:410 & ASTM-E 11 are same as in is:460.
3. Only sieves with square openings shall be used.

105. SCOPE OF WORK

105.1. The work to be carried out under the Contract shall consist of the various items as generally described in the Tender Documents as Well as in the Bill of Quantities furnished in the Tender Documents.

105.2. The works to be performed shall also included all general works preparatory to the construction of roads, bridges, canal crossings, drainage and all other related works. The works shall include work of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings and these Specifications and further drawings and orders that may be issued by the Engineer from time to time. The scope of work shall include whether specifically mentioned or not in the various clauses of these Specifications, all materials, apparatus, plant, equipment, tools, fuel, water, strutting, timbering, transport, offices stores, workshop, staff, labour and the provision of proper and sufficient protective works, diversions, temporary fencing and lighting. It shall also include: safety of workers, first-aid equipment, suitable accommodation for the staff and workmen with adequate sanitary arrangements, the effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or other charges arising out of the erection of works and the regular clearance of rubbish, reinstatement and clearing-up of the site as may be required on completion of work, safety of the public and protection of the works and adjoining land.

105.3. The Contractor shall ensure that all actions are taken to build in quality assurance in the planning and execution of works The quality assurance shall cover all stages of work such as setting out, selection of materials, selection of construction methods, selection of equipment and plant, deployment of personnel and supervisory staff, quality control testing, etc. The work of building in quality assurance shall be deemed to be covered in the scope of the work.

105.4. The Contractor shall furnish, at least 15 days in advance, his programme of commencement of item of work, the method of working he intends to adopt for various items of work such as site clearance, construction for embankment, sub-base, base, surface, culverts, bridges, retaining walls, well-sinking, cast-in-situ piling, construction of cast-in-situ prestressed concrete simply supported girders, cantilever construction of prestressed concrete superstructure, and such other items for which the Engineer demands the submission of the method of working. He shall provide information regarding the details of the method of working and equipment he proposes to employ and satisfy the Engineer about the adequacy and safety of the same. The sole responsibility for the safety and adequacy of the methods adopted by the contractor will, however, rest on the Contractor, irrespective of any approval given by the Engineer.

106. CONSTRUCTION EQUIPMENT

In addition to the general conditions indicated in the contract Documents, the following conditions regarding use of equipment in works shall be satisfied.

(a) The Contractor shall be required to give a trial run of the equipment for establishing their capability to achieve the laid down Specifications and tolerance to the satisfaction of the Engineer before commencement of the work.

(b) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the engineer.

(c) All the plant equipment to be deployed on the works shall be got approved from the Engineer for ensuring their fitness and efficiency before commencement of work.

(d) Any material or equipment not meeting the approval of the Engineer shall be removed from the site forthwith:

(e) No equipment will be removed from site without permission of the engineer;

(f) The Contractor shall also make available the equipment for site quality control work as directed by the Engineer.

107.1. The Contract Drawings provi ded fro tendering purposes shall be as contained in the Tender Documents and shall be used as a reference only. The Contractor should visualize the nature and type of work contemplated and to ensure that the rates and prices quoted by him in the Bill of Quantities have due consideration of the qualitative and quantitative variations, as may be found at the site and complexities of work involves during actual execution/construction.

107.2. The tendered rates/prices for the work shall be deemed to include the cost of preparation, supply and delivery of all necessary drawings, prints, tracings and negative which the contractor is required to provide in accordance with the Contract.

107.3. Two copies of drawings, on the basis of which actual execution of the work is to proceed, shall be furnished free of cost to the Contractor by the Engineer progressively according to the work programme submitted by the Contractor and accepted by the engineer. Drawings for any particular activity shall be issued to the Contractor at least 30 days in advance of the scheduled date of the start of the activity.

107.4. Examination and/or approval by the Engineer of any drawings or other documents submitted by the Contractor shall not relieve the Contractor of this responsibilities or liabilities under the Contract.

108. SITE INFORMATION

108.1. The information about the site of work and site conditions in the Tender Documents is given in good faith for guidance only but the Contractor shall satisfy himself regarding all aspects of site conditions.

108.2. The location of the works and the general site particulars are as generally shown on the Site plan/Index plan enclosed with the Tender Documents.

108.3. Whereas the right-of-way to the bridge sites/road works shall be provide to the Contractor by the Engineer, the Contractor shall have to make his own arrangement for the land required by him for site offices, labour camps, stores, etc.

108.4. The quarry charts enclosed with the Tender Documents indicated the location of quarries and other sources from which naturally occurring the location are available, for guidance of the Contractor. The leads indicated in the said charts are only approximate. It is assumed

that the Contractor has inspected the quarries, borrow areas etc., before quoting his rates for the work to assess the availability of construction materials in required quantity and quality.

109. SETTING OUT

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

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

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

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

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

109.6. The contractor will be the sole responsible party for safe-

guarding all survey monuments, bench marks, beacons, etc. The Engineer will provide the Contractor with the data necessary for setting out of the centre line. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Engineer of any apparent errors or discrepancies in such dimensions or levels. The Contractor shall, in connection with the staking out of the centre line, survey the terrain along the road and shall submit to the Engineer for his approval, a profile along the road centre line and cross-sections at intervals as required by the Engineer.

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

109.8. The work of setting out shall be deemed to be a part of general works, preparatory to the execution of work and no separate payment shall be made for the same.

109.9. Precision automatic levels, having a standard deviation of ±2 mm per km, and fitted with micrometer attachment shall be used for all double run leveling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target, having an accuracy of one second. Measurement of distances shall be done preferably using precision instruments like Distomat.

110. PUBLIC UTILITIES

110.1. 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.

110.2. Notwithstanding the fact that the information on affected serviced may not be exhaustive, the final position of these servi ce within the works shall be supposed to have been indicated based on the information furnished by different bodies and to the extent the bodies and familiar with the final proposals. The intermediate states 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 t the period of notice and duration of diversionary works and 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 in order to maintain the required co-ordination. During 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 alternations are put in hand.

110.3. No clearance or alterations to the utility shall be carried out unless specially ordered by the Engineer.

110.4. 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.

110.5. The Contractor may be required to carry out certain wo rks for and on behalf of the various bodies and he shall also provide. with the prior approval of the Engineer, such assistance to the various bodies as may be authorized by the Engineer.

110.6. 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.

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

111. PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

111.1. 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.

111.2. Borrowpits for Embankment Construction

Borrowpits shall not be dug in the right-of-way of the road. The stipulations in Clause 305.2.2. shall govern.

111.3. Quarry Operations

The Contractor shall obtain materials from quarries only after the consent of the Forest Department or other concerned authorities is obtained. The quarry operations shall be undertaken within the purview of the rules and regulations in force.

111.4. Control of Soil Erosion, Sedimentation and Water Pollution

The Contractor shall carry out the works in such a manner that soil erosion is fully controlled, and sedimentation and pollution of natural water courses, ponds, tanks and reservoirs is avoided. The stipulations in Clause 306 shall govern,

111.5. Pollution from Hot-Mix Plants and Batching Plants

Bituminous hot-mix plants and concrete batching plants shall be located sufficiently away from habitation, agricultural operations or industrial establishments. The Contractor shall take every precaution to reduce the levels of noise, vibration, dust and emissions from his plant and shall be fully responsible for any claims for damages caused to the owners of property, fields and residences in the vicinity.

111.6. Substances Hazardous to Health

The Contractor shall not use or generate any materials in the works which are hazardous to the health of persons, animaJs 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.

111.7. Use of Nuclear Gauges

Nuclear gauges shail 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.

111.8. The Contractor must take all reasonable steps to minimise dust nuisance during the construction of the works.

111.9. All existing highways and roads used by vehicle of the Contractor or any of his sub-contractors or suppliers of materials or plant, and similarly any new road* which are part of 'the works and which are being used by traffic, shall be kept clean and clear of all dust/mud or other extraneous materials dropped by the said vehicles or their tyres. Similarly, all dust/mud or other extraneous materials from the works spreading on these highways shall be immediately cleared by the Contractor.

111.10. Clearance shall be effected immediately by manual sweeping and removal of debris, or, if so directed by the Engineer, by mechanical sweeping and clearing equipment, and all dust, mud and other debris shall be removed entirely from the road surface. Additionally, if so directed by the Engineer, the road surface shall be hosed or watered using suitable equipment.

111.11. Any structural damage caused to the existing roads by the Contractor's construction equipment shall be made good without any extra cost.

111.12. Compliance with the foregoing will not relieve the Contractor of any responsibility for complying with the requirements of any Highway Authority in respect of the roads used by him.

112. ARRANGEMENT FOR TRAFFIC DURING CONSTRUCTION

112.1. 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 pant of the existing carriageway tinder improvement, or along a temporary diversion constructed close to the highway. The Contractor shall take prior approval of the Engineer regarding traffic arrangements during construction.

112.2. 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 atleast 150 mm thick granular base course covered with bituminous surface dressing in a width of atleast 1.5 m and the surface 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 atleast 20 m long with additional paved width of 2.5 m shall be provided at every 0.5 km interval.

In case of widening 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. However, in case where on the request of the Contractor, work on existing two-lane carriageway is allowed by the Engineer with traffic using part of the existing carriageway, stipulations as in para above shall apply.

After obtaining permission of the Engineer, the treated shoulder shall be dismantled, the debris disposed of and the area cleared as per the direction of the Engineer.

112.3. 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) 200 mm (compacted) granular subbase;

(it) 225 mm (compacted) granular base course; and

(iii) Premix carpet with Seal Coal/Mix Seal Surfacing.

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

112.4. 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, markings, flags, lights and flagmen as may be required by the Engineer for the information and protection of traffic approaching or passing through the section of the highway under improvement. 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.

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.

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 reflectory type, if so directed by the Engineer.

112.5. Maintenance of Diversions and Traffic Control Devices

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

112.6. Measurements for Payment and Rate

All arrangements for traffic during construction including provision of temporary cross drainage structures, if required, and treated shoulder as described in Clause 112,2 including their maintenance, dismantling and clearing debris, where necessary, shall be considered as incidental to the works and shall be the Contractors responsibility.
The construction of temporary diversion including temporary cross drainage structures as described in Clause 112.3, shall be measured in linear metre and the unit contract rate shall be inclusive of full compensation for construction (including supply of material, labour, tools etc.). maintenance, final dismantling, and disposal.

113. GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENT

113.1. 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 lumpsum contracts.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits:

(i)	length and breadth	10 mm
(it)	height, depth or thickness of earthwork, sub grade, sub-bases, bases, surfacing and structural members	5 mm
(iii)	areas	0.01 sq. m.
(iv)	cubic contents	0.01 cu. m.

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

113.2. Measurement of Lead for Materials

Where lead is specified in the Contract for construction materials, the same shall be measured as described hereunder:

Lead shall be measured over the shortest practicable route and not the one actually taken and the decision of the Engineer in this regard shall be taken as final. Distances upto and including 100 m shall be measured in units of 50 m, exceeding 100 m but not exceeding 1 km in units of 100 m and exceeding 1 km in units of 500 m, the half

and greater than half of the unit shall be reckoned as one and less than half of the unit ignored. In this regard, the source of the material shall be divided into suitable blocks and for each block, the distance from the centre of the block to the centre of placing pertaining to that block shall be taken as the lead distance.

113-3. Measurement of Pavement Thickness for Payment on Volume Basis

The finished thickness of sub-base, base and bituminous courses to be paid on volume basis shall be computed in the following manner: Levels shall be taken before and after construction, at grid of points 10 m centre to centre longitudinally in straight reaches but 5 m at curves. Normally, on two-lane roads, the levels shall be taken at four positions transversely, at 0.75 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 lone at locations specified by the Engineer.

Suitable references for the transverse grid lines should be left in the form of embedded bricks on either 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, atleast 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 no extra cost immediately after the measurements are recorded.

113.4. Checking of Pavement Thickness for Payment on Area 7Basis

Where payment for any bituminous course in Section 500 is allowed to be made on 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.

113.5. Measurement of Bituminous Courses for Payment on Weight Basis

Plant-mixed bituminous materials for pavement courses where designated to be paid on weight basis shall be weighed on accurate scales approved by the Engineer. Approved scales shall mean scales that are of size, capacity, kind and type suitable for the weighing to be done, and these shall be properly and adequately installed and maintained. Prior to the use of the scales and as frequently thereafter as the Engineer may deem necessary to ensure accuracy, the scales shall be checked and approved by the Engineer, or the Engineer may direct the Contractor to have the scales checked by other competent agency at the cost of the Contractor.

Location of the scales shall be as designated by the .Engineer, Trucks used for hauling the material to be weighed shall be weighed empty daily at such times as the Engineer directs, and each truck shall bear a plainly legible identification mark.

For materials specified to be measured by weight, the Engineer will have the option to make measurements of the finished work by volume in accordance with Clause 113.3 and such volumes shall be converted into weight for payment purposes. The factor for conversion from volume measurement to weight measurement shall be computed from the representative density of the compacted material at site determined at locations approved by the Engineer,

114. SCOPE OF RATES FOR DIFFERENT ITEMS OF WORK

114.1. For item rate contracts, the contract unit rates for different items of work shall be payment in full for completing the work to the requirements of the Specifications including full compensation for all the operations detailed in the relevant sections of these Specifications under "Rates". In the absence of any directions to the contrary, the rates are to be considered as the full inclusive rate for finished work covering all labour, materials, wastage, temporary work, plant, equipment, ovcr-

head charges and profit as well as the general liabilities, obligations, insurance and risks arising out of General Conditions of Contract.

114.2. The item rates quoted by the Contractor shall, unless otherwise specified, also include compliance with/supply of the following :

(i) General works such as selling out, clearance of site before setting out and clearance of -works after completion;

(ii) A detailed programme for the construction and completion of the worlc(using CPM/ PERT techniques) giving, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials and equipment, fabrication of special products/equipment and their in* stallation and testing, and for all activities of the Employer that are likely to affect the progress of work, etc., including updating of all such activities on the basis of the decisions taken at the periodic site review meetings or as directed by the Engineer;

(iii) Samples of various materials proposed to be used on the Work for conducting tests thereon as required as per the provisions of the Contract;

(iv) Design of mixes as per the relevant Clauses of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant Clauses of these Specifications to be submitted to the Engineer for his approval before use on the Works;

(v) Detailed design calculations and drawings for all Temporary Works (such as form-work; staging, centering; specialised constructional handling and launching equipment and the like);

(vi) Detailed drawings for templates, support and end anchorage, details for prestressing cable profiles, bar bending and cutting schedules for reinforcement, material lists for fabrication of structural steel, etc;

(vii) Mill test reports for all mild and high tensile steel and cast steel as per the relevant provisions of the Specifications;

(viii) Testing of various finished items and materials including bitumen, cement, concrete, bearings as required under these Specifications and furnishing test reports/certificates;

(ix) Inspection Reports in respect of formwork, staging, reinforcement and other items of work as per the relevant Specifications;

(x) Any other data which may be required as per these Specifications or the Conditions of Contract or any other annexures/schedules forming part of the Contract;

(xi) Any other item of work which is not specifically provided in the Bill of Quantities but which is necessary for complying with the provisions of the Contract;

(xii) All temporary works, formwork and false work;

(xiii) Establishing and running a laboratory with facilities for testing for various items of works as specified in Section 900 and other relevant Clauses, where there is no separate item in the Bill of Quantities for establishing and running a laboratory;

(xiv) Cost of in-built provisions for Quality Assurance;

(xv) Cost of safeguarding the environment; and

(xvi) Cost of providing "as-built drawings" in original and two sets of prints.

114.3. Portions of road works beyond (he limits and/or any other work may be got constructed by the Employer directly through other agencies. Accordingly, other agencies employed by the Employer may be working in the vicinity of the Works being executed by the Contractor. The Contractor shall liaise with such agencies and adjust his construction programme for the completion of work accordingly and no claim or compensation due to any reason whatsoever will be entertained on this account. The Employer will be indemnified by the Contractor for any claims from other agencies on this account.

115. METHODOLOGY AND SEQUENCE OF WORK

Prior to start of the construction activities at site, the Contractor shall, within 30 days after the date of the Letter of Acceptance, submit to the Engineer for approval, the detailed construction methodology including mechanical equipment proposed to be used, sequence of various activities and schedule from start to end of the project. Programme relating to pavement and shoulder construction shall be an integrated activity to be done simultaneously in a coordinated manner. The methodology and the sequence shall be so planned as to provide proper safety, drainage and free flow of traffic.

116. CRUSHED STONE AGGREGATES

Where the terms crushed gravel/shingle, crushed stone, broken stone or stone aggregate appear in any part of the Tender Documents or Drawings issued for work, they refer to crushed gravel/crushed shingle/crushed stone aggregate obtained from integrated crushing plant having appropriate primary crusher, secondary crusher and vibratory screen.

117. APPROVAL OF MATERIALS

Approval of all sources of material for work shall be obtained in writing from the Engineer before their use on the project.

118, SUPPLY OF QUARRY SAMPLES

Raw and processed samples of the mineral aggregates from the approved quarry shall be submitted by the Contractor at no extra cost.

119. USE OF SURFACES BY CONSTRUCTION TRAFFIC

119.1. Ordinarily, no construction traffic shall be allowed on pavement under construction unless authorised by the Engineer. Even in that case the load and intensity of construction traffic should be so regulated that no damage is caused to the subgrade or pavement layers already constructed. Where necessary, service roads shall be constructed for this purpose and the same shall be considered as incidental to the work.

119.2. The wheels or tracks of plant moving over the various pavement courses shall be kept free of deleterious materials,

119.3. Bituminous base course shall be kept clean and uncontaminated as long as the same remains uncovered by a wearing course or surface treatment. The only traffic permitted access to the base course shall be that engaged in laying and compacting the wearing course or that engaged on such surface treatment where the base-course is to be blinded and /or surface dressed. Should the base course or tack coat on the base course become contaminated, the Contractor shall make good by clearing it to the satisfaction of the Engineer, and if this is impracticable, by removing the layer and replacing it to Specification without any extra cost.

120. SITE OFFICE FOR ENGINEER AND OTHER SUPERVISORY STAFF

120.1. Scope

The work covers the construction and provision of furnished site office accommodation for the supervisory staff of Engineer and main taining the same.

120.2. Description

The Contractor shall arrange to provide fully furnished office accommodation constructed as shown in drawings. Work includes providing electric supply, all electrical items like lights, fans and complete wiring, providing water supply including all pipes, fittings, tanks, tube well, pumps, valves etc. complete, septic tank, sewer lines, drains, fencing, internal surfaced roads etc. complete as shown on the drawings. The Contractor shall provide the office accommodation within 4 months from the date of the commencement of work or 3 months from the date of providing the land and the working drawings for the construction of office accommodation, whichever is later. List of furniture to be

provided and maintained for Engineer's site office shall be as in Table 100-2.

Table 100-2. LIST OF FURNITURE TO BE PROVIDED AND MAINTAINED FOR ENGINEER'S _SITE OFFICE

S.No.	Item	Specifications	Nos. Reqd.*
1.	Executive table (for the Engineer)	Make - Godrej Modal No. T-I08 or equivalent	
2.	Executive chair (for the Engineer)	Make-Godrej Model No, PCH-701 or equivalent	
3.	Table (for Site Engineer. Accountant and Head Clerk)	Make-Godrej Model No. T-104 or equivalent.	
4.	Ordinary chair Type I(For the Engineer, Accountant. Head Clerk and visitors)	Make-Godrej Model No. CHR-6 or equivalent.	
5.	Table (for ail other staff)	Make-Godrej Model No T-IOI or equivalent	
6.	Ordinary chair-Type II (for all other staff and visitors)	Make-Godrej Model No. CHR-6 or equivalent	
7.	Stool	Make-Godrej Model No. ST-2 or equivalent.	
8.	Steel Almirah 1980mm x 915mm x 485mm	Make-Godrej Model No, 1 Storewcl plain or equivalent	
9.	Steel Atmirah 1270mrn x 765 mm x 440 mm	Make-Godrej Model Minor plain or equivalent	
10.	Racks - 5 Tier 1800 mm x 900 mm x 375 mm	Made of slotted angles and M.S. Sheets of Godrej make	
11.	Typewriter	Electronic-Bilingual (English & Hindi) Network make or equivalent.	

S.No.	Item	Specifications	Nos. Reqd.*
	SICE! Cash Chest of size 1.5' x 1.5' (450 mm x 450 mm) (approx.)	Make-Godrej Storewel or equivalent	
	Air Coolers	The cooler* shall have 24" (60cm) size fan with suitable pump and shall be of either GEC, Khaitan or Cool Home make or equivalent	
	Room Heaters	The heaters shall be of 2000 W capacity - Bajaj make or equivalent	
	Ceiling Fans 1400 mm size	Ceiling fans shall be of approved make and colour	
	Computer with printer	PC 486 with hard disc capacity 230 MB. Maths coprocessor. Two disc drives of 5.25" (132 mm) and 3.5" (88 mm), 14" (350 mm) size colour VGA monitor lelter-quality dotmatrix printer of 132 columns and 101 Key board	
	Photocopier	Make RICOH Model FT 4065 or equivalent	

* Numbers to be decided by the Engineer as per requirements of the Project.

120.3. Ownership

The site office with all services, furniture and finings shall be the property of the Employer. The land for the site office shall be provided by the Engineer and the location shall be as indicated in the Drawings.

120.4. Maintenance

The Contractor shall arrange to maintain the site office until the issue of Taking over Certificate for the complete work. Maintenance includes the day to day upkeep of the building and the surroundings, attending to repairs to various parts of the building, furniture, fittings, office equipment and the connected services as and when necessary, including the periodic white/colour washing of building and painting of wood work, steel work, replacing the broken window/door/ventilator

glasses, furniture and other hardware and maintaining necessary watch and ward during day and night.

The Contractor shall arrange to provide uninterrupted supply of electricity and water for the office building. In case of failure of main power/water supply, alternate source shall be available for providing uninterrupted supply. All sources, tappings and connected equipment and fittings, piping, tanks, wiring and all accessories of the main alternate power/water supply, for the site office accommodation shall be the property of the Employer,

120.5. Measurements for Payment

The measurement for construction and provision of site office shall be in square metres of the plinth area of the office accommodation and the payment shall be made after the completion and handing over of the buildings with connected services fully furnished including office equipment for occupation.

If the Contractor fails to hand over the furnished office accommodation within the period stipulated under Clause 120,2, an amount of Rs. 15,000 per month or part thereof shall be debited to the Contractor's account for the period of delay.

The measurement for maintenance of Engineer's site office accommodation shall be on maintenance months and shall be made on completion of satisfactory maintenance every month.

If at any stage, the Contractor fails to carry out the required maintenance satisfactorily, an amount of Rs. 5000 per month or part thereof shall be debited to the Contractor's account. In addition, the month/months during which the Contractor fails to carry out the required maintenance satisfactorily shall not be measured for payment.

If the Contract works are not completed within the stipulated period or within the granted extended time of completion, maintenance of site office accommodation in accordance with Clause 120,4 shall be carried out by the Contractor at his own cost and as such no payment shall be made for the same. In case of any failure by the Contractor to do so, an amount of Rs. 15,000 per month or part thereof shall be debited to the Contractor's account.

120.6. Rate

The Contract unit rate for constructing and providing the site office accommodation shall include the expenses of all the operations involved

in construction of the building including all services, fittings, fixtures, furniture, fencing, internal surfaced roads, as mentioned under Clause 120.2.

The Contract unit rate for maintenance shall include expenses towards all items of works detailed in Clause 120.4 including power and water charges for supply from the mains and for providing uninterrupted supply of power and water from alternate sources in case of failure of main supply.

121. FIELD LABORATORY

121.1. 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.

121.2. Description

The Contractor shall arrange to provide fully furnished and adequately equipped field laboratory constructed as shown in drawings. 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 in Clause 120.2.

The floor space requirement for the field laboratory shall be as indicated in the drawing , It shall include office space for the Materials Engineers, one from the Contractor's side and another from the Engineer's side and a store for the storage of samples. The remaining space shall be provided for the installation of equipment, laboratory tables and cupboards, working space for carrying out various laboratory tests, besides a wash basin, toilet facility and a curing tank for the curing of samples, around 4m x 2m x 1m in size and a fume chamber. The furnishing in each of two offices of the Materials Engineers shall be as provided for the Site Engineer in Table 100-2. Wooden/concrete working table with a working platform area of about 1m x 10m shall be provided against the walls, also providing wooden cupboards above and below the working tables to store accessories such as sample moulds etc. Atleast 4 racks of slotted angles and M.S. sheets as at Sl.No. 10 of Table 100-2 and atleast 6 stools for laboratory test operators as at Sl.No 7 of Table 100-2 shall also be provided.

121.3. Laboratory Equipment

The following items of laboratory equipment shall be provided in the field laboratory.

121.3.1. General

(i)	Oven – Electrically operated, thermostatically controlled, range upto 200° C sensitivity 1 °C	1 No.
(ii)	Platform balance 300 kg capacity	1 No.
(iii)	Balance 20 kg capacity - self indicating type	1 No.
(iv)	Electronic Balance 5 kg capacity accuracy 0.5 gm	2 No.
(v)	Water bath-electrically operated and thermostatically controlled with adjustable shelves, sensitivity 1°C	1 No.
(vi)	Thermometers: Mercury-in-glass thermometer range 0° to250°C Mercury-in-steel thermometer with 30cm stem, range upto 30Q°C	4 No.
(vii)	Kerosene or gas stove or electric hot plate	1 No.
	Glasswares, spatulas, wire gauzes. steels cales, measuring tape, casseroles, katahis, enameled trays of assorted sizes, pestle-mortar, porcelain dishes, gunny bags, plastic bags, chemicals, digging tools like pickaxes, shovels etc.	As required
(viii)	Set of IS sieves with lid and pan: 450 rnm diameter; 63mm, 53mm, 37.5mm, 26,5mm, 13.2mrn, 9.5 mm 6.7mm and 4.75mm size 200 mm diameter: 2.36mrn, 2.0mm, 1.18mm, 600micron, 425micro 300micron, 150micron, and 75micron	 1 Set. 2 Sets.
(ix)	Water testing kit	1 Set.
(x)	First aid box	1 Set.
121.3.2.For soil sand aggregates		
(i)	Riffle Box	1 No.
(ii)	Atterberg Limits (liquid and plastic limits) determination apparatus	1 Set.

(iii)	Compaction Test Equipment both 2.5 kg and 4.5 kg rammers (Light and Heavy compactive efforts)	1 set
(iv)	Dry Bulk Density Test apparatus (sand pouring cylinder, tray, can etc.) complete	1 set
(v)	Speedy Moisture Meter complete with chemicals	1 set
(vi)	Post.-hole Auger with extensions	1 set
(vii)	Core cutter apparatus 10 cm dia, 10/15 cm height, complete with dolly, rammer etc.	1 set
(viii)	Aggregate Impact Value Test apparatus/Los Angeles Abrasion Test apparatus	1 set
(ix)	Flakiness and Elongation Test Gauges	1 set
(x)	Standard measures of 30, 15 and 3 litres capacity along with standard tamping rod	1 set
(xi)	California Bearing Ratio lest apparatus	1 set
(xii)	Unconfined compression test apparatus	1 set
	121.3.3. For bitumen and bituminous mixes	
(i)	Penetrometer with standard needles	1 set
(ii)	Riffle box—small size	1 No.
(iii)	Centrifuge type bitumen extractor, hand operated, complete with petrol/commercial benzene	1 set
(iv)	Marshall stability test apparatus, complete with all accessories	1 set
(v)	Field density bottle along with cutting tray, chisel, hammer and standard sand	2 Nos.
(vi)	3 m straight edge	1 No.
(vii)	Camber board	1 No.
(viii)	Core cutting machine with 10 cm dia diamond cutting edge	1 set
(ix)	Vacuum pump and 3 specific gravity bottles	1 set

121.3.4. For cement and concrete

(i)	Vicat apparatus for testing setting limes	1 set
(ii)	Slump testing apparatus	4 sets
(iii)	Compression and Flexural strength testing machine of 200 tonne capacity with additional dial for flexural testing	1 No.
(iv)	Needle Vibrator	2 Nos,
(v)	Air Meter	1 No.
(vi)	Vibrating hammer for vibrating dry mix as for Dry Lean Cement concrete sub-base	1 No.

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

121.4. Ownership

If provided as a separate payable item in the Bill of Quantities, the field laboratory building and equipment shall be the property of the Employers and the land for laboratory will be provided by the Employer.

121.5. Maintenance

If provided for as a separate payable item in the Bill of Quantities, the Contractor shall arrange to maintain the field laboratory in a satisfactory manner until the issue of Taking Over Certificate for the complete work. Maintenance includes all activities described in Clause 120.4.

121.6. Measurements for Payment

If provided as a separate payable item in the Bill of Quantities, the measurement for payment for the construction of the field laboratory shall be on square metres of plinth area.
The supply of testing equipment, the erection, maintenance and running the same shall be on a lump sum basis.

121.7. Rate

If provided in die Bill of Quantities as a separate payable item, the contract unit rate for constructing and providing the field laboratory shall include expenses of all operations involved in construction of the building including all services, fittings, fixtures, furniture and fencing as mentioned in Clause 121.2.

The Contract unit rate for maintenance shall include expenses towards all items of works and equipment in Clauses 121.2 and 121,3 including power and water charges for supply from the mains and for .providing uninterrupted supply of power and water from alternate sources in case of failure of main supply.

The Contract lumpsum rate for the supply, erection, maintenance and running of testing equipment shall include cost of supply, installation and running including all consumables like chemicals and reagents.

122. SITE RESIDENTIAL ACCOMMODATION FOR ENGINEER AND OTHER SUPERVISORY STAFF

122.1. Scope

The work covers the provision and maintenance of unfurnished site residential accommodation for the Engineer and other supervisory staff.

The Contractor shall arrange to provide residential accommodation constructed as shown in the drawings.

Work includes providing electric supply, all electrical items like wiring, switches, all fittings, lights, fans, etc. complete; providing water supply and sanitation including all pipes, fittings, tanks, tube well, pumps, valves etc. complete; septic tank, sewer lines, drains, fencing, internal roads etc., complete as shown in the drawings.

122.2. Ownership

The site residential accommodation with all services and fittings etc., shall be the property of the Employer. The land for the residential accommodation shall be provided by the Engineer and the location shall be as indicated by the Engineer. The Contractor shall provide the residential accommodation within 4 months from the date of commence - ment of the work or 3 months from the date of providing land and the working drawings for the construction of residential accommo - dation, whichever is later.

122.3. Maintenance

The Contractor shall arrange to maintain the supervisory staff residential accommodation until the issue of Taking Over Certificate for the complete work.

Maintenance includes attending to repairs to various parts of the building, fittings etc. and the connected services as and when necessary, including the annual white/colour washing of the building and periodic painting of wood and steel work; replacing the broken window/door, ventilator glasses and other hardware; and maintenance of internal roads.

The Contractor shall arrange to provide uninterrupted supply of electricity and water for the buildings. In case of failure of main water or power supply, suitable alternate arrangement shall be made for

providing uninterrupted supply. All sources/tappings and connected equipment and fittings, piping, tanks, wiring and all other accessories of the main and alternate power/water supply for the residential accommodation shall be the property of the Employer.

122.4. Measurement for Payment

The measurement for construction of the residential accommodation shall be on square metres of plinth area of the accommodation. The payment shall be made after the residential accommodation, complete with all services, fencing etc., is constructed and handed over for occupation. If the Contractor fails to complete and hand over the complete residential accommodation within the period stipulated under Clause 122.2, an amount of Rs. 50,000 per month or part thereof shall be debited to the Contractor's account for the period of delay.

The measurement for maintenance of supervisory staff residential accommodation shall be in maintenance months and shall be made on completion of satisfactory maintenance every month. If at any stage the Contractor fails to carry out the required maintenance satisfactorily, an amount of Rs. 25,000 per month or part thereof shall be debited to the Contractor's account. In addition, the month/months during which the Contractor fails to carry out the required maintenance satisfactorily shall not be measured for payment.

If the Contract works are not completed within the stipulated period or within the granted extended time of completion, maintenance of residential accommodation in accordance with Clause 122.3 shall be carried out by the Contractor at his own cost and as such no payment shall be made for the same. In case of any failure by the Contractor to do so, an amount of Rs. 60,000 per month or pan thereof shall be debited to the Contractor's account.

122.5. Rate

The Contract unit rate for constructing and providing residential accommodation for (he Engineer and other supervisory staff shall include cost of all the operations involved in construction of buildings and connected services and fittings, fencing etc. complete.

The Contract unit rate for maintenance shall include the expenses for all items of work detailed in Clause 122.3 including provision of uninterrupted supply of power and water.

123. PROVIDING AND MAINTAINING WIRELESS COMMUNICATION SYSTEM

123.1. Scope

The work covers the provision and maintenance of wireless communication systems with necessary mobile/base trans -receivers and other accessories.

123.2. Supply

The Contractor shall arrange to supply, install and commission the complete wireless system of approved quality suitable for a range of upto 65 km. The system shall consist of the following:

(a) Mobile Trans-receiver suit able for mounting on 4 wheelers with Microphone assembly, Mobile Antenna with Cable and External Speaker assembly (3 W audio output) with all necessary fittings and accessories - 10 lets.

(b) Base Trans-receivers with Microphone assembly, suitable Antenna, external speaker unit (3 W audio output) with all necessary fittings and accessories - 3 sets,

(c) Hand held radio sets - 10 Nos.

The Contractor shall provide the complete wireless system within 12 months from the date of commencement of work or 8 months from the date on which frequency is allotted to him by the Govt. Department, whichever is later. He shall submit a guarantee for replacement of any defective trans-receiver/trans -receivers during the currency of the contract.

123.3. Approval

The Contractor shall arrange to obtain all necessary statutory approvals from various Government bodies for operating the system. He shall also fulfil the requirements laid down by various Government Departments and obtain the frequency to operate the wireless system.

123.4. Maintenance

The Contractor shall arrange to maintain the entire wireless system including the mobile and base trans-receivers and all accessories until the issue of the Taking Over Certificate for the complete work. He shall replace any Trans-receiver or accessory which goes out of order, at his own cost and provide all necessary spares and attend to all repairs necessary for keeping the complete system in satisfactory working condition. On issue of the Taking Over Certificate after obtaining clearance from the Engineer, the Contractor shall dismantle the complete wireless system and hand over to the Engineer,

123.5. Measurements for Payment

The measurement for supply and installation of wireless system shall be on lumpsum basis for the complete system as described in the preceding paras.

If the Contractor fails to commission and hand over the complete wireless system in the stipulated time, an amount of Rs. 10,000 per month or part thereof shall be debited to the Contractor's account.

The measurement for maintenance of the wireless system shall be on maintenance months and shall be made on completion of satisfactory maintenance every month. If the Contractor fails to carry out the required maintenance as directed by the Engineer at any stage of work, an amount of Rs. 5000 per month or part thereof shall be debited to the Contractor. In addition, the month/months during which the Contractor fails to carry out the required maintenance shall not be measured for payment. If die Contract Works are not completed within the stipulated period or within granted extended time of completion, the maintenance of wireless system in accordance with Clause 123.4 shall be carried out by the Contractor at his own cost and as such, no payment shall be made for the same. In case of any failure by the Contractor to do so, an amount of Rs. 8000 per month or part thereof shall be debited to the Contractor's account.

123.6. Rates

The Contract unit rate for the supply and installation of wireless system shall cover all the expenses towards the supply of all necessary items and expenses towards obtaining statutory approvals and operating frequency, erection, commissioning and handing over, guarantee for replacement of the trans -receiver/trans -receivers (which are found defective) during the currency of the Contract and all other incidentals.

The Contract unit rate for the maintenance of wireless system shall be payment in full for carrying out periodic servicing and checking of the system, replacement of components, attending to all necessary repair, payment of taxes, if any, and other incidentals to keep the complete system in satisfactory working condition.

124. PROVIDING AND MAINTAINING VEHICLES FOR THE ENGINEER

124.1. Scope

The work covers providing and maintaining of hard top passenger

cars and /or hard top jeeps for use by the Engineer as described under the Bill of Quantities.

124.2. Description

The passenger cars shall be petrol or diesel driven and may be Ambassador or equivalent having cylinder capacity of minimum 1400 cc. The hard top jeeps shall be 4 W Drive either petrol or diesel driven and may be Maruti Gypsy Model MG - 410, Mahindra & Mahindra Jeep Model MM-540/MM-440 or equivalent. The number of vehicles to be provided by the Contractor shall be decided by the Engineer at various times, out of the total provision in the Bill of Quantities and indicated in writing.

The Contractor shall provide within one month from the date of order by the Engineer, vehicles as indicated above. The vehicles shall be provided and maintained until issue of the Taking Over Certificate for the complete Work. Initially, new vehicles shall be provided. In case of vehicles of Indian make, a vehicle shall be replaced with a new vehicle after a maximum run of 75,000 km or two years whichever is earlier. In case of vehicles of foreign make approved by the Engineer, the vehicle shall be replaced with a new vehicle after a maximum run of 1,00,000 km or three years whichever is earlier. All necessary taxes for operating the vehicles shall be fully paid and all necessary papers shall be provided as required by prevailing Motor Vehicles Act with comprehensive insurance cover for the vehicles. The vehicles shall be provided day and night as required by the Engineer. The Contractor shall also make available drivers having valid licence at such times and for such duration as instructed by the Engineer.

124.3. Maintenance

The vehicles shall be maintained in a smooth running condition. All expenses required for keeping the vehicles in smooth running condition such as fuel, lubrication oil and other consumables, necessary service and maintenance, drivers, repairs and replacement etc. are to be met by the Contractor. In the event of any vehicle being off the road for maintenance or on account of breakdown, the Contractor shall provide substitute vehicle(s) immediately. If the Contractor at any time fails to provide vehicle(s) or substitute vehicle(s) as specified above, an amount of Rs. 500 per day or part thereof for each vehicle (that the Contractor failed to provide) shall be debited to the Contractor's account. Also the number of days for which the vehicle(s) were not provided shall not be included for payment.

If the Contract Works are not completed within the stipulated period or within the granted extended time of completion, provision and maintenance of vehicles in accordance with Clause 124,1 through 124.4 shall be carried out by the Contractor at his own cost and no payment shall be made for the same. In case of any failure by the Contractor to do so, an amount of Rs. 700 per day or part thereof per vehicle shall be debited to the Contractor's account.

124.4. Withdrawal of Vehicles

The Contractor shall withdraw particular vehicle/vehicles for the non-use by the Engineer if so directed by the Engineer. In such cases-the instructions for non-use of vehicle shall be given in writing 15 days in advance and the withdrawal of vehicles shall not be for a period of less than 15 days continuously at a time.

124.5. Measurements for Payment

The payment for providing and maintaining vehicles shall be on vehicle day basis for actual number of days the vehicles were provided in satisfactory working order. No payment shall be made for the period of withdrawal as per Clause 124.4 irrespective of the fact whether vehicle was available or not.

124.6. Rates

The Contract unit rate for providing and maintaining vehicles for Engineer shall include all expenses towards providing and keeping the vehicles in smooth running condition including taxes etc., mentioned in the preceding paras.

125. SUPPLY OF COLOUR RECORD PHOTOGRAPHS AND ALBUMS

125.1. Scope

The work covers the supply of photographs, negatives and albums to serve as a permanent record of various stages/facets of the work needed for an authentic documentation as approved by the Engineer.

125.2. Description

The Contractor shall arrange to take colour photographs at various stages/facets of the work including interesting and novel features of the work as desired by the Engineer. The photographs shall be of acceptable quality and they shall be taken by a-professionally competent photographer with camera having the facility to record the date of

photographs taken in the prints and negative. The Contractor shall supply two colour prints of each of the photographs taken to the standard postcard size mounted in albums of acceptable quality. Also the negative in 35 mm size shall be supplied for each photograph. Each photograph in the album shall be suitably captioned.

125.3. Measurements for Payment

Supply of two copies of colour record photographs mounted in the albums and the negative thereof shall be measured in number of record photographs supplied.

Supply of additional prints of co lour record photographs shall be measured in number of additional prints supplied.

125.4. Rate

The rate for the supply of record photographs shall include the cost of taking the photographs, developing and obtaining colour prints, cost of album, mounting of photographs and captioning the same etc.

The rate for additional colour prints shall similarly include all costs incurred.

The photographs and materials including negatives shall form a par: of the records of the Department and the prints of the same cannot be supplied to anybody else or published without the written permission of the Department.

126. SUPPLY OF VIDEO CASSETTES

126.1. Description

The work consists of taking video films of important activities of the work as directed by the Engineer during the currency of the project and editing them to a video film of playing time not less than 60 minutes and upto 180 minutes as directed by the Engineer, It shall contain narration of the activities in English by a competent narrator. The edition of the video film and the script for narration shall be as approved by the Engineer. The video cassettes shall be of acceptable quality and the film shall be capable of producing colour pictures.

126.2. Measurements for Payment

The measurement shall be by number of sets of edited master cassettes each with four copies thereof.

126.3. Rates

The contract unit rate shall include all expenses for making video films with the help of a professionally competent photographer, editing, narration and supplying the final edited master cassette alongwith four copies thereof.

200

Site Clearance

201. CLEARING AND GRABBING

201.1. Scope

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

201.2. Preservation of Property/Amenities

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

During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that effect vide Clause 306, Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including -he procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works as stipulated in Clause 306.3.

201.3. Methods, Tools and Equipments

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade. Also, all vegetation such as

roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/subgrade shall be removed between fill lines to the satisfaction of the Engineer. On areas beyond these limits, trees and stumps required to be removed as directed by the Engineer shall be cut down to 1 m below ground level so that these do not present an unsightly appearance.

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

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

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

201.4. Disposal of Materials

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

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

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

201.5. Measurements for Payment

Clearing and grubbing for road embankment, drains and cross-drainage structures shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be deemed to be a part of works preparatory to embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same. Cutting of

trees upto 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

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

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

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

201.6. Rates

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

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

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

202. DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/PAVEMENTS

202.1. Scope

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

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

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

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

202.2. Dismantling Culverts and Bridges

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

Unless otherwise specified, the superstructure portion of culverts/ bridges shall be entirely removed and other parts removed below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of 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 to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be

left in place so as to project into 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 as is designated by the Engineer to be salvaged.

202.3. 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 stockpiled at designated locations if the material is to be used later or otherwise arranged for disposal as directed (see Clause 202.5).

202.4. 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,

202.5. Disposal of Materials

All materials obtained by dismantling shall be the property of Government. Unless otherwise specified, materials having any salvage

value shall be placed in neat stacks of like materials within the right – of-way, as directed by the Engineer with all lifts and upto a lead of 1000 m.

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

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

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

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

202.6. Measurements for Payment

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

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

202.7. Rates

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

300

Earthwork, Erosion Control and Drainage

301. EXCAVATION FOR ROADWAY AND DRAINS

301.1. Scope

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

301.2. Classification of Excavated Material

301.2.1. Classification : All materials involved in excavation shall be classified by the Engineer in the following manner:

(a) Soil
This shall comprise topsoil, turf, land, sill, loon, day, mud, peat. Mack cotton toil, loft shale or loose mooium, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under mil category.

(b) Ordinary Rock (not requiring blasting this shall include:

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

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

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

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

(c) Hard Rock (requiring blasting)

This shall comprise:

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

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

(iii) boulders requiring blasting.

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

(e) Marshy Soil

This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soil) excavated fromother areas requiring continuous pumping or bailing out of water.

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

3013. Construction Operations

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

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

301.3.3. Excavation - General : All excavations shall be carried out in conformity with the directions laid here-in -under and in a manner

approved by the Engineer. The work ..shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

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

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/ width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements of Clause 305.

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

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

301.3.4. Methods, tools and equipment: Only such methods, tools and equipment as approved by the Engineer shall be adopted/used in the work. If so desired by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

301.3.5. Rock excavation : Rock, when encountered in road excavation, shall be removed upto the formation level or as otherwise indicated on the drawings. Where, however, unstable shales or other un-suitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, 'the excavation operations shall be so carried out that at no point on cut formation the rock protrudes above the specified levels. Rocks and large boulders which are likely to cause

differential settlement and also local drainage problems should be removed to the extent of 500 mm below the formation level in full formation width including drains and cut through the side drains.

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

Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the Engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when pierced by a crowbar shall be removed.

Where blasting is to be resorted to, the same shall be carried out to Clause 302 and all precautions indicated therein observed.

Where presplitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out to Clause 303.

301.3.6. Marsh excavation : The excavation of soils from marshes/ swamps shall be carried out as per the programme approved by the Engineer.

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

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

301.3.8. Excavation for surface/sub-surface drains : Where the Contract provides for construction of surface/sub-surface drains to Clause

309, excavation for these shall be carried out in proper sequence with other works as approved by the Engineer.

301.3.9. Slides : If slips, slides , over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides etc. shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

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

301.3.11. Disposal of excavated materials : All the excavated materials shall be the property of the Employer. The material obtained from the excavation of roadway, shoulders, verges, drains, cross-drainage works etc., shall be used for filling up of (i) roadway embank ment, (ii) the existing pits in the right -of-way and (iii) for landscaping of the road as directed by the Engineer, including levelling and spreading with all lifts and lead upto 1000 m and no extra payment shall be made for the same.

All hard materials, such as hard moorum, rubble, etc., not intended for use as above shall be stacked neatly on specified land as directed by the Engineer with all lifts and lead upto 1000 m.

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

3013.12, Backfilling : Backfilling of masonry /concrete/hume pipe drain excavation shall be done with approved material after concrete/ masonry/hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and/or not to cause differential settlement. All space between the drain walls and the side of the excavation shall be refilled to the original surface making due allowance for settlement, in layers generally not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such *as* mechanical tamper, rammer or plate compactor as directed by the Engineer.

301.4. Plying of Construction Traffic

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

301.5. Preservation of Property

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

301.6. Preparation of Cut Formation

The cut formation, which serves as a subgrade, shall be prepared to receive the" sub-base/base course as directed by the Engineer. Where the material in the subgrade (t hat is within 500 mm from the lowest level of the pavement) has a density less than specified in Table 300-2, the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 305.

Any unsuitable material encountered in the subgrade level shall be removed as directed by the Engineer and replaced with suitable material compacted in accordance with Clause 305.

In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the Engineer, laid and compacted in accordance with the respective Specifications for these materials. The unsuitable material shall be disposed of in accordance with Clause 301.3.11. After satisfying the density requirements, the cut formation shall be prepared to receive the subbase/base course in accordance with Clauses 310 and 311 to receive the sub-base/basc course.

301.7. Finishing Operations

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

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

The finished cut formation shall satisfy the surface tolerances described in Clause 902,

Where directed, 'the topsoil removed earlier and conserved (Clauses 301.3.2 and 305.3.3) shall be spread over cut slopes, where feasible, berms and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

301.8. Measurements for Payment

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

At the option of the Engineer , the Contractor shall leave depth indicators during excavations of such shape and size and in such

positions as directed so as to indicate the original ground level as accurately as possible. The Contractor shall see that these remain intact till the final measurements are taken.

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

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

(j)	Loosening and recompacting the loosened material at subgrsde	... cu. m.
(ii)	Loosening and removal of unsuitable material and replacing with a suitable material and compacting to required density	... cu. m.
(iii)	Preparing rocky subgrade	... sq. m,
(iv)	Stripping including storing and reapplication of topsoil	... cu. m.
(v)	Disposal of surplus material beyond initial 1000 m lead	... cu. m,

301.9. Rates

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

(i) selling out;
(ii) transporting the excavated materials and depositing the same on sites of embankments, spoil banks or stacking as directed within all lifts and lead upto 1000 m or as otherwise specified;
(iii) trimming bottoms and slopes of excavation;
(iv) dewatering;
(v) keeping the work free of water *as* per Clause 311; and
(vi) all labour, materials, tools, equipment, safety measures, testing and incidentals necessary to complete the work to Specifications.

Provided, however, where presplitting is prescribed to achieve a

specified slope in rock excavation, the same shall be paid for vide Clause 303.5.

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

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

301.9.4. The Contract unit rate for item of preparing rocky subgrade as per Clause 301.6 shall be full compensation for providing, laying and compacting granular base material for correcting surface irregularities including all materials, labour and incidentals necessary to complete the work and all leads and lifts.

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

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

302. BLASTING OPERATIONS

302.1. General

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

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

The magazine for the storage of explosives shall be built to the designs and specifications of the Explosives Department concerned and located at the approved site. No unauthorized person shall be admitted-

into the magazine which when not in use shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine shall have an effective lightning conductor. The following shall be hung in the lobby of the magazine:

(a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar.

(b) A statement of up-to-date stock in the magazine.

(c) A certificate showing the last date of testing of the lightning conductor.

(d) A notice that smoking Is strictly prohibited.

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

302.2. Materials, Tools and Equipment

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

302.3. Personnel

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

302.4. Blasting Operations

The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the man in charge only.

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

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

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

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

When blasting is done with dynamite and other high explosives, dynamite cartridges shall be prepared by inserting the square cut end of a fuse into the detonator and finishing it with nippers at the open end, the detonator gently pushed into the primer leaving l/3rd of the copper tube exposed outside. The paper of the cartridge shall then be closed up and securely bound with wire or twine. The primer shall be housed into the explosive. Boreholes shall be of such size that the cartridge can easily go down. The holes shall be cleared of all debris and

explosive inserted. The space of about 200 mm above the charge shall then be gently filled with dry clay, pressed home and the rest of the tamping formed of any convenient material gently packed with a wooden rammer.

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

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

302.5. Misfire

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

(i) Sufficient lime shall be allowed to account for the delayed blast. The man-in-charge shall inspect all the charges *and* determine the missed charge.

(ii) If it is the blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.

(iii) In case of charges of gelignite, dynamite, etc., the man-in-charge shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 300 mm of tamping and the direction then ascertained by placing a stick in [he hole. Another hole may then be drilled 150 mm away and parallel to ii. This hole shall then be charged and fired when the misfired hole should explode at the same lime. The man-in-charge shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

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

302.6. Account

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

303. PRESPLITTING ROCK EXCAVATION SLOPES

303.1. General

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

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

303.2, Construction Operations

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

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

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

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

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

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

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

If necessary, to reduce shatter and overbreak of the presplit surface, the first line of the production holes shall be drilled parallel to the slope line at the top of the cut and at each bench level thereafter. Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

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

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

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

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

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

All charges in each presplitting pattern shall be detonated simul-taneously.

3033. Tolerances

The presplit face shall not deviate more than 300 mm from the plane passing through adjacent drill holes, except where the character of the

rock is such that, as determined by the Engineer, irregularities are unavoidable. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 300 mm. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the side drains,

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

303.4. Measurements for Payment

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

303.5. Rates

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

304. EXCAVATION FOR STRUCTURES

304.1. Scope

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

304.2, Classification of Excavation

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

304.3. Construction Operations

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

304.3.2. Excavation : Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

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

Where blasting is to be resorted to, the same shall be carried out in accordance with Clause 302 and all precautions indicated therein observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc. shall be taken to prevent any damage.

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

relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

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

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

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

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area.

The Contractor shall take all precautions in diverting channels and in discharging die drained water as not to cause damage to die works, crops or any other property.

304.3.4. Preparation of foundation : The bottom of the foundation shall be levelled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed. In the event of excavation having been made deeper than that shown on the drawings or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation at the cost of the Contractor as per Clause 2104.1. Ordinary filling shall not be used for the purpose to bring the foundation to level.

When rock or other hard strata is encountered, it shall be freed

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

if the depth of the fill required is more than 1.5n above the top of the footing, filling upto 1.5m above top of footing shall be done with lean concrete (1:3:6 nominal mix) followed by bulders grouted with cement.

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

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

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

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

304.3.8. Disposal of surplus excavated materials: Clause 301.3.11 shall apply.

304.4. Measurements for Payment

Excavation for structures shall be measured in cu. m. for each class

of material encountered, limited to the dimensions shown on the drawings or as directed by the Engineer. Excavation over increased with, cutting of slopes, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for separately.

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

304.5. Rates

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

(i) Setting out:

(ii) construction of necessary cofferdams, cribs, sheeting, shoring and bracing and their subsequent removal:

(iii) removal of all logs, stumps, grubs and other deleterious matter and obstructions, for placing the foundations including trimming of bottoms of excavations.]

(iv) foundation sealing, dewatering including pumping when no separate provision for it is made in the Contractor:

(v) backfilling, clearing up the site and disposal of all surplus material within all lifts and leads upto 1000 m or as other wise specified; and

(vi) all labour, materials, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to Specification.

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

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

305. EMBANKMENT CONSTRUCTION

305.1. General

305.1.1. Description : These Specifications shall apply to the construction of embankments including subgrades, earthen shoulders and

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

305.2. Materials and General Requirements

305.2.1. Physical requirements:

305.2.1.1. The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/ subgrade.

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

(») 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 70 and plasticity index exceeding 45; and

(f) Materials with sails resulting in leaching in the embankment.

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

305.2.1.3. Any fill material with a soluble sulphate consent exceeding 1.9 grams of sulphate (expressed as SO_3) per litre when tested in accordance with BS : 1377 Test 10, but using a 2:1 water-soil ratio shall not be deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of the Permanent Works,

Materials with a total sulphate content (expressed as SO_3) exceeding 0.5 per cent by mass, when tested in accordance with BS : 1377 Test

9 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

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

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

TABLE 300-1. DENSITY REQUIREMENTS OF EMBANKMENT AND SUBGRADE MATERIALS

S. No,	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2720 (Part 8)
1.	Embankments up to 3 metres height, not subjected to extensive flooding,	Not less than 15.2 kN/cu.m.
Z	Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cu. m.
3.	Subgrade and earthen shoulders/verges/backfill	Not less than 17.5 kN/cu. m.

Notes: (1) This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.
(2) The Engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.
(3) The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table 30Q-Z

305.2.2. General requirements :

305.2.2.1. The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same Contract.

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

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

Borrowpits 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 from the toe of the embankment required as per the consideration of stability with a minimum width 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.

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

Where the excavation reveals a combination of acceptable and un - acceptable 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.

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

TABLE 300-2. COMPACTION REQUIREMENTS FOR EMBANKMENT AND SUBGRADE

Type of work/ material		Relative compaction *as* percentage of max. laboratory dry density *as* per IS: 2720 (Part g)
1.	Subgrade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays	
	a) Subgrade and 500 mm portion just below the subgrade	Not allowed Not
	b) Remaining portion of embankment	less than 90

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 7) or (Part 8), as the case may be, appropriate for each of the fit! materials he intends to use.

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

(iii) The Dry density-moisture content -CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

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

305.3. Construction Operations

305.3.1. Setting out : After the site has been cleared to Clause 201, the work shall be set out to Clause 301.3.1, The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/subgrade shall be built sufficiently wider than the

design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

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

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

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

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

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 per cent relative compaction with respect to the dry density as given in Table 300-2, the ground shall be loosened upto a level 0.5 m below the subgrade level, watered and compacted in layers in accordance with Clauses 305.3,5 and 305.3.6 to not less than 97 per cent of dry density as given in Table 300-2.

Where so directed by the Engineer, any unsuitable material occurring

in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

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

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the Engineer. Where the ground on which an embankment is to be built has any of the material types (a) to (f) in Clause 305.2.1, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

305.3.5. Spreading material in layers and bringing to appropriate moisture content

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

305.3.5.2. Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, discing or harrowing until a uniform moisture content is obtained throughout the depth of the layer.

If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun. till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 per cent above to 2 per cent below the optimum moisture content determined in accordance with IS:2720 (Part 7) or IS:2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

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

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

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

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

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per Clause 305.4.1 immediately before placing the subsequent fill.

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

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

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

The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval.

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

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

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

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

305.3.8. Repairing of damages caused by rain/spillage of water: The soil in the affected portion shall be removed in such areas as

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

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

The topsoil, removed and conserved carrier (Clause 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 rnm 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 requirement of Clause 30S,

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

305.4. Construction of Embankment and Subgrade under Special Conditions

305.4.1. Earthwork for widening existing road embankment: When an existing embankment and/or subgrade is to be widened and its slopes are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the

old slope for ensuring adequate bond with the fresh embankment/subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment/subgrade. However, when -the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

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

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

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

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

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

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

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

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

305.4.4, Embankment and subgrade around structures : To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structures, the Contractor shall, at points to be determined by the Engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit die 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 twice the height of the road from the back of die abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of die 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 15:2720 (Part 5). Filling behind abutments and wing, walls for ail structures shall conform to the general guidelines given in Appendix 6 of IRC:78 (Standard Specifications and Code of Practice Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and Compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 300-2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in Clause 2502/309.3.2 (B) unless otherwise specified in the Contract.

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

305.4.5. Construction of embankment over ground incapable of supporting construction equipment : Where embankment is to

be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in Clause 305.3.

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

305.4.7, Earthwork for high embankment : In the case of high embankments, the Contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The Contractor shall then furnish the soil test data and design o f high embankment for approval of the Engineer, who reserves the right to accept or reject it.

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

Where required, the Contractor shall surcharge embankments or other areas of fill with approved material for the periods specified in the Contract. If settlement of surcharged fill, results in any surcharging

material, which is unacceptable for use in the fill being surcharged, lying below formation level, the Contractor shall remove the unacceptable material and dispose it as per direction of the Engineer. He shall then bring the resultant level up to formation level with acceptable material.

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

305.5. Plying of Traffic

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

305.6. Surface Finish and Quality Control of Work

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

305.7. Subgrade Strength

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

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

305.8. Measurements for Payment

Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cu.m. of suitable material brought to site from road and drainage excavation forms one cu.m. of compacted fill and all bulking or shrinkage shall be ignored.

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

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

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

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

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

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

Dismantling and removal of existing cement concrete pavement shall be measured vide Clause 202.6.

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

305.9. Rates

305.9.1. The Contract unit rates for the items, of embankment and subgrade construction shall be payment in full for carrying out the required operations including full compensation for :

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

(ii) Setting out;

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

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

(v) Coil of watering or drying of material in borrow areas and/or embankment and subgrade during construction as - required;

(vi) Spreading in layers, bringing to appropriate moisture content and compacting to Specification requirements;

(vii) Shaping and dressing top and slopes of the embankment and subgrade including rounding of comers;

(viii) Restricted working at sites of structures;

(ix) Working on narrow width of embankment and subgrade;

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

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

(xii) Dewatering; and

(xiii) Keeping the embankment/completed formation free of water as per Clause 311.

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

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

305.9.4. Clause 301.9.2 shall apply as regards Contract unit rate for the item of loosening and rccompacting the embankment/subgrade foundation.

305.9.5. Clauses 301.9.1 and 305.8 shall apply as regards Contract rates for items of removal of unsuitable material and replacement with suitable material respectively.

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

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

305.9.8. The Contract unit rate for providing and laying .filter material behind abutments shall be payment in full for carrying out

the required operations including all materials, labour, tools, equipment and incidentals to complete the work to Specifications.

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

305.9.10. Clause 305.4.7 shall apply as regards Contract unit rate for construction of high embankment. It shall include cost of instru mentation, its monitoring and settlement period, where specified in the Contract or directed by the Engineer.

306. SOIL EROSION AND SEDIMENTATION CONTROL

306.1. Description

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

306.2. Materials

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

306.3. Construction Operations

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

The surface area of erodible earth material exposed by clearing and grubbi ng, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor may be directed to provide immediate permanent or temporary erosion and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contami - nation of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the construction of temporary berms, dikes,

sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as required on the plans.

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

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

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

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

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

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

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

306.4. Measurements for Payment

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

306.5. Rates

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

307. TURFING WITH SODS

307.1. Scope

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

307.2. Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to die locality where it is to be used, and shall be practically free from weeds or other undesirable mailer. 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 rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

307.3. Construction Operations

307.3.1. 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, stump s 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 plans. 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 plans. After spreading, the materials arc incorporated in the soil by discing or other means to the depths shown on the pians.

307.3.2. 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 lamped 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 flowover 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 tin's followed by its thorough compaction.

307.33. 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 sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

307.3.4. 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:

307.3.5. 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,

307.4. Measurements for Payment

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

307.5. Rate

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

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

(ii) all labour, tools, equipmems and incidentals Lo complete the work in accordance with these Specifications.

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

308. SEEDING AND MULCHING

308.1. Scope

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

308.2. Material s

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

Fertilizer shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully putrefied organic matter such as cow Mulching material] shall consist of straw, hay, wood shavings or sawdust, and shall be delivered dry. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as a mulch or be injurious to the plant growth.

B. Topsoil: Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides 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 per cent and more than 12 per cent organic matter.

C. Bituminous Emulsion: A suitable grade of bituminous cutback or 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.

D. Netting: Jute netting shall be undyed jute yam woven into a uniform open weave with approximate 2,5 cm square openings.

Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 2 cm x 2 cm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sq. m.

308.3. Seeding Operations

308.3.1. 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 plans, unless otherwise approved by the Engineer. The seed-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. AH stones 150 mm in smallest dimension and larger shall be removed. The s oil 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 or 2 round trips of the roller or approved equipment. .

308.3.2. 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.

308.3.3. 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,

308.3.4. Soil moisture and watering requirements: Soil-moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting.

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

308.4. Mulching, Applying Bituminous Emulsion and Jute Netting/ Geonetting

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 shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the plans 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 shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil.

308.5. Maintenance

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

308.6. Measurements for payment

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

308.7. Rate

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

309. SURFACE/SUB-SURFACE DRAINS

309.1. Scope

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

309.2. Surface Drains

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

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

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

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

309.3. Sub-surface Drains

309.3.1. 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.

309.3.2. Materials

A. Pipe : Perforated pipes for the drains may be of metal/asbestos cement/ cement concrete/PVC, and unperforated pipes of vitrified clay/cement concrete/ asbestos cement. The type, size and grade of the pip: *10* be used shall be ai 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, DM stands for the size of the sieve that allows 85 per cent of the material to pass through it.

B. 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? 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 there of) 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 10 Class II grading of Table 300-3.

   (iii) Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class 111 grading of Table 300-3.

Thickness of backfill material around the pipe shall be as shown on the drawings subject to being at least 15 0 mm alround in all cases.

Geosynthetics for use with subsurface drain shall conform to the re - quirements as per Section 700.

Table 300.3. GRADING REQUIREMENTS FOR FILTER MATERIAL

	Per cent passing by weight		
Sieve Designation	Class I	Class 11	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	—
ISO micron	3-15	—	—
90 micron	0-5	0-4	0-3

309.3.3. Trench excavation: Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the drawings provided that width of trench at pip e 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.

309.3.4. 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. Unless otherwise provided, longitudinal gradient of the pipe shall not be less than 1 in 100.

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

Perforated pipes, unless otherwise specified, shall be placed with their perforations down to minimise 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 t he open joints wrapped with suitable pervious material (like double layer of hessian, suitable Geosynthetics or some other material 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 309.3.2B) 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 die top by means of 150 mm thick layer of compacted clay so as to prevent percolation of surface water.

309.3.5. Use of geosynthetic in laying of pipe and backfilling : After excavating the trench for subsurface drain, the filter fabric shall be placed, ihe pipe installed and the trench backfilled with permeable material according to dimensions and details shown on the plans. Surfaces to receive filter fabric prior to placing shalJ 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 expense.

309.3.6. Drain outlet: The outlet for a sub-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 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.

309.3.7. Aggregate drains : Aggregate drains snail 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 plan.

Trenches for aggregate drains shall be excavated to a minimum width of 300 mm and to the depth shown on the plans 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 at Table 300-4. Type B grading may be used only where the drain is designed to intercept surface water flowing to the pipe and is likely to get slowly blocked. Type A grading allows a much wider range.

TABLE 300-4. **GRADING REQUIREMENTS FOR AGGREGATE DRAINS**

Sieve Size	Per cent pas sing by weight	
	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	—

309.4. Measurements for Payment

Measurement for surface and sub -surface drains shall be per running metre length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cu. m.

309.5. Rates

The Contract unit rates for surface and subsurface drains shall be payment in full for all items such as excavation, dressing the sides and bottom; providing lining, turfing, pitching, masonry, concrete and plas - tering; providing, laying and jointing pipes; providing, laying and compacting backfill and bed of granular material; providing, fixing and painting of cover etc. including full compensation for all materials, labour, tools, equipment and other incidentals to complete the work as shown on drawings with all leads and lifts except for remo val of unsuitable material for which the lead shall be 1000 m. Provision of inlets, gratings, sumps, outlet pipes, bedding, disbursers etc. wherever required shall be incidental to construction of drain. The Contract unit rate for disposal of surplus and unsuitable material beyond the initial 1000 m lead shall be in accordance with Clause'304.5.3.

310. PREPARATION AND SURFACE TREATMENT OF FORMATION

Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade 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) AH surfaces below carriageway, laybyes. fo otways and hard shoulders shall after reinstatement of any soft areas to the required Specifications be well cleaned and freed of mud and slurry.

(b) The surface shall be compacted by + passes of a smooth wheeled roller of 80 to 100 kN weigh! after spraying requisite amount of water, if required, before the commencement of rolling.

(c) The formation shall, wherever necessary, be regulated and trimmed to the re - quirements of Clause 305.3.9 with motor grader,

(d) The trimmed formation shall be rolled *by* one pass of smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

Where the completed formation is not immediately covered with sub - base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the Engineer. The entire work of surface treatment of formation shall be deemed as incidental to the work of sub -base/base course to be provided on the subgrade and as such no extra payment shall be made for the same.

311. WORKS TO BE KEPT FREE OF WATER

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

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

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

312. WATER COURSES AT CULVERTS

312.1. Excavation carried out in the diversion, enlargement, deepening or straightening water courses at culverts, where necessary, shall include the operations such as clearing, grubbing, removal of vegetation, trimming of slopes, grading of beds, disposal of excavated

materials, pumping, timbering etc. necessary for dealing with ihe flow of water.

312.2. The beds and sloping sides of water courses shall, where shown on the Drawings, be protected against the action of water by rubble paving to form a flat or curved surface as indicated. The protection shall consist of large smooth faced stones or of blocks of precast 0oncrete. Stones for rubble paving shall be roughly dressed square. No stone shall be less than 255 mm in depth nor less than 0.02 cu. m. in volume and no rounded boulders shall be used. After completion of construction of culverts, temporary diversion of water course, if any, shall be closed and water course restored for now through the culvert as per the direction of the Engineer.

312.3. Measurements for Payment

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

312.4. Rates

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

313. CONSTRUCTION OF ROCKFILL EMBANKMENT

313.1. Scope

In normal circumstances, the embankment should not be constructed with rockfill material. However, where specifically permitted by iht; Engineer because of imperative economic or technical reasons, construction of rockfill embankments shall be in accordance with the lines, grades and cross-sections as shown in drawings or as directed by the Engineer.

Rockfill shall not be used at least for a depth of 500 mm below the formation level. There should be a minimum of 500 mm thick earthen cushion over the rockfill.

313.2. Material

The size of rock pieces used in rockfill embankments shall be such that they can be deposited in layers so as to suit the conditions

evaluated in the field compaction trials or as directed by the Engineer. The rockfill shall consist of hard, durable and inert material, preferably maximum size not exceeding 300 mm and per cent finer than 125 mm not exceeding 10 per cent.

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

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

313.3. Spreading and Compaction

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

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

313.4. Measurements for Payment

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

313.5. Rate

The Contract unit rate shall be paid in full for carrying out all the above operations including cost of rockfill, broken fragments and blinding material and shall provide full compensation for all items as per Clause 305.9.1 and 305.9.2.

400

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

401. GRANULAR SUB-BASE

401.1. Scope

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

401.2. Materials

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

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

401.2.2. Physical requirements: The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part 111). The water absorption value of the coarse aggregate shall be determined as per IS : 2386 (Pan 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS : 383.
For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

TABLE 400-1. GRADING FOR CLOSE-GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading 11	Grading III
75.0 mm	100	—	—
53.0 mm	80-100	100	—
26.5 mm	55-90	70-100	100-
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

TABLE 400-2. GRADING FOR COARSE GRADED GRANULAR SUB -BASK MATERIALS

IS Sieve Designation	Per cent by weight passing the IS Sieve		
	Grading 1	Grading II	Grading III
75.0 mm	100	—	—
53.0 mm		100	
26.5 mm	55-75	50-80	100
9,50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<10
CBR Value (Minimum)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the ihrce grading! when vested according to IS : 2720 (Pan 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

401.3. Strength of sub-base

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

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

401.4. Construction Operations

401.4.1. Preparation of subgrade : Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 as applicable shall be prepared by removing all vegetation and other

extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80 -100 kN smooth wheeled roller.

401.4.2. Spreading and compacting : The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of a 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.

When the sub-base material consists of combination of materials mentioned in Clause 401.2.1, mixing shall be done mechanically by the mix-in-place method.

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

Moisture content of the loose material shall be checked in accordance with 15:2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS:2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0,7 MN/m^2 or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super-

elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

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

401.5. Surface Finish and Quality Control of Work

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

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

401.6. Arrangements for Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with Clause 112.

401.7. Measurements for Payment

Granular sub -base shall be measured as finished work in position in cubic metres.

The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

401.8. Rate

The Contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including full compensation for :

(i) making arrangements for traffic lo Clause 112 except for initial treatment to verges, shoulders and construction of diversions;

(ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and lifts;

(iii) all labour, tools, equipment and incidentals to complete the work to the Speci - fications;

(iv) carrying out the work in pan widths of road where directed; and

(v) carrying out the required tests for quality control.

402. LIME TKEATED SOIL FOR IMPROVED SUB-GRADE/SUB -BASE

402.1. Scope

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

402.2. Materials

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

402.2.2. Lime : Lime for lime -soil stabilisation 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 per cent 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.

402.2.3. Quantity of lime in stabilised 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 to 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/Unconfmed Compressive Strength (UCS) value specified in the Contract. The laboratory CBR/UCS value shall be at least 1.5 limes the minimum field value of CBR/UCS stipulated in the Contract.

402.2.4. Water : The water to be used for lime stabilisation shall be clean and free from injurious substances. Potable water shall be preferred.

402.3. Construction Operations

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

402.3.2. Degree of pulverisation: For lime stabilisation, the soil before addition of stabiliser, shall be pulverised using agricultural implements like disc harrows and rotavators to the extern that it passes the requirements set out in Table 400-3 when tested in accordance with the method described in *Appendix 3.*

TABLE 400-3. SOIL PULVERISATION REQUIREMENTS FOR LIME STABILISATION

IS Sieve designation	Minimum per cent by weight passing the IS Sieve
26.5 mm	100
5.6 mm	SO

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

The equipment used for mix-in-place construction shall be a rotavaior or similar approved equipment capable of pulverising 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 stabilised material. If so desired by the Engineer, trial runs with the equipment shaJl be carried out to establish its suitability for work.

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

402.3,4. Mix-in -place method of construction: Before deploying the equipment, the soil after it is made free of undesirable vegetation or other deleterious matter shall be spread uniformly on the prepared subgrade in a quantity sufficient to achieve the desired compacted thickness of the stabilised layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled at the discretion of 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 subgrade shall be pulverised to die required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits mentioned hereinafter. The blending or stabilising material shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

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

402.3.5. Construction with manual means: Where manual mixing is permitted, the soil from borrow areas shall first be freed of all vegetation and other deleterious matter and placed on the prepared subgrade. The soil shall then be pulverised 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 pulverised soil, the blending material(s) 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, ihe mixed material shall be levelled up to the required thickness so that it is ready to be rolled.

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

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

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

the prepared material ahead of the mixing operation shall be determined by the Engineer.

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

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

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

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

402.3.8. Rolling: Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with approved equipment preceded by a few passes of lighter rollers if necessary. Rolling shall commence at edges and progress towards the centre, except at superelevated portions' where it shall commence at the inner edge and progress towards 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 per cent 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.

402.3.9. Curing: The sub-base course shall be suitably cured for a minimum period of 7 days after which subsequent pavement courses shall be laid to prevent the surface from drying out and becoming

friable. No traffic of any kind shall ply over the completed sub -base unless permitted by the Engineer.

402.4. Surface Finish and Quality Control of Work

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

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

402.5. Strength

When lime is used for improving the subgrade, the soil-lime mix shall be tested for its CBR value. When lime stabilised 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.

402.6. Arrangements of Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with Clause 112.

402.7. Measurements for Payment

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

402.8. Rates

The Contract unit rate for lime stabilised soil sub-base shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v).

403. CEMENT TREATED SOIL SUB-BASE/BASE

403.L Scope

This work shall consist of laying and compacting a sub-base/base course of soil treated with cement 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.

403.2. Materials

403.2.1. Material to be stabilised: The material used for cement

treatment shall be soil including sand and gravel, lateritc, ,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 per cent and a plasticity index not grater than 20per cent determined in accordance with 15:2720 (Part 5). The physical requirements for the material to be treated with cement for use in a base course shall be same as for Grading I Granular Sub-base, Clause 401.2.2.

403.2.2. Cement: Cement for cement stabilisation shall comply with the requirements of IS: 269, 455 or 1489.

Table 400-4. GRADING LIMITS OF MATERIAL FOR STABILISATION' WITH CEMENT

IS Skve size	Percentage by mass passing	
	Sub -base	Base
	Finer than;	Within the range:
53,0 mm	100	100
37.5 mm.	95	95-100
19.0 mm	45	45-100
9.5 mm	35	35-100
4.75 mm	25	25-100
600 micron	8	8-65
300 micron	5	5-40
75 micron	0	0-10

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

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

403.2.5. Water: The water to be used for cement stabilisation shall be clean and free from injurious substances. Potable water shall be preferred.

4033. Construction Operations

403.3.1. Weather limitations : Stabilisation shall not be done when the air temperature in the shade is less than 10°C.
403.3.2. Degree of pulverisation : For stabilisation, the soil before addition of stabilizer, shall be pulverised, where necessary, to the extent that it passes the requirements as set out in Table 400-5 when tested in accordance with the method described in *Appendix 3.*

TABLE 400-5. SOIL PULVERISATION REQUIREMENTS FOR CEMENT STABILISATION

IS Sieve designation	Minimum per cent by weight passing the IS sieve
26.5 mm	100
5.6 mm	80

403.3.3. Clauses 402.3.3 to 402.3,5 shall apply as regards spreading and mixing the stabiliser except that cement or lime p lus cement as the case may be, shall be used as the stabilising material.

403.3.4. Moisture content for compaction: The moisture content at compaction checked vide IS: 2720 (Part 2) shal! not be less than the optimum moisture content corresponding to IS: 2720 (Part 8} nor more than 2 per cent above it.

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

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

403.4. Surface Finish and Quality Control of Works

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

403.5. Strength

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

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

403-6. Arrangements for Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with Clause 112.

403.7. Measurements for Payment

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

403.8. Rates

The Contract unit rate for cement treated soil sub-base/base with pretreatment with lime if required shall be payment in full "for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v).

404. WATER BOUND MACADAM SUB -BASE/BASE5

404.1. Scope

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

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

404.2, Materials

404.2.1. Coarse aggregates : Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jha ma) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Materials other than crushed or broken' stone and crushed slag shall be used in sub-base courses only. If crushed gravel/ shingle is used, not less than 90 per cent by weight of the gravel/ shingle pieces .retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400-6, The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS : 2386 (Part 5).

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

TABLE 400 -6. PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WATER BOUND MACADAM FOR SVJB-BASE/BASE COURSES

Test		Test Method	Requirements
1.	* Los Angeles Abrasion value Or	IS:2386 (Pan-4)	40 per cent (Mai)
	* Aggregate Impact value	IS: 2386 (Part -4) or IS:5640**	30 per cent (Max)
2.	Combined Flak mess and Elongation Indices (Total) ***	IS 23 86 (Part-1)	30 per cent (Max)

* Aggregate may satisfy requirements of cither of the two tests.

** Aggregates like bride metal, kankar, laterite etc. 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.

404.2.3. Crushed slag : Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 kN per 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 : 1W7
(ii)	Sulphur content	:	Maximum 2 per cent
(iii)	Water absorption	:	Maximum 10 per cent

404.2.4, Overburnt (Jhama) brick aggregates : Jhama brick aggregates shall be made from overburm bricks or brick bats and be free from dust and other objectionable and deleterious materials.

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

TABLE «0-7. GRADING REQUIREMENTS OF COARSE AGGREGATES

Grading No.	**Size Range**	**IS Sieve Designation**		**Per cent by weight passing**
1.	90 mm to 45 mm	125	mm	100
		90	mm	90-100
		63	nun	25-60
		45	mm	0-15
		22.4	mm	0-5
2.	63 mm *to* 45 mm	90	mm	100
		63	mm	0-100
		53	mm	25-75
		45	mm	0-15
		22.4	mm	0-5
3.	53 mm to 22.4 mm	63	mm	100
		53	nun	95-100
		45	mm	65-90
		22.4	mm	0-10
		11.2	mm	0-5

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

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

Screenings shall conform to the grading set forth in Table 400-8. The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 400-9. The table also gives the quantities of materials (loose) required for 10 m^2 for sub-base/base compacted thickness of 100/75 mm.

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

TABLE 400-8. GRADING FOR SCREENINGS

Grading Classifi-cation	Size of Screenings	IS Sieve Designation	Per cent by weight passing the IS Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95-100
		5.6 mm	15-35
		180 micron	0-10
B	11,2 mm	11.2 mm	100
		5.6 mm	90.100
		180 micron	15-35

TABLE 400-9. APPROXIMATE QUANTITIES OF COARSE AGGREGATES AND SCREENINGS REQUIRED FOR 100/75 MM COMPACTED THICK-NESS OF WATER BOUND MACADAM (WBM) SUB-BASE/BASFJ COURSE FOR 10M ^{1} AREA

Classifi-cation	Size Range	Compacted thickness	Loose Qty	Screenings			
				Stone Screening		Crushable Type such as Moorum or Gravel	
				Grading Clasi-fication & Size	For. WBM Sub-base/ base Course (Loose quantity)	Grading Classi-fication & Size	Loose Qty.
Grading	90 mm to 45 mm	100 mm	1.21 to 1.43 m^3	Type A 13.2 mm	0.27 to 0.30 m^3	Not uniform	0.30 to 0.32 m^3
Grading 2	63 mm to 45 mm	73 nun	0.91 to 1.07 m^3	Type A 13,2 mm	0.12 to 0.15 m^3	-do-	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 3	53 mm to 22.4 mm	75 mm	-do-	-do-	0.18 to 0.21 m^3	-do-	-do-

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

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 $m^3/10m^2$ and 0.08-0. lO$m^3/10m^2$ for 100 mm compacted thickness.

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

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

4043. Construction Operations

404.3.1. Preparation of base: The surface of the subgrade/ sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and crossfall (camber) arid made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water. Any sub-base/base/surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course) to Clause 501 of these Specifications.

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

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

404.3.3. Spreading coarse aggregates : The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/ base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3, as specified in Clause 404.2.5. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimise the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

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

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

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

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

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

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

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

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

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses as per Clause 407.4,1.

404.3.5. Application of screenings: After the coarse aggregate has been rolled to Clause 404.3.4, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading .motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be

accompanied by dry rolling and 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 aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

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

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

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

404.3.7. Application of binding material: After the application of screenings in accordance with Clauses 404.3.5 and 404.3.6. the binding material where it is required to be used (Clause 404.2.7) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

404.3.8. Setting and drying: After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding

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

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

404.4. Surface Finish and Quality Control of Work

404.4.1. The surface finish of construction shall conform 10 the requirements of Clause 902.

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

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

404.4.4. Reconstruction of defective macadam: The finished surface of water bound macadam shall conform to the tolerance of surface regularity as prescribed in Clause 902. However, where the surface ir-regularity of the course exceeds the tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and recompacted. In no case shall depressions be filled up with screenings or binding material.

404.5. Arrangement for Traffic

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

404.6. Measurements for payment

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

404.7. Rate

The Contract unit **rate** for water bound macadam sub-base/base course shall be payable in full for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v) including arrangement of water used in the work as approved by the Engineer,

405. CRUSHED CEMENT CONCRETE SUB-BASE/BASE

405.1. Scope

This work shall consist of breaking and crushing the damaged cement concrete slabs and recompacting the same as sub-base/base course in one or more layers. Where specified, it shall also include treating the surface of the lop layer with a penetration coat of bitumen. The work shall be performed on such widths and lengths as may be specified, in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as otherwise directed by the Engineer.

405.2. Materials

405.2.1. Coarse aggregate : Coarse aggregate for this work shall be broken cement concrete slabs crushed to a size not exceeding 75 mm and as far as possible, conforming to one of the gradings given in - Table 400-7.

405.2.2. Key aggregate : Key aggregate for the penetration coat shall consist of crushed stone, crushed gravel, shingle or other stones. It shall be clean, strong, durable, of fairly cubical shape and free of disintegrated pieces, organic o r other deleterious matter and adherent coatings. The aggregate shall be hydrophobic and of low porosity.

The aggregate shall be of 11.2 mm size defined as 100 per cent passing through 13.2 mm sieve and retained on 5,6 mm sieve and shall satisfy the physic al requirements set forth in Table 500-3.

405.2.3. Binder: Binder for the penetration coat for the top layer shall be bitumen of a suitable grade, as directed by the Engineer and satisfying the requirements of IS: 73,217 or 454, as applicable or any approved cutback or emulsion, satisfying the requirements of IS:8887.

405.3. Construction Operations

405.3.1. General: Crushed cement concrete sub-base/base course may be constructed in one or two layers, depending upon the thickness of the concrete slabs dismantled and crushed. The thickness of each layer shall, however, not exceed 100 mm in case of sub-base and 75 mm in case of base course.

The course shall be constructed as water bound macadam to Clause 404, using crushed cement concrete as coarse aggregate except that no screenings or binding material need be applied. Where specified,

the top layer shall be treated with a penetration coat of binder described in Clause 405.3.2.

4053.2. Application of penetration coat over the top layer: Before the application of the penetration coat, the surface shall be cleaned of dust, dirt and other foreign matter, using mechanical broom or any other equipment specified by the Engineer. Dust removed in the process shall be blown off with the help of compressed air.

The binder shall be heated to the temperature appropriate to the grade of bitumen used and sprayed on the dry surface in a uniform manner at the rate of 25 kg per 10 m^2 area in terms of the residual bitumen with the help of either self-propelled or towed bitumen pressure sprayer with self-heating arrangement and spray nozzle capable of spraying bitumen at specified rates and temperatures so as to provide a uniform, unbroken spread of bitumen. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably corrected.

Immediately after the application of binder, the key aggregates, in a clean and dry state shall be spread uniformly on the surface at the rate of 0.13 m^3 per 10 rm^2 area, preferably by means of a mechanical gritter, capable of spreading aggregate uniformly at specified rates or otherwise manually with the approval of the Engineer, so as to cover the surface completely. Immediately after the application of the key aggregates, the entire surface shall be rolled to Clause 506.3.8.

405.4. 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 material and works shall be exercised by the Engineer in accordance with Section 900.

405.5. Arrangements for Traffic

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

405.6. Measurements for Payment

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

Penetration coat shall be measured as finished work in square metres.

405.7. Rates

405.7.1. The Contract unit rate for crushed cement concrete sub-base/base course shall be payment in full for carrying out the required operations including full compensation for:

(i) making arrangements for traffic to Clause 112 except for initial treatment to verges/shoulders and construction of diversions;

(ii) breaking the cement concrete slabs, 'crashing, sieving and recompacting the slab material as sub-base/base course;

(iii) all labour, toots, equipment and incidentals to complete the work to the Specifications; and

(iv) carrying out the work in part widths of road where directed.

405.7.2. The Contract unit rate for penetration coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 504.8.

406. WET MIX MACADAM SUB -BASE/BASE

406.1. Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared subgrade/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 arc used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the Engineer.

406.2. Materials

406.2.1. Aggregates

406.2.1.1. Physical requirements: Coarse aggregates .shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4,75 mm sieve shall have-at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400 -10 below,

Table 400-10. PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WET MIX MACADAM FOR SUB-BASE/BASE COURSES

	Test	Test Method	Requirements
1.	*Los Angles Abrasion value or	IS: 2386 (Part-4)	40 per cent (Max)
	* Aggregate Impact value	IS: 2386 (Part-4) or IS: 5640	30 per cent (Max)
2.	Combined Flakiness and Elongation Indices (Total)	IS: 2386 (Part-4)	30 per cent (Max)

* Aggregate may satisfy requirements of either of the two tests.

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

406.2.1.2. Grading requirements: The aggregate shall conform to the grading given in Table 400-11.

Table 400-11. GRADING REQUIREMNTS OF AGGREGATES FOR WET MIX MACADAM

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

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

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

406.3. Construction Operations

406.3.1. Preparation of base: Clause 404.3.1. shall apply.

406.3.2.1. 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 407.4.1.

406.3.3. Preparation of mix : Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part -8) after replacing the aggregate fraction retained *on_22A* mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, dup allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

406.3.4. Spreading of mix : Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub- base/base in required quantities. In no case should 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 either by a payer finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly al! over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver finisher shall be self-propelled, having the following features :

(i) Loading hoppers and suitable distribution mechanism

(ii) The screed shall have lamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.

(iii) The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

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.

406.3.5. Compaction: After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN 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 or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre 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 centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

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

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

Rolling should not be done when the subgrade is soft or yielding or when it causes a wave-like motion m the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and

crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

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

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

406.3.6. Setting and drying: After final compaction of wet mix mac-adam course, the road shall be allowed to dry for 24 hours.

406.4. Opening to Traffic

Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

406.5. Surface Finish and Quality Control of Work

406.5.1. Surface evenness : The surface finish of construction shall conform to the requirements of Clause 902,

406.5.2. Quality control : Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

406.6. Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to subgrade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re - shaped with added premised material or removed and replaced with fresh premixed material as applicable and recompacted 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 cas e shall depressions be filled up with unmixed and ungraded material or fines,

406.7. Arrangement for Traffic

During the period of construc tion, arrangement of traffic shall be done as per Clause 112,

406.8. Measurements for Payment

Wet mix macadam shall be measured as finished work in position in cubic metres.

406.9. Rates

The Contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.8.

407. SHOULDERS, ISLANDS AND MEDIAN

407.1. 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.

407.2, 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 each 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 Clause 409.3.4 or 409.3.5.

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 bricks 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.

407.3. Size of Shoulders/Median/Islands

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

407.4. Construction Operations

407.4.1. Shoulder: 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 earth shoulder layer. The adjacent layers having same material shall be laid and compacted together.

In all cases where paved shoulders have to be provided along side of existing carriageway, the existing shoulders shall be excavated in full width and to the required depth as per Clause 301,3,7, Under no circumstances, box cutting shall be done for construction of shoulders.

Compaction requirement of earthen shoulder shall be as per Table 300-2. In the case of bituminous courses, work on shoulder (earthen/ hard/paved), shall start only after the pavement course has been laid and compacted.

During all stages of shoulder (earthen/hard/paved) construction, the required crossfall shall be maintained to drain off surface water.

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

407.4.2. 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 alter filling with earth shall be turfed with grass or planted with shrubs and in case of granular fill it can be finished with tiles/slabs as directed by the Engineer.

407.4.3. Brick/stone block edging: The bricks/stones blocks shall be laid on edge, with the length parallel to the transverse direction of rolled into position by a light roller and made flush with the finished level of the pavement.

407.5. 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.

407.6. Measurement for Payment

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

(i) For excavation in cu. m.

(ii) For earthwork/granular fill in cu. m.

(iii) For sub-base, base, surfacing courses in units as for respective items.

(iv) For kerb in running metres.

(v) For turfing and tile/slab finish in sq. m.

(vi) For Brick/stone block edging in se. m.

407.7. Rate

The Contract unit rate for shoulder (hard/paved/earthen with brick or stone block edging), island and median construction shall be payment in full for carrying out the required operations including full compensation for all components listen in Clause 408.8 (i) to (v) as applicable. The rate for brick/stone block edging shall include the cost of sand cushion.

408. CEMENT CONCRETE KERB AND KERB WITH CHANNEL

408.1. Scope

This work shall consist of constructing cement concrete kerbs and kerbs with channel in the central median and/or along the footpaths specified in the drawings.

108.2. Materials

Kerbs and kerb with channel shall be provided in cement concrete of grade M20 in accordance with Section 1700 of these Specification.

408.3. Type of Construction

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

408.4. 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.

408.5. Construction Operations.

408.5.1. Kerbs shall be laid on firm foundation of minimum 150 mm thickness and extending minimum 100 mm beyond the kerb which may consist of extended width of pavement or concrete of M 15 grade cast in situ or bituminous premix material of the same Specification as the profile corrective course. Before laying ti-c foundation, its base shall be levelled, watered and compacted with plate compactor/power rammer. In case of foundation consisting of granular material, the base of foundation shad be well compacted with plate compactor/power rammer and bituminous primer applied @ 14.6 kg/l0 sq. m.

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

408.5.3. After laying the kerbs and just prior to hardening of the concrete, saw-cut grooves shall be provided at 10 m intervals or as specified by the Engineer.

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

408.5.5. Vertical and horizontal tolerances with respect to true line and level shall be ±6 mm.

408.6. Measurements for Payment

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

Foundation of kerb, where separately provided shall be measured in linear metre for complete item of work.

408.7. Rates

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

409. FOOTPATHS AND SEPARATORS

409.1. Scope

The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the Engineer. The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed.

409.2. Materials

The footpaths and separators shall be constructed with any of the following types :

(a) Cast-in-situ cemenl concrete of Grade M20 as per Section 1700 of the Specifi cations.

(b) Precast cement concrete blocks/tiles of Grade M20 as per Section 1700 of the Specifications. The minimum thickness of the cement concrete block/tile shall be 25 mm and minimum size shall be 300 mm x 300 mm.

(c) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The minimum thickness of the natural stone slab shall be 25 mm and minimum size shall be 300 mm x 300 mm.

409.3. Construction Operations

409.3.1. Drainage pipes below the footpath originating from the kerbs shall be first laid in the required slope and connected to the drains/sumps/storm water drain/drainage chutes as per provisions of the diwings, or as specified.

409.3.2. Portion on back side of kerbs shall be filled and compacted with granular sub-base material as per Clause 401 of the Specifications in specified thickness.

409.3.3. The base shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings with the

following ;-

(3) Minimum 150 mm thick, compacted granular sub-base material as per Clause 401 of the Specifications.

(b) Minimum 25 mm thick cement concrete of Grade M 15,

Over the prepared base, precast concrete blocks/tiles/natural stone slabs and/or cast-in-situ slab shall be set/laid as described in Clauses 409.3,4 and 4093.5.

4093.4, Precast cement concrete blocks/tiles/natural stone slab:

The blocks/tiles/slabs shall be set on a layer of average 12 mm thick cement-sand mortar (1:3) laid on prepared base in such a way that there is no rocking. The gaps between the blocks/tiles/slabs shall not be more than 12 mm and shall be filled with cement-sand mortar (1:3).

409.3,5. Cast-in-situ cement concrete: The minimum thickness of the cement concrete shall be 25 mm and it shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per Section 1700 of the Specifications.

409.4. Measurements for Payment

Footpaths and separators shall be measured in sq. metre between inside of kerbs.

409.5. Rates

Contract unit rates shall be inclusive of full compensation of all labour, materials, tools, equipment and incidentals to construction of footpaths. Cost of providing pipes and arrangement for their discharge into appropriate drainage channels shall be incidental to the construction of footpaths.

410. CRUSHER-RUN MACADAM BASE

410.1. Scope

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

410.2. Materials

The material to be used for the work shall be crushed rock. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4,75 mm sieve shall have at least two fractured faces. It shall be free from any organic mailer and other deleterious substances and shall be of such nature that it can be compacted readily under watering and

Stances and shall be such nature that it can be compacted readily under watering and rolling to form a firm, stable base. The aggregate shall conform to the grading and quality requirement shown in Tables 400-12 and 400-13.

At the option of the contractor, the grading for either 53 mm maximum size or 37.5 mm maximum size shall be used, except that once a grading is selected, it shall not be changed without the Engineer's approval.

400.12. AGGREGATE GRADING REQUIREMENTS

Sieve size	Per cent passing by weight	
	53 mm max. size	**37.5 mm max. size**
63 mm	100	
45 mm	87-100	100
22.4 mm	50-85	90-100
5.6 mm	25-45	35-55
710 micron	10-25	10-30
90 micron	2-9	2-9

TABLE 400-13. PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR CRUSHER-RUN MACADAM BASE

	Test	Test Method	Requirements
1.	*Los Angeles Abrasion value or	IS : 2386 (Part - 4)	40 maximum
	* Aggregate Impact value	IS : 2386 (Part- 4) or IS : 5640	30 maximum
2.	Combined Flakiness and Elongation Indices (Total)	IS : 2386 (Part-1)	30maximum
3.	** Water absorption	IS : 2386 (Pan-3)	2 per cent Maximum
4.	Liquid Limit of material passing 425 micron	IS : 2720 (Part-5)	Not more than 25
5.	Plasticity Index of material passing 425 micron	IS : 2720 (Part-5)	Not more than 6

* Aggregate may satisfy requirements of either of the two tests.

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

410.3. Construction Operations

410.3.1. Preparation of subgrade: Any ruts, deformations or soft yielding places which occur in the sub-base or subgrade shall be corrected and compacted to the required density before the aggregate base course is placed thereon.

410.3.2. Spreading, watering, mixing and compaction: The aggregate shall be uniformly deposited on the approved subgrade by means of the hauling vehicle with or without spreading devices. Aggregate will be distributed over the surface to the depth specified on the plans or as directed by the Engineer.

After the base course material has been deposited, it shall be thoroughly blade-mixed 10 full depth of the layer by alternately blading the entire layer to the centre and back to the edges of the road. It shall then be spread and finished to the required cross-section by means of a motor grader.

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

Alternatively, mixing of the crusher run material and water may be done in a mixing plant as per Clause 406.3.3.

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

410.4. Surface Finish and Quality Control or Work

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

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

410.5. Arrangements for Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with Clause 112.

410.6. Measurements for Payment

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

410.7. Rate

The Contract unit rate for crusher run macadam base shall be payment in full for carrying out the required operations including full compensation for items as in Clause 401.8 (i) to (v).

500

Base and Surface Courses (Bituminous)

501. GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

501.1. General

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

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

501.2. Materials

501.2.1. Binder: The binder shall be an appropriate type of bituminous material complying with the relevant Indian Standard (IS), as defined in the appropriate Clauses of these Specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the Contract or by the Engineer. Where penetration grades of bitumen are specified, they are referred to by a single-figure designation in accordance with IS:73. Thus bitumen grade 35 refers to a bitumen in the penetration range 30 to 40. Where Modified Binder is specified, the Clause 521 of these Specifications shall apply.

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

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

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

501.2.3. Fine Aggregates: Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36mm 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.

501.2.4. Source of material: The source of all materials to be used on the project must be tested to the satisfaction of and be expressly approved by the Engineer. The Engineer 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, will require a new mix design, and laying trials, where the mix is based on a job mix design. Stockpiled from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain sufficient material for at least 5 days work.

501.3. Mixing

Pre-mixed bituminous materials, including bituminous macadam, dense bituminous macadam, semi-dense bituminous concrete and bituminous concrete, shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures can be found in Table 500-5 of these Specifications; the difference in temperature between the binder and aggregate should 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.

If a continuous mixing-plant is to be used for mixing the bituminous bound macadam; the Contractor must demonstrate by laboratory analysis that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading. Further details are available in the Manual for Construction and Supervision of Bituminous Works.

501A Transporting

Bituminous materials shall be transported in clean insulated vehicles, and unless otherwise agreed by the Engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the Engineer, a thin

coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

501.5. Laying

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

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

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

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

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

and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

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

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

(i) For laying regulating courses of irregular shape and varying thickness.

(ii) In confined spaces where it is impracticable for a paver to operate.

(iii) For footways.

(iv) At the approaches to expansion joints at bridges, viaducts or other structures.

(v) For laying mastic asphalt in accordance with Clause 515.

(vi) For filling of potholes.

(vii) Where directed by the Engineer.

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

(i) At the edges of the layers of material and at gullies and manholes.

(ii) At the approaches to expansion joints at bridges, viaducts or other structures.

(iii) As directed by the Engineer.

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

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

501.6. Compaction

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

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

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

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

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

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

501.7. Joints

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

(i) by heating the joints with an approved joint beater when the adjacent width is being laid, but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of material, to within the specified range of minimum rolling temperature and maximum temperature at any stage for the material, for a width not less, Am 75 mm, The Contractor shall have equipment available, for use in the event of a beater breakdown, to form joints by method (iii);

(ii) by using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling;

(iii) bycuttmgbaeklbeexposedjou<,foradistanceequaltothespecifiedlayerthickness, to vertical face, discarding all loosened material and coating the vertical face completely, with 80/100 penetration grade hot bitumen, or cold-applied bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2 mm, before the adjacent width is laid.

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

501.8. Preparation of Surface

501.8.1. Scope : This work shall consist of preparing an existing granular Or black-topped surface bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by the Engineer. The existing surface shall be firm and clean,

and treated with Prime or Tack coat as shown on the drawings as otherwise stated in the Contract.

501.8.2. Materials

501.8.2.1. For scarifying and re-laying the granular surface: The material used shall be coarse aggregate salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregate and screenings so that aggregates and screenings thus supplemented correspond to Clause 404: Water Bound Macadam or Clause 406: Wet Mix Macadam of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

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

501.8.2.3. For profile corrective course: A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings, or as indicated in the Contract Documents. The profile corrective course shall be laid to tolerances and densities as specified for wearing course if a single layer, or base course, if it is to be covered with a wearing course layer.

501.8.2.4. Profile corrective course and its application: 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 drawings.

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

(ii) Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral pan 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.

501.8.3. Construction Operations

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

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

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

501.8.3.2. Scarifying existing bituminous surface: Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying layer, by a suitable method approved by the Engineer. After removal, all loose and disintegrated material, the underlying layers which might have been disturbed should be suitably reworked and compacted to line and level. After supplementing the base material as necessary with suitable fresh stone, the compacted finished surface shall be primed in accordance with Clause 502. Reusable materials shall be stacked as directed by the Engineer within 1000 m of their origin.

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

501.83.4. Laying the profile corrective course

501.8.3.4.1. 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 501.8.2.4, or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.

501.8.3.4.2. 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 and compacted to the requirements of the particular Specification.

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

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

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

501.8.4. Surface finish and quality control of work: The relevant provisions of Section 900 shall apply.

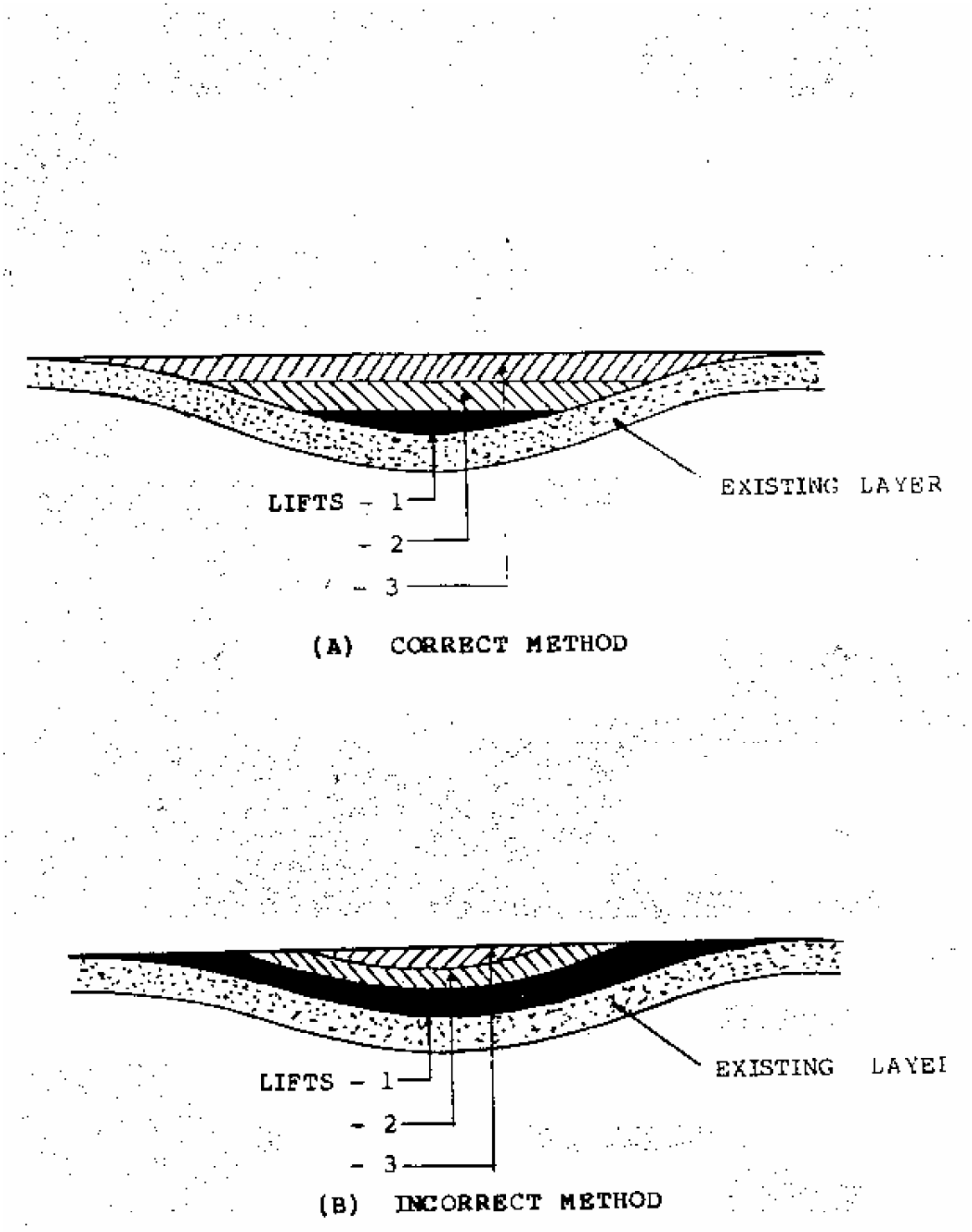
501.8.5. Arra ngements for traffic: During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

501.8.6. Environmental protection: The provisions of Clause 111 of the Ministry's Specification for Road and Bridge Works (third revision) 1995 and the provision of ***Annexure A to Clause 501*** shall apply.

501.8.7. Measurement for payment

501.8.7.1. Potholes and cracks: The work of filling potholes shall be measured separately and be paid for in square metres.

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



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

Figure. 500-1, Methods for providing corrective course for short sags and depressions

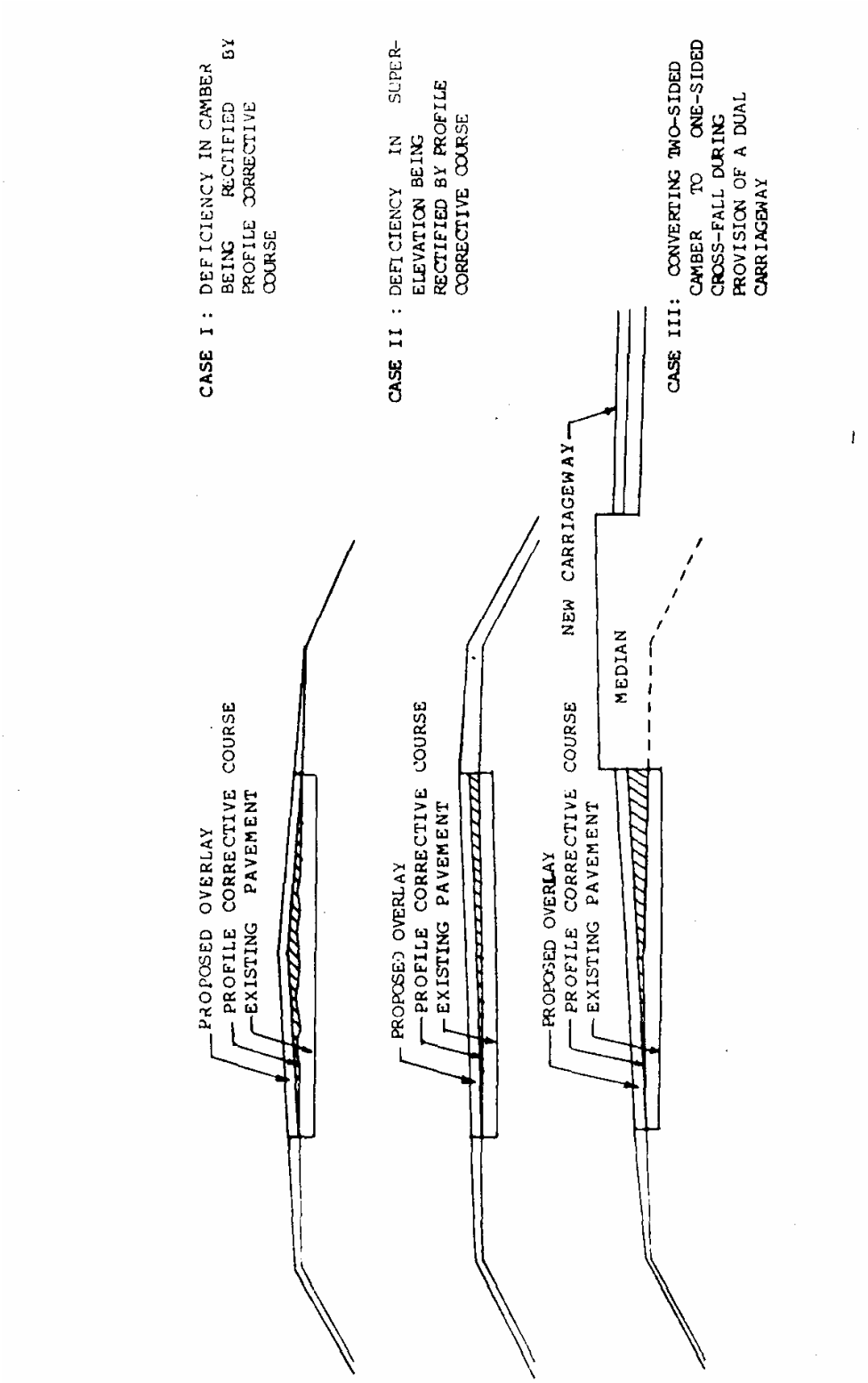


Figure. 500-2. Correction of Camber or Superelevation

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

501.8.7.2. Scarifying: Scarifying the existing bituminous surface shall be measured on a square metre basis.

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

501.8.7.4 Prime coat: Prime coat is to be measured and paid for on a per square metre basis.

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

501.8.8. Rates

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

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

(i) Making arrangements for traffic to Clause 112 except for initial treatment to verge, shoulders and construction of diversions;

(ii) Preparation of the surface to receive the material.

(iii) Providing all materials to be incorporated in the work including arrangement for stock yards, all royalties, fees rents where necessary and all leads and lifts;

(iv) Mixing, transporting, laying and compacting the mix, as specified.

(v) All labour, tools, equipment, plant including installation of hot mix plant, power supply un its and all machinery, incidental to complete the work to these Specifications;

(vi) Carrying out the work in part widths of the road where directed; (vii) Carrying out all tests for control of quality; and

(viii) The rate shall cover the provision of bitumen at the rate specified in the contract, with the provision that the variation in actual percentage of bitumen used will be assessed and the payment adjusted accordingly.

(ix) The rates for premixed material are to include for all wastage in cutting of joints etc.

(x) The rates are to include for all necessary testing, mix design, transporting and testing of samples, and cores. If there is not a project specific laboratory, the Contractor must arrange to carry out all necessary testing at an outside Laboratory, approved by the Engineer, and all costs incurred are deemed to be included in the rate quoted for the material.

(xi) The cost of all plant and laying trials as specified to prove the mixing and laying methods is deemed to be included in the Contractor's rates for the material.

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

The contract unit rate for sealing cracks by applying fog spray shall be inclusive of providing all materials, tools, labour and plant and carrying out the work. The contract unit rate for sealing cracks by providing emulsion slurry seal shall be as set forth in Clause 516.9.

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

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

Annexure 'A' to Clause 501

Annexure 'A'

PROTECTION OF THE ENVIRONMENT

1. General

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

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

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

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

2. Water Quality

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

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

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

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

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

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

3. Air Quality

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

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

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

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

4. Noise:

4.1. The Contractor shall: consider noise as an environmental constraint in his planning and execution of the Works.

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

5. Control of Wastes

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

6. Emergency Response

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

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

7. Measurement

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

502. PRIME COAT OVER GRANULAR BASE

502.1. Scope

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

502.2. Materials

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

(i) Surfaces of low porosity; such as wet mix macadam and water bound macadam,

(ii) Surfaces of medium porosity; such as cement stabilised soil base,

(iii) Surfaces of high porosity; such as a gravel base.

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

TABLE 500-1. VISCOSITY REQUIREMENT AND QUANTITY OF LIQUID BITUMINOUS PRIMER

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

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

502.3. Weather and Seasonal Limitations

Bituminous primer shall not be applied to a wet surface (see 502.4.2) or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Surfaces which are

to receive emulsion primer should be damp, but no free or standing water shall be present.

502.4. Construction

502.4.1. Equipment: The primer distributor shall be a self-propelled pi or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying of small & areas, inaccessible to the distributor, or in narrow strips shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

502.4.2. Preparation of road surface: The surface to be primed shall be prepared in accordance with Clauses 501.8. and 902 as appropriated Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not , to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

502.43. Application of bituminous primer: The viscosity and rate of application of the primer shall be as specified in the Contract, or as determined by site trials carried out as directed by the Engineer. Where a geosynthetic is proposed for use, the requirements of Clauses 704.3.2 and 704.4 of the Ministry's Specification for Road and Bridge Works (thirtfrevision) 1995 shall apply. The bituminous primer shall be sprayed uniformly in accordance with Clause 501.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.

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

502.4.5. Tack coat: Over the primed surface, a tack coat should be applied in accordance with Clause 503.

502.5. Quality Control of Work

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

502.6. Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

502.7. Measurement for Payment

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

502.8. Rate

The contract unit rate for prime coat with adjustments as described in Clause 502.7 shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v) of the Ministry's Specification for Road and Bridge Works (third revision) 1995, and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of 0.6 kg per square metre, with adjustment, plus or minus, for the variation between this amount and the actual amount approved by the Engineer after the preliminary trials referred to in Clause 502.4.3.

503. TACK COAT

503.1. Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous road surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or instructed by the Engineer.

503.2. Materials

503.2.1. Binder: The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the

Contract or as directed by the Engineer. The use of cutback bitumen as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer.

503.3. Weather and Seasonal Limitations

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

503.4. Construction

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

503.4.2. Preparation of base: The surface on which the tack coat is to be Applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clauses 501.8 and 902 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

503.43. Application of tack coat: The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract then it shall be at the rate specified in Table 500-2. The normal range of spraying

TABLE 500-2. RATE OF APPLICATION OF TACK COAT

Type of Surface	Quantity of liquid bituminous material in Kg per sq. m. area
i) Normal bituminous surfaces	0.20 to 0.25
ii) Dry and hungry bituminous surfaces	0.25 to 0.30
iii) Granular surfaces treated with primer	0.25 to 0.30
iv) Non bituminous surfaces	
a) Granular base.(not primed)	0.35 to 0.40
b) Cement concrete pavement	0.30 to 0.35

temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C if RC-70/MC-70 is used. Where a geosynthetic is proposed for use, the provisions of Clauses 704.3.2 and 704.4.4 of the Ministry's Specification for Road and Bridge Works (third revision) 1995 shall apply. The method of application of the tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

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

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

503.5. Quality Control of Work

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

503.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

503.7. Measurement for Payment

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

503.8. Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in Clause 401.8 (i) to (v) of the Ministry's Specification for Road and Bridge Works (third revision) 1995 and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat at 0.2 kg

per square metre, with the provision that the variance in actual quantity of bitumen used will be assessed and t he payment adjusted accordingly.

504. BITUMINOUS MACADAM

504.1. Scope

This work shall consist of construction in a single course having 50mm to 100mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications. Bituminous macadam is more open graded than the dense graded bituminous materials described in Clauses 507, 508 and 509.

504.1. Materials

504.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73, and of the penetration indicated in Table 500-4.

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

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

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

(text is corrupted in book)
or naturally occurring, material, 01 a combination of the two, passing 2.36 mm sieve and retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

TABLE 500-3. PHYSICAL REQ1REMENTS FOR COARSE AGGREGATES FOR BITUMINOUS MACADAM

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

Notes: 1. IS: 2386 Part I
2. IS: 2386 Part I
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386 Part 5
5. IS: 2386 Part 3
6. IS: 6241
7. The water sensitivity test is only to be carried out if the minimum retained coating in the stripping test is less than 95%.

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

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

504.2.5. Proportioning of material: The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-4. The binder content shall be within a tolerance of ± 0.3 per cent by weight of total mixture when individual specimens are taken for quality control tests in accordance with the **(text is corrupted in book)**

504.3. Construction Operations

504.3.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

TABLE 500-4. COMPOSITION OF BITUMINOUS MACADAM

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

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

504.3.2. Preparation of the base: The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clauses 501.8 and 902.3 as appropriate, and a prune coat, shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer.

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

504.3.4. Preparation and transportation of the mixture: The provisions of Clauses 501.3 and 501.4 shall apply.

504.3.5. Spreading: The provisions of Clauses 501.5.3 shall apply.

TABLE 500-5. MANUFACTURING AND ROLLING TEMPERATURES

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

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

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

504.4. Surface Finish and Quality Control of Work

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

504.5. Protection of the Layer

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

504.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

504.7. Measurement for Payment

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

504.8. Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include for, all components listed in Clause 501.8.8.2. (i) to (xi).

This page is not proper printing and text missing

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

TABLE 500-6. COMPOSITION OF PENETRATION MACADAM

	Cumulative per cent by weight of total aggregate passing			
	For 50 mm compacted Thickness		For 75 mm compacted Thickness	
IS Sieve Designation (mm)	Coarse Aggregate	Key Aggregate	Coarse Aggregate	Key Aggregate
63	—	—	100	—
45	100	—	58 - 82	—
26.5	37- 72	—	—	100
22.4	—	100	5 - 27	50 -75
13.2	2 - 20	50 -75	—	—
11.2	—	—	—	5 - 25
5.6	—	5 -25	—	—
2.8	0-5	0-5	0-5	0-5
Approx. Loose aggregate quantities cu.m/m^2	0.06	0.015	0.09	0.018
Binder quantity (penetration grade)[1] (kg/m^2)	5		6.8	

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

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

The requirements given in Clause 501.6 and 501.7 shall apply.

After initial dry rolling, the surface shall be checked with a crown

template and a 3 metre straight-edge. The surface shall not vary more than 10 mm from die template or straight-edge. All surface irregularities exceeding the above limit shall be corrected by removing or adding aggregates as required.

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

505.3.6. Application of bituminous material: After the coarse aggregate has been rolled and checked, the bituminous binder shall be applied, at the rate given in Table 500-6, in accordance with Clause SOI, and at a temperature directed by the Engineer.

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

In certain circumstances, depending on the type and size of aggregate used, the Engineer may direct the placing of a bed of clean sand or quarry fines, hot exceeding10mm in thickness, on the prepared foundation before placing the coarse aggregate. The sand or fine material shall be slightly wetted, just sufficient for it to slurry up during the compaction process. Where cut back is used, if flooding of the binder occurs it should be applied in two operations, or as directed by the Engineer.

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

Where directed by the Engineer, the surface shall be swept and the quantity of key aggregate adjusted to ensure uniform application, with all the surface voids in the coarse aggregate being filled without excess. The entire surface shall then be rolled with a 8 - 10 tonnes smooth steel wheel roller (or vibrating roller operating in non-vibratory mode) in accordance with the procedure specified in Clause 505.3.5.

505.4. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials

supplied and the works carried out the relevant provisions of Section 900 shall apply.

505.5. Surfacing

The Penetration Macadam shall be provided with a surfacing (binder/ wearing course) within a maximum of forty-eight hours. If there is to be any delay, the penetration macadam shall be covered by a seal coat to the requirements of Clause 513 before opening to traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

505.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

505.7. Measurement for Payment

Penetration Macadam base course shall be measured as finished work in square metres.

505.8. Rate

The contract unit rate for Penetration Macadam course shall be payment in full for carrying out the required operations including, but not necessarily limited to, all components listed in Clause 501.8.8.2 (i) to (xi).

506. BUILT-UP SPRAY GROUT

506.1. Scope

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

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

506.2, Materials

506.2.1. Bitumen: Clause 504.2.1. shall apply. Where permitted by the Engineer, an appropriate grade of emulsion complying with IS 8887 may be used.

506.2.2. Aggregates: The coarse aggregate shall conform to Clause 504.2.2.

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

TABLE 500-7. GRADING REQUIREMENTS FOR COARSE AND KEY AGGREGATES FOR BUILT-UP SPRAY GROUT

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Coarse Aggregate	Key Aggregate
53.0	100	—
26:5	40 -75	—
22.4	—	100
13.2	0-20	40 -75
5.6	—	0-20
2.8	0-5	0-5

506.3. Construction Operations

506.3.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

506.3.2. Equipment: The provisions of Clause 505.3.2 shall apply.

506.3.3. Preparation of base: The base on which the built-up spray grout course is to be laid shall be prepared, shaped and compacted to the specified lines, grades and cross-sections in accordance with Clauses 501 and 902 as appropriate. A prime coat shall be applied in accordance with Clause 502 with approved primer as directed by the Engineer.

506.3.4. Tack coat: A tack coat shall be applied in accordance with the procedure described in Clause 503, as directed by the Engineer.

506.3.5. Spreading and rolling coarse aggregates for the first layer: Immediately after the application of prime or tack coat, the clean, dry and dust free coarse aggregates shall be spread uniformly and evenly,

by mechanical means, at the rate of 0.5 cu. m. per 10 sq. m. area.

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

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

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

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

506.3.7. Spreading and rolling of coarse aggregate for the second layer: Immediately after the first application of the binder, the second layer of coarse aggregates shall be spread and rolled in accordance with the procedure detailed in Clause 506.3.5.

506.3.8. Application of binder - second spray: The second aggregate layer shall then be sprayed with binder at the rate of 15 kg/10 sq. m. (measured in terms of residual bitumen content) in accordance with Clause 506.3.6.

506.3.9. Application of key aggregate: Immediately after the second application of binder, key aggregates shall be spread uniformly and evenly, preferably by mechanical means, at the rate of 0.13 cu.m./10 sq.m. so as to cover the surface completely. The key aggregate shall be clean, dry and free from dust and deleterious matter. If necessary, the surface shall be swept to ensure uniform application of the key aggregates. The entire

surface shall then be rolled with an 8-10 tonnes smooth wheel steel roller in accordance with Clause 506.3.5. While rolling is in progress, additional key aggregates, where required, shall be spread by hand. Rolling shall continue-until the entire course is thoroughly compacted and the key aggregates are firmly in position.

506.4. Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of Clause 902. All materials shall comply with the requirements of the relevant provisions in Section 900 of the Specifications.

506.5. Final Surfacing

The built-up-spray-grout shall be provided with final surfacing within a maximum of forty-sight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before it is open to traffic. Where the seal coat is required as a result of the selected method of performing this operation, then it shall be considered incidental to the work and shall not be paid for separately.

506.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

506.7. Measurement for Payment

Built-up spray grout shall be measured as finished work in square metres.

506.8. Rite

The contract unit rate for built-up spray grout shall be payment in full for carrying out the required operations as specified. The rate shall include for, but not necessarily be limited to the components listed in Clause 50 L8.8.2. (i) to (xi).

507. DENSE GRADED BITUMINOUS MACADAM

507,1. Scope

This clause specifies the construction of Dense Graded Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder

and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50mm to 100mm.

507.2. Materials

507.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS: 73, and of the penetration indicated in Table 500-10 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

507.2.2. 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 substances. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table 500-8, for dense bituminous macadam.

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

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

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

TABLE 500-8. PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR DENSE GRADED BITUMINOUS MACADAM

Property	Text	Specification
Cleanliness (dust)	Grain size analysis [1]	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined)[2]	Max 30%
Strength*	Los Angeles Abrasion Value[3]	Max 35%
	Aggregate Impact Value[4]	Max 27%
Durability	Soundness:[5]	
	Sodium Sulphate	Max 12%
	Magnesium Sulphate	Max 18%
Water Absorption	Water absoption[6]	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[7]	Minimum retained coating 95%
Water Sensitivity	Retained Tensile Strength	Min80%

Notes: 1. IS:2386Part I
2. IS: 2386 Part I
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386Part4*
5. IS:2386Part5
6. IS: 2386 Part 3
7. IS: 6241
8. AASHTOT283**

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

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

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

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

TABLE 500-9. GRADING REQUIREMENTS FOR MINERAL FILLER

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

The filler shall be free from organic impurities and have a Plasticity Index not greater than *4.* The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent

by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

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

TABLE 500-10. COMPOSITION OF DENSE GRADED BITUMINOUS MACADAM PAVEMENT LAYERS

Grading	1	2
Nominal aggregate size	**40mm**	**25 mm**
Layer Thickness	**80-100 mm**	**50-75 mm**
IS Sieve [1] (mm)	**Cumulative % by weight of total aggregate passing**	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	2«^2	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 [2]	Min4.0	Min4.5
Bitumen grade (pen)	65 or 90	65 or 90

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.

507.3. Mixture Design

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

TABLE 500-11. REQUIREMENTS FOR DENSE GRADED BITUMINOUS MACADAM

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

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

TABLE 500-12. MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Practice Size[1] (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent[2]		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0'	11.0	12.0	13.0
37:5	10.0	11.0	12.0

Notes: 1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10'per cent.
2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

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

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

507.3.3. Job mix formula: The Contractor shall inform the Engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:

  (a) Binder type, and percentage by weight of total mixture;

  (b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.

(v) The results of tests enumerated in Table 500-11 as obtained by the Contractor;

(vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch,

(vii) Test results of physical characteristics of aggregates to be used;

(viii) Mixing temperature and compacting temperature.

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

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

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

5073.4. Plant trials - permissible variation in job mix formula: Once the laboratory job mix formula is approved, the Contractor shall

carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 500- 13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

TABLE 500-13. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder coarse	Wearing coarse
Aggregate passing 1 9mm sieve or larger	±8%	±7%
Aggregate passing 13.2mm, 9.5mm	±7%	±6%
Aggregate passing 4.75min	±6%	±5%
Aggregate passing 2.36mm, 1 . 1 8mm, 0.6mm	±5%	±4%
Aggregate passing 0.3mm, 6.15mm	±4%	±3%
Aggregate passing 0.075nim,	±2%	±1.5%
Binder content	±0.3%	±0.3%
Mixing temperature	±10°C	±10°C

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

507.3.5. Laving 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 SO 1. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The area of the laying trials shall be a minimum of 100 sq. m. of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor .shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and

methodology 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.

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.

507.4. Construction Operations

507.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

507.4.2. Preparation of base: The 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. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where-mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

507.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 704 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

507.4.4. Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

507.4.5. 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.

507.4.6. Tack coat: Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of Clause 503, or as directed by the Engineer.

507.4.7. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

507.4.8. Spreading: The provisions of Clauses 501.5.3 and 501.5.4. shall apply.

507.4.9. 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.

507.5. Opening to Traffic

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

507.6. Surface Finish and Quality Control of Work

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

507.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

507.8. Measurement for Payment

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tons or by the square metre at a specified thickness as detailed on the Contract drawings, or documents, or as directed by the Engineer.

507.9. Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the all required operations as specified, and shall include, but not necessarily limited to all components listed in Clause 501.8 8.2 (i) to (xi). The rate shall include the provision of bitumen, at 4.25 per cent by weight of the total mixture.

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

508. SEMI-DENSE BITUMINOUS CONCRETE

508.1. Scope

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

508.2. Materials

508.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-15, for semi dense bituminous concrete, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

508.2.2. Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-14.

508.23. Fine aggregates: The fine aggregates shall be all as specified in Clause 507.2.3.

508.2.4. Filler: Filler shall, be generally as specified in Clause 507.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-14 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

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

508.3. Mixture Design

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

TABLE 500-14. PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR SEMI DENSE BITUMINOUS CONCRETE PAVEMENT LAYERS

Property	Test	Specification
Cleanliness (dust)	Grain size analysis'	Max 5% passing 0.075mm sieve
Panicle shape	Flakiness and Elongation Index (Combined)[2]	Max 30%
Strength*	Los Angeles Abrasion Value[3] Aggregate Impact Value[4]	Max 35% Max 27%
Polishing	Polished Stone Value[5]	Min55
Durability	Soundness:[6] Sodium Sulphate Magnesium Sulphate	 Max 12% Max 18%
Water Absorption	Water absorption[7]	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[9]	Minimum Retained Coating 95%
Water Sensitivity**	Retained Tensile Strength[8]	Min 80%

Notes: 1. IS: 2386 Part 1

2. IS: 2386 Part 1 (the elongation test may be done only on non-flaky aggregates in the sample)

3. IS: 2386 Part 4*

4. IS: 2386 Part 4*

5. BS: 812 Part 114

6. IS: 2386 Part 5

7. IS: 2386 Part 3

8. AASHTOT283**

9. IS: 6241

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

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

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

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

TABLE 500-15. COMPOSITION OF SEMI DENSE BITUMINOUS CONCRETE PAVEMENT LAYERS

Grading	**1**	**2**
Nominal aggregate size	**13mm**	**10mm**
Layer Thickness	**35-40 mm**	**25-30 mm**
IS Sieve [1] (mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5		
19	100	
13.2	90-100	100
9.5	70-90	90-100
4.75	35-51	35-51
2.36	24-39	24-39
1.18	15-30	15-30
0.6	-	-
0.3	9-19	9-19
0.15	-	-
0.075	3-8	3-8
Bitumen content % by mass of total mix [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.

TABLE 500-16. REQUIREMENTS FOR SEMI DENSE BITUMINOUS 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
Per cent air voids	3-5
Per cent voids in mineral aggregate (VMA)	See Table 500-12
Per cent voids filled with bitumen (VFB)	65-78

508.3.3. Job mix formula: The procedure for formulating the job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500- 1 6 as obtained by the Contractors.

508.3.4. Plant trials - permissible variation in job mix formula: The requirements for plant trials shall be alt as specified in Clause 507.3.4, and permissible limits for variation as shown in Table 500-13.

508-3.5. Laying trials: The requirements for laying trials shall be all as specified iii Clause 507.3.5.

508.4. Construction Operations

508.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

508.4.2. Preparation of base: The surface on which the Semi Dense Bituminous material is to be laid shall be prepared in accordance with Clauses 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 access, other approved methods shall be used as directed by the Engineer.

508.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 704 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

508 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 522.

508.4.5. Tack coat: Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the requirements 'of Clause 503.

508.4.6. Mixing and transportation of the mixture: The provisions as specified in Clauses 501. 3. and 501.4 shall apply.

508.4.7. Spreading: The general provisions of Clauses 501.5.3 and 501.5.4 shall apply.

508.4.8. 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.

508.5. Opening to Traffic

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

508.6. Surface Finish and Quality Control

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

508.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

508.8. Measurement for Payment

The measurement shall be all as specified in Clause 507.8.

508.9. Rate

The contract unit rate shall be all as specified in Clause 5Q7.9, except that the rate shall include the provision of bitumen at 4.75. pe* cent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

509. BITUMINOUS CONCRETE

509.1. Scope

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

509.2. Materials

509.2.1. Bitumen: The bitumen shall be paving bitumen of

Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-18, for bituminous concrete, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

509.2.2. Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

509.2.3. Fine aggregates: The fine aggregates shall be all as specified in Clause 507.2.3.

509.2.4. Filler: Filler shall be generally as specified in Clause 507.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-17 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

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

509.3. Mixture Design

5093.1. Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-19.
The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

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

509.3.3. Job mix formula: The procedure for formulating the job

TABLE 500-17. PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR BITUMINOUS CONCRETE PAVEMENT LAYERS

Property	Test	Specification
Cleanliness (dust)	Grain size analysis [1]	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index	Max 30% (Combined)[2]
Strength*	Los Angeles Abrasion Value[3]	Max 30%
	Aggregate Impact Value[4]	Max 24%
Polishing	Polished Stone Value[3]	MinS5
Durability	Soundness:[6]	
	Sodium Sulphate	Max 12%
	Magnesium Sulphate	Max 18%
Water Absorption	Water absorption[7]	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[9]	Minimum retained coating 95%
Water Sensitivity**	Retained Tensile Strength[8]	Min80%

Notes: 1. IS: 2386 Part 1
2. IS: 2386 Part 1 (the elongation test may be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386 Part 4*
5. BS: 812 Part 114
6. IS: 2386 Part 5
7. IS: 2386 Part 3
8. AASHTOT283**
9. IS: 6241

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

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

mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-19 as obtained by the Contractors.

509L3.4. Plant trials - permissible variation in job mix formula:

The requirements for plant trials shall be all as specified in Clause 507.3.4, and permissible limits for variation as shown in Table 500-13.

509.3.5. Laving trials: The requirements for laying trials shall be all as specified in Clause 507.3.5.

509.4. Construction Operations

509.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

TABLE 500-18. COMPOSITION OF BITUMINOUS CONCRETE PAVEMENT LAYERS

Grading	**1**	**2**
Nominal aggregate size	**13mm**	**10mm**
Layer Thickness	**35-40 mm**	**25-30 mm**
IS Sieve [1] (mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5	100	
19	79-100	100
13.2	59-79	79-100
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 [2]	5.0-6.0	5.0-7.0
Bitumen grade (pen)	65	65*

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

TABLE 500 -19. REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

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

509.4.2. 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 access, other approved methods shall be used as directed by the Engineer.

509.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 704 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

509.4.4. Stress absorbing layer. Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance- with the requirements of Clause 522.

509.4.5. Tack coat: Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the requirements of Clause 503.

509.4.6. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

509.4.7. Spreading: The general provisions of clauses 501.5.3 and 501.5.4 shall apply.

509.4.8. Rolling: The general provisions of clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

509.5. Opening to Traffic

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

509.6. Surface Finish and Quality Control

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

509.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be

made in accordance with the provisions of Clause 112 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

509.8. Measurement for Payment

The measurement shall be all as specified in Clause 507.8.

509.9. Rate

The contract unit rate shall be all as specified in Clause 507.9, except that the rate shall include the provision of bitumen at 5.0 per cent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

510. SURFACE DRESSING

510.1. 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. For information on the Design of Surface Dressing refer to the Manual for Construction and Supervision of Bituminous Works.

510.2. Materials

510.2.1. Binder: The binder shall have a kinematic viscosity lying in the range IxlO4 to TxlO5 centistokes at the expected range of road surface temperatures at the construction site during the period of laying. The type of binder to be used will be stated in the Contract documents and shall .comply with one of the following:

Paving Bitumen IS:73

Bitumen Emulsion IS:8887

510.2.2. Aggregates: The chips shall conform to the requirements of Clause 504.2.2., except that their water absorption shall be restricted to a maximum of 1 per cent and they shall have a Polished Stone value, as measured by the method given in BS812 (Part 114), of not less than 60. The chips shall be single sized, clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter and conforming to one of the gradings given in Table 500-21.

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

TABLE 500-20. NOMINAL RATES OF SPREAD FOR BINDER AND CHIPPINGS (1)

Chipping Size mm	Binder (penetration grade bitumen) kg/m^2	Chips Cum/m^2
19	1.2	0.015
13	1.0	0.010
10	0.9	0.008
6	0.75	0.004

Note: (1) These rates of spread are for pricing purposes - see Clause 510.2.3 and Clause 510.8

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

(3) Refer to Manual for Construction and Supervision of Bituminous Works for the procedure of determining the rates of spread of binder and chips.

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

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

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

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

510.3. Construction operations

510.3.1. Weather and seasonal limitations : Clause 501.5.1 shall apply.

TABLE 500-21. GRADING REQUIREMENTS FOR CHIPS FOR SURFACE DRESSING

IS Sieve Designation mm	Cumulative per cent by weight of total aggregate passing for the following nominal sizes (mm)			
	19	13	10	6
26.5	100	-	-	-
19.0	85-100	100	-	-
13.2	0-40	85-100	100	-
9.5	0-7	0-40	85-100	100
6.3	-	0-7	0-35	85-100
4.75	-	-	0-10	-
3.35	-	-		0-35
2.36	0-2	0-2	0-2	0-10
0.60		-		0-2
0.075	0-1.5	0-1.5	0-1.5	0-1.5
Minimum 65% by weight of aggregate	Passing 19 mm, retained 13.2mm	Passing 13.2 mm, retained 9.5 mm	Passing 9.5 mm, retained 6.3mm	Passing 6.3 mm, retained 3.35mm

510.3.2. 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 by burning off, or manually, as specified in the Contract or directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and / or compressed air, or any other approved equipment / method as specified in the Contract or by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be damp).

510.3.3. Application of binder : The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for the grade of binder used shall be as given in Table 500-22 and the rate of spray as given in 510.2.3.

5103.4. Application of stone chips : The equipment and general

TABLE 500-22. SPRAYING TEMPERATURES FOR BINDERS

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

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

5103.5. Rolling : Rolling of the chips should preferably be carried out by a pneumatic tyred roller in accordance with Clause 501.6 and Clause 501.7. Traditional steel wheeled rollers tend to crush the aggregates and if their use cannot be avoided their weight should be limited to 8 tonnes. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

510.3.6. Application of second coat of surface dressing : Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for 2 or 3 weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clauses 510.3.3 to 510.3.5.

510.4. 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.

510.5. Surface Finish and Quality Control of Work

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

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

510.6. Arrangements for Traffic

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

510.7. Measurement for Payment

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

510.8. Rate

The Contract unit rate for surface dressing, based on the notional rates of spread for binder and each size of chippings given in Clause 510.2.3, which shall be adjusted, plus or minus, for the difference between the notional rates; of spread and the rates of spread determined as described in the Manual for Construction and Supervision of Bituminous Works, and approved by the Engineer, multiplied by the rates entered in the Bill of Quantities for binder and each size of chipping. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

511. OPEN-GRADED PREMIX SURFACING

511.1. Open-graded Premix Surfacing using Penetration Bitumen or Cutback.

511.1.1. Scope : This work shall consist of the preparation, laying and compaction of an open-graded premix surfacing material of 20 mm

thickness composed of small-sized aggregate premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of these Specifications, to serve as a wearing course.

511.1.2. Materials

511.1.2.1. Binder : The binder shall be a penetration bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS: 73.

511.1.2.2. Aggregate: The aggregate shall conform to Clause 504.2.2 except that the water absorption shall be limited to a maximum of 1 per cent. The Polished Stone Value, as measured by the test in BS 812- (Part 114), shall not be less than 55.

511.1.2.3. Proportioning of materials: The materials shall be proportioned in accordance with Table 500-23.

511.13. Construction operations

511.1.3.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

511.1.3.2. 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

TABLE 500-23. QUANTITIES OF MATERIALS REQUIRED FOR 10 m' OF ROAD SURFACE FOR 20mm THICK OPEN-GRADED PREMIX SURFACING USING PENETRATION BITUMEN OR CUTBACK

Aggregates		
(a)	Nominal Stone size 13.2mm (passing 22.4 mm sieve and retained on 11.2 mm sieve) -	0.18m[1]
(b)	Nominal Stone size 1 1.2mm (passing 13.2 mm sieve and retained on 5.6 mm sieve).	0.09m[3]
	Total	0.27m[3]
Binder (quantities in terms of straight run bitumen)		
(a)	For 0.18 m [3] of 13.2mm nominal size stone at 52 kg bitumen per m [3]	9.5kg
(b)	For 0.09 m' of 11.2 mm nominal size stone at 56 kg bitumen per m [3]	5.1 kg
	Total	14.6kg

accordance with Clause 502 as directed by the Engineer.

511.1.3.3. Tack coat: A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

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

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

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

511.1.3.5. Spreading and rolling : The pre mixed material shall be spread by suitable means to the desired thickness, grades and cross-full (camber) making due allowance for any extra quantity required to fill up depressions, if any. The cross-fall should be checked by means of camber boards and irregularities 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 toward the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

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

for this purpose. Excess use of water for this purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below 100° C. Joints along and transverse to the surfacing laid and compacted earlier shall be cut vertically to "heir full depth so as to expose fresh surface which shall be painted with a L in coat of appropriate binder before the new mix is placed against it.

511.1.3.6. Seal coat : A seal coat conforming to Clause 513 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

511.1.4. 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 513.4.

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

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

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

511.1.8. Rate : The contract unit rate for open-graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

511.2. Open graded premix surfacing using cationic bitumen emulsion

511.2.1. 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.

511.2.2. Materials

511.2.2.1. Binder : The binder for Premix wearing course shall be cationic bitumen emulsion of Medium Setting (MS) grade complying with I.S.8887 and having a bitumen content 65 per cent minimum by weight. For liquid seal coat RS grade of Cationic bitumen emulsion shall be used. Where expressly specified in the Contract MS grade emulsion shall be used or otherwise directed by the Engineer. Slow Setting (SS) grade Cationic bitumen Emulsion shall be used for premix seal coat.

511.2.2.2. Aggregate : The requirements of Clause 511.1.2.2. shall apply.

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

TABLE 500-24. QUANTITIES OF AGGREGATE FOR 10 M1 AREA

(A)	**Premix Carpet**	
(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
(B)	For Seal Coat: Refer to Clause 513.	

TABLE 500-25. QUANTITIES OF EMULSION BINDER

		For 10m^2 area
(B)	**For Seal Coat:**	
	(a) for liquid seal coa:	12 to 14 kg
	(b) for premix seal coat	10 to 12 kg

511.2.4. Construction operations

511.2.4.1. 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.

511.2.4.2. 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 507.4.2 where an existing bituminous surface is to be overlaid.

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

51 1.2.4.4. 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, or directed by the Engineer.

511.2.4.5. 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 which quantity will cover 5 sq.m. of road surface with 20 mm average thickness.

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

First the coarse aggregate of 13.2 mm size shall be placed into the mixer followed by 5 to 6.5 kg of Cationic bitumen emulsion and then the
(this line is corrupted in the text is also)
bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

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

remaining quantity of emulsion are added and mixed. Too much mixing shall be avoided.

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

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

The rolling shall start immediately after laying the premix. A smooth wheeled tandem roller of 8-10 tonnes shall be used, unless 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-directional cambered sections where rolling shall be carried out from the lower edge towards the higher edge parallel to the centre line of the road.

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

511.2.4.7. Seal coat: A seal coat, conforming to Clause 510 or Clause 513, as specified in the Contract, shall be applied 4 to 6 hours after laying the premix carpet.

511.2.5. Opening to traffic : Traffic should not be allowed over the

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

511.2.6. Surface finish and quality control : The surface finish of construction shall conform to the requirements of Clause 902.

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

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

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

511.2.9. Rate : The contract unit rate for premix carpet and seal coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

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

512. CLOSE-GRADED PREMIX SURFACING/ MIXED SEAL SURFACING

512.1. Scope

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

512.1.2. Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents.

512.2. Materials

512.2.1. Binder : The provisions of Clause 511.1.2.1 shall apply.

512.2.2. Coarse aggregates : The provisions of Clause 511.1.2.2 shall apply.

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

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

TABLE 500-26. AGGREGATE GRADATION

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

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

512.3. Construction Operations

The provisions of Clause 511.1.3.1 through 511.1.3.5 shall apply.

512.4. Opening to Traffic

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

512.5. Surface Finish and Quality Control of Work

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

512.6. Arrangements for Traffic

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

512.7. Measurements for Payment

Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square metres at a specified thickness. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

512.8. Rate

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

513. SEAL COAT

513.1. Scope

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

513.1.2. Seal coat shall be of either of the two types specified below:

(A) Liquid sea! 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 tine aggregate premixed \MI|I bituminous binder.

513.2. Materials

513.2.1. Binder : The requirements of Clauses 511.1.2.1 and 51 1.2.2.1 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 coal. 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.

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

513.2.3. 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 2.36mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metres per 10 square metres area.

513.3. Construction Operations

513.3.1. Weather and seasonal limitations: The requirements of Clause 501.5.1 shall apply.

513.3.2. 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.

513.3.3. Construction of Type A seal coat: Bitumen shall be heated to 150°C-163°C and sprayed at the rate specified on the dry surface in a uniform manner with a self-propelled mechanical sprayer as described in the Manual for Construction and Supervision of Bituminous Works. Immediately after the application of binder, stone chips, which shall be clean and dry, shall be spread uniformly at the rate specified on the surface preferably by means of a self-propelled or towed mechanical grit spreader so as to cover the surface completely. If necessary, the surface shall be brushed 10 ensure uniform spread of chips.

Immediately after the application of the cover material, the entire

surface shall be rolled with a 8 - 10 tonne smooth wheeled steel roller, 8 - 10 tonne static weight vibratory roller, or other equipment approved by the Engineer after laying trials if required. Rolling shall commence at the edges and progress towards the centre except in superelevated and unidirectional 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 panicles are firmly embedded in the binder and present a uniform closed surface.

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

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

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

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

513.4. 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 speed shall be rigorously limited to 16 km per hour until the following day.

513.5. Surface Finish and Quality Control of Work

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

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

513.6. Arrangements for Traffic

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

513.7. Measurement for Payment

Seal coat, Type A or B shall be measured as finished work, over the area specified to be covered, in square metres at the thickness specified in the Contract.

513.8. Rate

The contract unit rate for seal coat Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

514. SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES

514.1. Scope

This Specification 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 this Specification. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Specification Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective

Specification Clauses for the individual items given elsewhere in this Specification.

514.2. Sizes of Stone Aggregates

The stone aggregates shall be designated by their standard sizes in the Contract and shall conform to the requirements shown in Table 500-27.

TABLE 500-27. SIZE REQUIREMENTS FOR COARSE STONE AGGREGATES

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
(0	75 mm	106mm	63mm
(ii)	63 mm	90mm	53 mm
(iii)	45mm	53 mm	26.5 mm
(iv)	26.5 mm	45mm	22.4mm
(v)	22.4mm	26.5 mm	13.2mm
(vi)	13.2mm	22.4 mm	11.2mm
(vii)	11 .2 mm	13.2mm	6.7mm
(viii)	6.7mm	11 .2 mm	2.8 mm

514.3. Stacking

1. Coarse Aggregates:

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

2. Fine Aggregate: As stated in the individual relevant Specification Clauses.

The aggregates shall be stacked entirely clear of the roadway on even clear hard ground, 01 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 he stacked in locations liable to inundation or flooding.

The dimensions of the stockpiles and their location 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.

514.4. Quality Control of Materials

The Engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the Specification requirements, by carrying out tests for the specified properties.

Testing shall be to the following frequencies and the Engineer may, at his discretion, direct these to be modified according to requirements:

Coarse and fine: One test for each specified property per 50 m^3 of stone aggregates.

Stone filler: One test for each specified property for every five tonnes, subject to a minimum of one test for each consignment.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the Specification shall be rejected by the Engineer and removed from the work site.

514.5. Measurement for Payment

Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in Table 500-28, from the volume computed by stack measurements, to allow for bulking.

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

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

TAKLE 500-28. PER CENT REDUCTION IN VOLUME OF AGGREGATES

S. No.	Standard size of aggregates	Percentage reduction in volume computed by stack measurements to arrive at the volume to be paid for
1.	75 mm and 63 mm	12.5
2.	45 mm and 26.5 mm	10.0
3.	22.4 mm, 13.2 mm, 11.2 mm and 6.7 mm	5.0
4.	Fine aggregate	5.0

514.6. Rates

The contract unit rates for different sizes of coarse aggregate, fine aggregate and stone filler shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for :

(i) all royalties, fees, rents where necessary;

(ii) all leads and lifts; and

(iii) all labour, tools, equipment and incidentals to complete the work to the Specifications.

(iv) all necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

515. MASTIC ASPHALT

515.1. Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogeneous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and voidless mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

515.2. Materials

515.2.1. Binder: Subject to the approval of the Engineer, the binder shall be a paving grade bitumen meeting the requirements given in Table 500-29.

515.2.2. Coarse aggregate : The coarse aggregate shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from soft, organic or other deleterious substances. They shall satisfy the physical

TABLE 500-29. REQUIREMENTS FOR PHYSICAL PROPERTIES OF BINDER

Property		Test method	Requirement
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 <10°C), a softer penetration grade of 30/40 may be used.

requirements given in Table 500-3.

The percentage and grading of the coarse aggregate to be incorporated in the mastic asphalt depending upon the thickness of the finished course shall be as specified in Table 500-30.

TABLE 500-30. GRADE AND THICKNESS OF MASTIC ASPHALT PAVING, AND GRADING OF COARSE AGGREGATE

Application	Thickness range (mm)	Nominal size of coarse aggregate (mm)	Coarse aggregate content, % by mass of total mix
Roads and carriageways	25-50	13	40± 10
Heavily stressed areas i.e. junctions and toll pla zas	40 - 50	13	45 ± 10

Nominal size of coarse aggregate	13mrn
IS Sieve (mm)	Cumulative % passing by weight
19	100
13.2	88-96
2.36	0-5

Fine aggregate : The fine aggregate shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from soft or flaky pieces and organic or other deleterious substances.

Filler : The filler shall be 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 500-31.

TABLE 500-31. GRADING OF FINE AGGREGATE (INCLUSIVE OF FILLER)

I.S. Sieve	Percentage by weight of aggregate
Passing 2.36 mm but retained on 0.600 mm	0 - 25
Passing 0.600 mm but retained on 0.212 mm	10- 30
Passing 0.212 mm but retained on 0.075 mm	10 - 30
Passing 0.075	30 - 55

515.3. Mix Design

515.3.1. Hardness number: The mastic asphalt shall have a hardness number at the time of manufacture of 60 to 80 at 25°C prior to the addition of coarse aggregate and 10 to 20 at 25°C at the time of laying after the addition of coarse aggregate.

The hardness number shall be determined in accordance with the method specified in 18:1195-1978.

515.3.2. Binder content: The binder content shall be so fixed as to achieve the requirements of the mixture specified in Clause 515.3.1. and shall be in the range of 14 to 17 per cent by weight of total mixture as indicated in Table 500-32.

TABLE 500-32. COMPOSITION OF MASTIC ASPHALT BLOCKS WITHOUT COARSE AGGREGATE

IS Sieve	Percentage by weight of mastic asphalt	
	Minimum	Maximum
Passing 2.36 mm but retained on Q.600 mm	0	22
Passing 0.600 mm but retained on 0.212 mm	4	30
Passing 0.212 mm but retained on 0.075 mm	8	18
Passing 0.075 mm	25	45
Bitumen Content	14	17

515.3.3. Job mix formula : The Contractor shall inform the Engineer in writing at least 1 month before the start of the work of the job mix formula proposed to be used by him for the work, indicating the source and 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.

515.4. Construction Operations

515.4.1. 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.

515.4.2. 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.

515.4.3. Tack coat: A tack coat in accordance with Clause 503 shall be applied on the base or as directed by the Engineer.

515.4.4. Preparation of mastic asphalt: Penetration of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170°C to 210°C. Required quantity of bitumen shall be heated to 170°C to 180°C and added to the heated 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 mixture for a total period of 3 hours. During cooking and mixing, care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210°C.

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 Kgs each. Before use, these blocks shall be reheated to a temperature of not less than 175°C and not more than ?. 10°C, thoroughly incorporated with the requisite quantity of coarse aggregates and mixed continuously. Mixing shall be

continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-32.

The mixture shall be transported to the laying site in a towed mixer transporter having arrangement for stirring and keeping the mixture hot during transportation.

515.4.5. Spreading : The mastic asphalt shall be laic;, normally in one coat, at a temperature between 175°C and 210°C and spread uniformly by hand using wooden floats or by machine on the prepared and regulated surface. The thickness of the mastic asphalt and the percentage of added coarse aggregate shall be in accordance with Table 500-30 or as specified by the Engineer. Where necessary, battens of the requisite dimensions should be employed. Any blow holes that appear in the surface shall be punctured while the material is hot, and the surface made good by further floating.

515.4.6. Joints : All construction joints shall be properly and truly made. These joints shall be made by warming existing mastic asphalt by the application of an excess quantity of the hot mastic asphalt mixture which afterwards shall be trimmed to leave it flush with the surfaces on either side.

515.4.7. 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 9.5 mm sieve) or 9.5mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the Engineer. Hard stone chips, complying with the quality requirements of Table 500-17, shall be precoated with bitumen at the rate of 2 ± 0.4% of S-65 penetration grade. The addition of 2% of filler complying with Table 500-9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cu. m. per 10 sq. m. and rolled or otherwise pressed into the surface of the mastic layer when the temperature of the mastic asphalt is not less than 100°C.

515.5. Opening to Traffic

Traffic may be allowed after completion of the work when the mastic asphalt temperature at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature.

515.6. Surface Finish and Quality Control of Work

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

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

The surface of the mastic asphalt, tested with a straight edge 3.0m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7mm. The same limit shall also apply to the transverse profile when tested with a camber template.

515.7. Arrangements for Traffic

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

515.8. Measurement for Payment

Mastic asphalt shall be measured as finished work in square metres at a specified thickness, or by weight in tonnes as stated in the Contract.

515.9. Rate

The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under Clause 501.8.8.2. (i) to (ix).

516. SLURRY SEAL

516.1. Scope

Slurry seals are mixtures of fine aggregate, portland cement filler, bitumen emulsion and additional water. When freshly mixed, they have a thick consistency and can be spread to a thickness of 1.5 - 5 mm. They may be used to seal cracks, arrest fretting and fill voids and minor depressions, to provide a more even riding surface or a base for further treatment; they may also be used on top of a single coat surface dressing.

516.2. Materials

The materials for slurry seal immediately prior to mixing shall conform to the following requirements:

516.2.1. Emulsified bitumen: The emulsified bitumen shall be a cationic rapid setting type as approved by the Engineer, conforming to the requirements of IS: 8887. Where special mobile mixing machines are available, Class A4* rapid setting or Class K3* road emulsions to BS 434: Part 1 should be used to obtain very early resistance to traffic and rain. Generally, emulsion for slurry seal should be capable of producing a slurry that will develop early resistance to traffic and rain and is sufficiently stable to permit mixing with the specified aggregate, without breaking during the mixing and laying processes. If approved by the Engineer, a slow setting emulsion may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works.

516.2.2. Water : Water shall be of such quality that the bitumen will not separate from the emulsion before the slurry seal is in place.

The pH of the water must lie in the range 4 to 7, and if the total dissolved solids in the water amount to more than 500ppm, the Engineer may reject it, or order the Contractor to conduct a trial emulsion mix to demonstrate that it does not cause early separation.

516.2.3. Aggregate : The aggregate shall be crushed rock, or slag and may be blended, if required, with clean, sharp, naturally occurring sand free from soft pieces and organic and other deleterious substances to produce a grading as given in Table 500-33. The aggregates shall meet the requirements of the film stripping test (IS: 6241), and a suitable amount and type of anti-stripping agent added, as may be needed (details given in Appendix 5).

516.2.4. Additives: It is usual to use ordinary Portland cement, hydrated lime or other additives to control consistency, mix segregation and setting rate. The proportion of the additive should not normally exceed 2 percent by weight of dry aggregates.

---

* The corresponding grades m IS:8887 are only broadly classified as RS. MS and SS and further sub-classification is not available at present.

516.3. Mixture Design

A range of residual binder contents for each aggregate grading is given in Table 500-33. The optimum mixture design for the aggregate, additive, water and bitumen emulsion mixture should be determined in accordance with ASTM D 3910.

516.4. Construction Operations

516.4.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

TABLE 500-33. AGGREGATE GRADING, BINDER CONTENT AND APPROXIMATE COVERAGE RATE

Sieve Size (mm)	Percentage by mass pissing finished thickness of sealing		
	5mm	3mm	1. 5mm
9.5	100	-	-
4.75	90 - 100	100	—
3.35	-	80- 100	100
236	65 - 90	75-100	95-100
1.18	45 - 70	55 -90	70-95
u.600	30 - 50	35 -70	55-75
0.300	18- 30	20- 45	30- 50
0.150	10-21	10-25	10-30
0.075	5- 15	5- 15	5-15
Quantity of residual binder, percentage by mass of aggregate	7.5- 13.5	10- 16	12-20
Approximate coverage rate (kg/m^2)	8 -15	4-6	2-4

516.4.2. Surface preparation: Any necessary remedial work to the road surface and structure shall be completed either prior to or as part of the Contract and agreed as acceptable by the Engineer, according to the provisions of Clause 501.

Before slurry seal is applied, street furniture and, where directed by the Engineer, road markings, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box or the tools used for hand laying. Any packed mud or other deposits on the surface shall be removed, all organic growth shall be

removed by suitable means, and the surface shall be swept free of all loose material.

516.4.3. Tack coat: If required by the Engineer, a tack coat may be applied prior to the slurry seal, with or without grit or chips, in order to seal the existing substrata and enhance the bond to the existing road surface. Unless otherwise agreed by the Engineer, the rate of spread of tack coat shall be 0.15 to 0.30 litres/m^2 for bituminous surfaces and 0.4 to 0.6 litres/m^2 for concrete surfaces

516.4.4. Mixing and transportation of mixture: Mixing (and laying) techniques vary according to the type of emulsion used. For class A4 rapid setting and K3 emulsions, only special mobile mixing machines should be used. These carry supplies of aggregate, emulsion, water and filler (e.g. ordinary Portland cement or hydrated lime) and are fitted with metering devices to feed the ingredients in their correct proportions to a mixer fitted to the rear of the machine. From the mixer the slurry is fed into the screed box towed by the machine.

For all other emulsions, mixing may be by hand, concrete mixer or other mixer which effectively coats the aggregate uniformly and produces a slurry seal of suitable consistency for satisfactory laying. For large areas, a bulk transit concrete mixer may be used into which the ingredients (including water) are measured and mixed as the mixer travels to the area to be treated. A screed box fitted with an adjustable rubber screed should be towed by the mixer which feeds it during laying.

The special mobile mixing machine, when used, shall be capable of uniform application to provide a continuous surface without ridges or segregation. Before laying begins, the Contractor shall provide the Engineer with a test certificate showing test results for rate of application carried out under the supervision of a competent authority, demonstrating that the machine has been tested, using the system to be used in the Contract, not more than six weeks before the commencement of the work.

Where the material is to be hand laid, the slurry may be supplied to site pre-mixed in suitable containers and steps shall be taken to ensure that the material in each container is of an even consistency throughout the container immediately prior to use.

516.4.5. Application: Transverse joints for machine laid areas shall be formed with spreading, starting and finishing on a protective strip not

less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips.

Unless otherwise approved by the Engineer, longitudinal joints shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

Hand work around street furniture and other obstructions should meet the same performance requirements and form a homogeneous surface with the rest of the treated carriageway.

Footways and other confined areas may be spread by hand using squeegees and brooms. Transverse joints shall be formed with spreading, starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips. Kerb edges and other areas not being treated shall be suitably masked with self adhesive masking material. Footways shall be finished by dragging a dampened broom transversely over the footway under its own weight.

All voids, cracks and surface irregularities shall be completely filled, In warm dry weather the surface, immediately ahead of the spreading, shall be slightly damped by mist water spray applied mechanically, or for hand laying by a hand operated pressure sprayer, unless otherwise approved by the Engineer.

516.4.6. Rolling: The need for rolling shall be as instructed by the Engineer. Where rolling is required, a pneumatic-tyred roller having an individual wheel load between 0.75 and 1.5 tonnes shall be used, or as may be directed by the Engineer. Rolling shall commence as soon as the slurry has set sufficiently to ensure that rutting or excessive movement will not occur.

516.5. Opening to Traffic

Masking shall be removed after the slurry seal has been applied, without damage to the edge of the surfacing, and before opening the road or footway to traffic.

The Contractor shall remove surplus aggregate from the treated areas using a method agreed by the Engineer. The Contractor shall monitor the slurry seal closely for a minimum period of 2 hours and if necessary the

lane shall be swept again. The monitoring shall continue until the slurry seal has reached sufficient stability to carry unrestricted traffic. If there are signs of distress, the Engineer shall require the Contractor to reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage.

Further operations to remove subsequently loosened aggregate shall be carried out over the next 48 hours. The areas treated and adjacent side roads, footways and paved areas shall be kept substantially free of loose aggregate for a period of 30 days after completion of the work.

516.6. Surface Finish and Quality Control of Work

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

In addition, the finished slurry shall have a uniform surface texture throughout the work, without variations of texture within the lane width, or from lane to lane, due to segregation of aggregates, or due to variations in the emulsion/water content of the mixture.

The finished surface shall be free from blow holes and surface irregularities in excess of 3 mm beneath a 1 metre straight edge due to scraping, scabbing, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects which remain 24 hours after laying.

516.7. Arrangements for Traffic

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

516.8. Measurement for Payment

Slurry seal shall be measured as finished work as specified, in square metres.

516.9. Rate

The contract unit rate for slurry seal shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

517. RECYCLING OF BITUMINOUS PAVEMENT

517.1. Scope

This Clause of the Specifications covers the recycling of existing bituminous pavement materials to upgrade an existing bituminous pavement which has served its first-intended purpose. The work shall be performed on such widths and lengths as may be directed by the Engineer and may consist of pavement removal, stockpiling of materials from the old pavement, addition of new bitumen and untreated aggregate in the requisite proportions, mixing, spreading and compaction of the blended materials.

Recycling processes can be categorised into in-situ recycling (where processing takes place on site), and central plant recycling (where reclaimed material is processed off site). The processes can be further sub-divided into hot and cold processes. This Specification covers the hot process only. However, reclaimed aggregate from cold insitu recycling can be used in the Bituminous Cold Mix process specified in Clause 519, subject to the resultant mixes achieving the specified standards.

517.2. Reclaimed Bituminous Materials for Central Plant Recycling

517.2.1. Proportion of reclaimed materials less than 10 per cent: If not more than 10% of reclaimed bituminous material is to be used in the production of bituminous macadam or dense graded bituminous base or binder course material, then Clauses 517.2.2 to 517.2.9 do not apply. However:

a) all reclaimed bituminous material shall be pre-treated before use such that the material is homogeneously mixed and the maximum panicle size of reclaimed material does not exceed 40 mm.

b) the mixed material shall comply with the requirements of Clauses 504 or 507 as appropriate.

517.2.2. Proportions of reclaimed materials greater than 10 per cent: Reclaimed bituminous material of an amount greater than 10 per cent, may be used in the production of bituminous macadam and dense graded bituminous base and binder course material, subject to the requirements of Clauses 517.2.3 to 517.2.9 and subject to the satisfactory completion of full trial investigations in respect of all related materials, layer thickness, machine operations and finished works on a case-by-

case basis entirely at the contractors cost and subject to the approval of the Engineer. For estimating purposes, a maximum amount not greater than 30 per cent reclaimed bituminous material should be assumed.

517.2.3. Materials for recycled pavement: The recycled materials shall be a blend of reclaimed and new materials proportioned to achieve a paving mixture with the specified engineering properties. The reclaimed materials shall be tested and evaluated to find the optimum blend meeting the mixture requirements. Such testing and evaluation shall be carried out on representative samples, either cores sampled from the carriageway or samples taken from stockpiles in accordance with current practice. The sampling frequency should be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder. As an absolute minimum, one sample to represent 500m of lane carriageway shall be taken.

517.2.4. Bitumen extraction : The procedure described in ASTM D-2172 shall be used to quantitatively separate aggregate and bitumen from any representative sample of reclaimed bituminous pavement.

517.2.5. Aggregate evaluation: Mechanical sieve analysis (IS: 2386, Part I, wet sieving method) shall be performed on the aggregate portion of the reclaimed bituminous pavement sample to determine the grading. It is essential that the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material of sufficient quantity for the scheme being considered need to be identified either in existing pavements, from stockpiled planings of known origin or from another suitable source, before a decision can be made on the optimum percentage of reclaimed material.

After selecting the proportion of reclaimed materials to be recycled, the grading of the mixture may need adjustment, to meet Specification requirements, by the addition of selected aggregate sizes.

517.2.6. Evaluation of bitumen : When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10%, the penetration value of the recovered binder from the reclaimed bituminous material, before mixing, shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS 2000 : Part 397, when tested in

accordance with IS : 1203. Provided the above requirement is met, hardening of the old binder, during the original mixing process or through ageing, can be compensated for by adding a softer bitumen, to obtain the appropriate final grade of binder.

The determination of the type and amount of binder required to be added in the final mix is essentially a trial and error procedure.

After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified in Table 500-34.

TABLE 500-34. MINIMUM RECOVERED BINDER PENETRATION OF RECYCLED MIXTURE

Specified Grade of Binder (Penetration)	Minimum Recovered Penetration Value of Binder after Mixing
45	27
65	39
90	54

517.2.7. Rejuvenators: The use of rejuvenators, and a test to measure their effectiveness, is described in Clause 517.6.3.

517.2.8. Untreated aggregate : If necessary, - fresh untreated aggregate shall be added to the reclaimed bituminous pavement to produce a mix with the desired grading. The aggregate shall be checked for quality requirements in accordance with Table 500-3 or Table 500-8 as appropriate. Reclaimed aggregate, if any, or any aggregate normally used for the desired bituminous mixture, or both, may be used for this purpose.

517.2.9. Combined aggregate grading : The blend of reclaimed and new aggregate shall meet the grading criteria specified in the relevant parts of Clause 504 or 507, as appropriate and as approved by the Engineer. The blend of aggregates shall be checked for resistance to stripping as specified in Tables 500-3 or 500-8 as appropriate.

517.3. Mixture Design

The combined aggregate grading and binder content shall comply with the relevant tables in Clauses 504 or 507. For dense graded bituminous mixtures the mixture design shall also comply with the requirements of Table 500-11.

517.4. Reclaiming Old Pavement Materials

The removal of pavement materials to the required depth shall be accomplished either at ambient temperature (cold process) or at an elevated temperature (hot process), as approved by the Engineer.

517.4.1. Cold removal process: In the cold process, the ripping and crushing operations shall be carried out using scarifiers, grid rollers, or rippers or by any other means as directed by the Engineer. The removed materials shall be loaded and hauled for crushing to the required size as directed by the Engineer. Alternatively, cold milling or planing machines can be used to reclaim bituminous pavement to controlled depths. After the bituminous layers are removed, any remaining aggregate materials that are to be incorporated in the recycled hot mixture shall be scarified and removed. When the pavement material removal is completed, any drainage deficiencies shall be corrected. After that, the base/sub-base as the case may be shall be cut, graded and compacted to the required profile and density.

517.4.2. Hot removal process: In this process, the road surface shall be heated, by any suitable means approved by the Engineer, before scarification. A self propelled plant shall be used, and a milling drum that follows the planer removes the heated soft bituminous layer. The depth, width and speed of travel shall be adjusted to suit specific requirements as directed by the Engineer. During the heating process, the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

517.4.3. Stockpiling : In the cold process, the reclaimed bituminous pavement material shall be stockpiled with the height of stockpiles not exceeding 3 m. The reclaimed untreated aggregate base/sub-base material shall be stockpiled in the same manner as new aggregate. The number and location of stockpiles shall be carefully planned for efficient operation of the hot-mix plant.

517.5. Mixing and Laying

Generally, the requirements of Clauses 504.3 or 507.4, as appropriate, shall apply.

517.6. In Situ Recycling - The Remix and Repave Processes

These processes are suitable for the production of bituminous concrete wearing course in accordance with the provisions of Clause 509.

517.6.1. Scope: In the process of repaying, the existing surface is preheated and scarified but the scarified material is not removed. A layer of fresh bituminous mix material prepared in the integrated mixing unit of the plant is then spread evenly on the scarified surface to give a uniform profile. The spread material should be compacted as soon as possible after laying. In the process the total thickness of the pavement is increased by up to 50mm.

In the remix process, the scarified material should be taken from the mixing unit of the plant where it is recycled with fresh binder, aggregate and recycling agent. Then the recycled mixture is spread on the preheated surface and tamped and compacted to the required profile.

517.6.2. Heating and scarifying: Surfaces to be treated shall be heated by plant with surfaces insulated and fully enclosed. The heated width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilled onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified. A tolerance of ± 6 mm is permissible.

Where street furniture and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressing and large areas of road markings shall be removed by milling, planing, scarifying or by similar approved processes.

The heated surface shall be evenly scarified to comply with the requirements of this Clause. When street furniture is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If furniture needs to be repositioned on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the obstruction.

During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

517.6.3. Rejuvenator: For Remix, when required, rejuvenator shall be uniformly sprayed across the full-width of the processed material. The machine shall incorporate a meter for continuous verification of quantities which shall be within ±5% of the specified rate. The volume of rejuvenator shall vary in relation to the operating speed of the machine, which shall be related to the volume of material mixed or scarified.

The rejuvenator shall be a non-emulsified aromatic extract. Its properties shall be verified using the Rolling Thin Film Oven Test. Rejuvenation of the existing pavement may also be performed by adding new hot-mix bituminous material containing a soft binder of suitable penetration for restoring the binder in the existing pavement to the required penetration.

517.6.4. Mixing: When required, new hot-mix material shall be mixed with the heated and scarified road pavement material in a pugmill within the Remix machine, observing the mixing temperatures specified in Table 500-5.

After mixing, the recycled bituminous materials shall be automatically fed to a finishing unit, which spreads and levels the mixture to the specified thickness and cross-section. The new bituminous concrete wearing course shall be material complying with Clause 509.

517.6.5. Additional material (general): The proportion of new hot-mix bituminous material, and the proportion of existing bituminous pavement material shall be as directed by the Engineer, together with the amount the road surface level is to be raised (if any).

The type and quantity of the new hot-mix material shall be determined by using the Marshall Mix Design procedure specified in The Asphalt Institute Manual MS-2, before work commences. Remix designs shall incorporate the stated proportion of material sampled from the existing road surface.

When additional coarse or fine aggregate or filler are required to be added, they shall comply with the requirements of Clause 509.2. The amount of additional coarse or fine aggregate or filler to be added to the existing bituminous pavement material shall be notified to the Engineer.

517.6.6. Additional aggregate (remix process): The coarse

aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of Clause 509.2.

517.6.7. New surfacing (repave and remix/repave processes): New surfacing material shall be bituminous concrete wearing course complying with Clause 509, or other wearing course material approved by the Engineer.

The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°Cto 150°C.

517.6.8. Binder: The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS 2000 : Part 397 or an equivalent test. The penetration of the binder shall be in the range 35-70 pen.

517.6.9. Mixture design: The surfacing material shall be sampled from the paver hopper or augers. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced on site by rifling or quartering to approximately 5 kg and placed loose in an air-tight container.

The sample shall only be reheated once whilst within the container. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three Marshall test specimens prepared in accordance with the procedures specified in MS-2.

The bulk density of each specimen shall be measured before Marshall Stability testing. The mean stability and flow of the three specimens, measured in accordance with the procedures specified in MS-2, shall comply with the requirements of Table 500-19.

Finally the 3 Marshall specimens shall be combined and the maximum theoretical specific gravity (G_{mn}) of the mixture is determined in accordance with ASTM D 2041. This maximum theoretical specific gravity (G_{mm}) corresponds to 0% air voids in the mixture. The actual bulk specific gravity of a Marshall specimen determined in the Laboratory (G_{mm}) naturally be less than G_{mm} The percent air voids (P_a) in the specimen of the compacted mixture given by $P_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$ should meet the requirements of air voids laid down in Table 500-19.

517.7. Opening to Traffic

For recycled material forming the base or binder course layer, Clause 504.5 or 507.5 shall apply as appropriate. For recycled material forming the wearing course layer, Clause 509.5 shall apply.

517.8. Surface Finish and Quality Control

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

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

517.9. Arrangements for Traffic

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

517.10. Measurement for Payment

The recycled pavement work shall be measured in cubic metres or tonnes of finished work as stated in the Contract..

517.11. Rate

The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for all items as Clause 50.1.8.8.2. (i) to (xi)

518. FOG SPRAY

518.1. Scope

Fog spray is a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3mm 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.

518.2. Material

The bitumen emulsion shall be as specified in the Contract 01 as instructed by the Engineer. The emulsion shall be

SS-lh* (SS-1 can be used if the former is not available) complying with the requirements of ASTM D-977, or;

CSS-lh* (CSS-1 can be used it the 1'ornieris not available) complying with the requirements of ASTM U-2397.

Before use these emulsions shall be diluted, 1 part emulsion to 1 part water. Alternatively, Class A1 -40* or K1 -40* emulsions complying with the requirements of BS434:Part 1:1984 may be used. These emulsions have a lower viscosity than the above ASTM grades, they are rapid setting and they do not require to be diluted. Because of their low viscosity they should be used as soon as possible after delivery. If this is not possible, the drums should be very thoroughly rolled before use.

518.3. 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 518.4.2.).

518.4. Construction Operations

518.4.1. 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.

518.4.2. 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.

518.4.3. Application: The fog seal shall be applied at a rate of 0.5 - 1.0 litres/m3, using equipment such as pressure tank, flexible hose and spray bar or lance.

518.5. Blinding

If specified in the Contract or ordered by the Engineer, the fog spray shall be blinded with graded grit of 3mm size and under, coated with about 2 per cent of the emulsion by weight. The pre coated grit s hall be

---

* The grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

518.6. Quality Control of Work

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

518.7. Arrangements for Traffic

During the spraying operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112. The surface should not be opened to traffic for 24 hours after spraying. If pick-up does occur a light blinding of crusher dust or sand should be applied.

518.8. Measurement for Payment

Fog spray and blinding (if used) shall be measured in terms of surface area of application, for the area covered, in square metres.

518.9. Rate

The contract unit rate for fog spray and blinding (if used) shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi) as applicable to the work specified in these Specifications.

519. BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION)[1]

519.1. The Design Mix

Bituminous Cold Mix consists of a mixture of unheated mineral aggregate and emulsified or cutback bitumen. This Specification deals only with plant mix (as opposed to mixed-in-place). Two types of mix are considered, namely Designed Cold Mix and Recipe Cold Mix. The Design Mix procedure shall be used unless the Recipe Mix procedure is specifically approved by the Engineer.

---

[1]This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways, Transport Bhavan. Parliament Street, New Delhi-110 001. Fax #3710236

519.2. Designed Cold Mix

This Specification is based on The Asphalt Institute Manual MS-14, which contains additional information for guidance. These mixes are considered suitable for use as base course, appropriate to their stability, in new work or major repair work.

519.2.1. Materials

519.2.1.1. Binder: The binder shall be a bituminous emulsion as specified in AASHTO M 140 (ASTM D977)* or AASHTO M 208 (ASTM D2397)*, namely MS-2, MS-2h, HFMS-2, HFMS-2h, HFMS-2s, SS-1, SS-lh, CMS-2, CMS-2h, CSS-1 and CSS-In. Alternatively, a cutback bitumen as specified in AASHTO M 82 (ASTM D2027) or ASTM D 2026, namely MC 70, 250, 800 & 3000 and SC 250, 800 and 3000 may be used, or, if approved by the Engineer, an equivalent material which conforms with 1S:8887 and 18:217.

A general guide for the use of these binders is given in Table 500-35 and in the Manual for Construction and Supervision of Bituminous Works. However the final selection shall be made only after laboratory evaluation

TABLE 500-35. USES OK BITUMEN IN COLD MIX

Type of Construction	Emulsified Bitumen									Cutback Bitumen						
	Anionic					Cationic				Medium Curing (MC)				Slow Curing (SC)		
	MS-2, HFMS-2	MS-2H, HFMS-Sh	HFMS-2s	SS-1	SS-1h	CMS-2	CMS-2h	CSS-1	CSS=1h	70	250	800	3000	250	800	3000
Cold-Laid Plant Mix **Pavement Base and Surfaces**																
Open-Graded Aggregate	*	*				*	*									
Well-Graded Aggregate			*	*	*			*	*		*	*	*	*	*	*
Patching, Immediate Use				*	*						*	*			*	
Patching, Stockpile											*	*		*	*	

* The corresponding grades in 1S:8887 arc only broadly classified as RS, MS and SS and further sub-classification is not available at present.

with the aggregates to be used. The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

519.2.1.2. Aggregates: The aggregates shall comply with the requirements of Clause 504.2.2. and 504.2.3. If the aggregates are not properly coated with anionic emulsion or cutback bitumen, a small amount of hydrated lime, an approved antistripping agent (see Appendix 5) or a change to cationic emulsion shall be proposed by the Contractor, for the approval of the Engineer.

519.2.1.3. Aggregate grading and binder content: The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part 1, (wet sieving method), shall fall within the limits shown in Table 500-36.

519.2.2. Mixture Design

519.2.2.1. Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-37.

519.2.2.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-41. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

519.2.2.3. Job Mix Formula: The Contractor shall inform the Engineer in writing, at least one month before the start of the work, the job mix formula proposed for us e in the works and shall give the following details:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:

  (a) Binder, as percentage by weight of total mixture;

  (b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The results of tests enumerated in Table 500-39 as obtained by the Contractor;

(v) 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 mixture and its different

TABLE 500-36. AGGREGATE GRADING AM) BITUMEN CONTENT

Nominal maximum size (mm)	**9.5**	**13.2**	**19.0**	**26.5**
Allowable thickness (mm)	**25-35**	**36-50**	**51-75**	**76-100**
IS Sieve (mm)	**Cumulative**	**% by weight of total aggregate passing**		
37.5				100
26.5			100	90-100
19.0		100	90-100	
13.2	100	90-100	-	56-80
9.5	90-100		60-80	
4.75	60-80	45-70	35-65	29-59
2.36	35-65	25-55	20-50	19-45
0.30	6-25	5-20	3-20	5-17
0075	2-10	2-9	2-8	1-7
	[1]Guide to binder content, % by weight of total mixture			
Cutback	Min 4 to Max 6			
Emulsion	Min7toMax 10			

[1]To be determined by the modified Marshall Test.

TABLE 500-37. MIXTURE REQUIREMENTS FOR DESIGNED COLD MIX

Parameter	**Emulsion[1]**	**Cutback[2]**
Minimum Stability (kN at 22. 2°C) Emulsion (kN at 25"C) Cutback	2.2 for paving	2.2 for maintenance 3.3 for paving
	50[1]	25[4]
Percent maximum stability loss on soaking	2	2
Minimum flow (mm)		
Compaction level (number of blows)	50	75
Per cent air voids	3-5[5]	3-5
Per cent voids in mineral aggregate (VMA)	Sec Table 500-38	
Percent minimum coating'	50	-

Notes : [1]Using "Marshall method for emulsified asphalt -aggregate cold mixture design". Appendix K, MS -14.
[2]Using "Marshall method for cut -back asphalt -aggregate cold mixture design". Appendix H. MS-14.
[3]With vacuum saturation Mid immersion.
[4]Hour days soak at 25°C.
[5]Refers to total voids in the mix occupied by air and water.
[6]Coating Test, Appendix 1;, MS-14.

TABLE 500-38. MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Particle Size IS Sieve (mm)	Minimum VMA (per cent)
9.5	16.0
12.5	15.0
19.0	14.0
25.0	13.0
37.5	12.0

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 and approved by the Engineer before actually using the materials.

519.2.2.4. Permissible variation from the job mix formula : It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-39. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

519.2.3. Construction operations

519.2.3.1. 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

TABLE 500-39. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder course	Wearing course[6]
Aggregate passing 19mm sieve or larger	±8%	±7%
Aggregate passing 13.2mm, 9.5mm	±7%	±6%
Aggregate passing 4.75mm	±6%	±5%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	±5%	±4%
Aggregate passing 0.3mm, 0.15mm	±4%	±3%
Aggregate passing 0.075mm	±2%	± 1.5%
Binder content	±0.3%	±0.3%

volatiles in cool and humid conditions. Wind increases the rate of evaporation.

519.2.3.2. 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.

519.2.3.3. 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.

519.2.3.4. Preparation and transportation of the mixture: Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

(a) rotary drum type concrete mixer;

(b) single or twin shaft concrete or macadam mixer;

(c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the Contractor's nominated laying procedure methodology.

519.2.3.5. Spreading: Designed cold mix shall be placed only when the specified density can be obtained. The mixture shall not be placed on

any wet surface or when weather conditions will otherwise prevent it.-, proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture.

If climatic conditions and aggregate grading permit evaporation of moisture or volatiles without aeration by manipulation, a conventional self-propelled asphalt paver shall be used to place designed cold mix.

Other methods of spreading may be used as approved by the Engineer.

519.2.3.6. Compaction: Initial compaction of the laid material shall be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thicknesses being 25-100mm and all compaction being in accordance with Clause 501.6 and Clause 501.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

519.2.4. Opening to traffic: Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated, as determined by the Engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

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

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

519.2.7. Measurement for payment: Designed Cold Mix shall be measured as finished work, for the area covered, in cubic metres, by weight in metric tonnes, or by square metres at a specified thickness as specified in the Contract.

519.2.8. Rate : The contract unit rate for Designed Cold Mix shall

be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi). The rate shall cover the provision of the specified grade of cutback in the mix at 5 per cent of the weight of the total mix or emulsion at 8 per cent of the weight of the total mix, with the provision that the variation of quantity of binder will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted as per the rate for cutback or emulsion quoted in the Bill of Quantities.

Recipe Cold Mix

519.3. Recipe Cold Mix

This Specification is based on BS434:Part 2:1984 which contains additional information. These are premixes made with emulsion binder which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. These mixes are considered suitable for use only for emergency and minor repair work and temporary road surface improvement.

519.3.1. Materials

519.3.1.1. Binder: Emulsions of sufficient stability for mixing with the particular graded aggregate should be used. Grades of emulsion quoted are in accordance with BS434: Part 1:1984 but comparable grades to IS or AASHTO specifications may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works. The corresponding grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

519.3.1.2. Aggregates: Any normal, clean, but not necessarily dry, aggregate can be used, provided that it has a sufficiently high crushing strength with regard to the traffic to be earned. Typical gradings are given in Table 500-40.

519.3.1.3 Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (wet sieving method)the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 500-40. The grade and range of quantity of emulsion are also indicated in this table. The actual quantity of emulsion to be used shall be approved by the Engineer after seeing the results of trial mixes made in the laboratory.

TABLE 500-40. COMPOSITION OF RECIPE MIXES

Nominal Size (mm) and Type of Macadam	**40 Single course**	**40 Open textured base course**	**14 Open textured wearing course**	**6 Medium textured wearing course**	**Fine coated**
Allowable Thickness (mm)	**75-100**	**75-100**	**31-50**	**21-30**	**15-20**
IS Sieve Size mm	**Cumulative % by weight of total aggregate passing**				
45	100	100	-	-	-
37.5	90-100	90-100	-	-	-
26.5	55-90	55-85	-	-	-
19	-	-	100	-	-
13.2	35-55	15-35	90-100	-	-
9.5	-	-	55-75	100	-
6.3	20-30	-	25-45	90-100	100
3.35	10-20	0-10	15-25	45-65	-
2.36	-	-	-	-	75-100
1.18	-	-	-	10-30	-
0.60		-	-	-	30-55
0.30	2-10	-	-	-	-
0.15	-	-	-	-	10-25
0.075	-	-	2-6	2-8	5-15
	Emulsion grade and quantity				
Generally	A2 – 57[4]	or	A2 – 50[4]		
Under some circumstances				A3	A3
Quantity[1] litres/stone	55 70	45 to 65	70 to 90	85to 100	100 to [2][3] 120

Note: (l) For pricing purposes the lower quantity in these ranges should be assumed

(2) With coarser grading quantity may sometimes be reduced to 80 lilres/stonne and finer grading it may sometimes be increased up to 135 litres/stonne.

(3) Use 0 - 70 litres/stonne of water as necessary.

(4) A2-50 and A2-57 are Britis h grades of emulsion and their grading system is explained in the Manual

519.3.2. Construction operations

519.3.2.1. Weather and seasonal limitations: Construction with cold mix must not undertaken when ambient temperatures below 10°C are expected of generally when poor weather is predicted. Bitumen emulsion and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesive characteristics. Cold weather, rain, and high humidity slow down the rate of curing. Extra manipulation may be required to remove volitiles in cool or humid conditions. Wind increases the rate of evaporation.

519.3.2.2. Preparation of base: The base on which the cold mix is to be laid shall be prepared shaped and graded to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat if specified in the contract, or required by the Engineer, shall be applied in accordance with Clause 502, or as directed by the Engineer.

519.3.2.3. Tack coat: A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid if specified in the Contract or required by the Engineer.

519.3.2.4. Preparation and transportation of the mixture: Mixing shall be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate, and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

(a) rotary drum type concrete mixer,

(b) single or twin shaft concrete or macadam mixer,

(c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the chosen laying procedure.

519.3.2.5. Spreading: The mixed material should be spread immediately after preparation. The mixture shall be placed only when the specified density can be obtained. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is

straight and sharp and long enough to ensure finishing to close straight transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture. On surface courses, the tyres must be smooth.

The methodology for spreading shall be approved by the Engineer prior to laying, and if required a laying trial conducted to prove the laying method satisfactory before approval.

519.3.2.6. Compaction: Initial compaction of the laid material shall be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thicknesses being 25-100mm and all compaction being in accordance with Clause 501.6 and 501.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

519.3.3. Opening to traffic: Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

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

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

519.3.6. Measurement for payment: Recipe Cold Mix shall be measured as finished work, for the area instructed to be covered, in cubic - metres, by weight in metric tonnes, or in square metres at a specified thickness, as specified in the Contract.

519.3.7. Rate

The contract unit rate for Recipe Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi). The rate shall cover the provision of the specified grade of emulsion at the lower quantity in

the range for each type of mix indicated in Table 500-44 with the provision that the variation of quantity of emulsion will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted as per the rate for emulsion quoted in the Bill of Quantities.

520. SAND ASPHALT BASE COURSE1

520.1. Scope

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

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

520.2. Materials

520.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade S65 (60/70) or S90 (80/100), as specified in the Contract, both as per Indian Standard Specifications for "Paving Bitumen" IS:73.

520.2.2. Sand: The sand shall be clean, naturally occurring or blended material free from any deleterious substances, dry and well graded within the limits given in Table 500-41 and with other physical properties conforming to the requirements of this table.

520.2.3. 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 507.2.4.

520.3. Mix Design

520.3.1. Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-42.

---

[1]This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways. Transport Bhavan, Parliament Street, New Delhi 1 10 001. Fax No. * 3710236.

TABLE 500-41. SAND GRADING AND PHYSICAL REQUIREMENTS

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

Note : Maximum thickness for sand asphalt is 80 mm.

TABLE 500-42, REQUIREMENTS FOR SAND ASPHALT BASE COURSE

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

520.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-46. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2.

520.3.3. Job mix formula : The Contractor shall develop the job mix formula proposed for use in the works and shall give the following details:

(i) Source and location of all materials;
(n) Proportions of all materials expressed as follows where each is applicable:
(a) Binder, as percentage by weight of total mixture;
(b) Sand/Mineral filler as percentage by weight of total aggregate including mineral filler;

(iii) A single definite percentage passing each sieve for the mixed aggregate:

(iv) The results of tests enumerated in Table 500-46 as obtained by the Contractor:

(v) Test results of physical characteristics of aggregates to be used:

vi) Mixing temperature and compacting temperature

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

Approval of the job mix formula shall be based on independent testing by the Engineer for 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 and approved by the Engineer before actually using the materials.

520.3.4. Permissible variation from job mix formula : The Contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-43. These variations are intended to apply to individual specimens taken for quality control tests as described in Section 900.

520.4. Construction Operations

520.4.1. Weather and seasonal limitations : Clause 501.5.1 shall apply.

520.4.2. Preparation of base : The surface on which Sand Asphalt Basecourse Material is to be Ltd shall be prepared, shaped and graded to the profile required for the particular layer in accordance with Clauses 501 and 9(i2 as appropriate or as directed by the Engineer. The surface shall he 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 access, other methods shall be used as approved by the Engineer. A prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

TABLE 500-43. PERMISSIBLE VARIATIONS FROM I HE JOB MIX FORMULA

Description	Permissible variation
Aggregate passing 4.75mm	± 0%
Aggregate passing 2.36mm. 1.18mm. 0.6mm	± 5%
Aggregate passing 0.3mm. 0.15mm	± 4%
Aggregate passing 0.075mm	± 2%
Binder content	± 0.3%
Mixing temperature	± 10°C

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

520.4.4. Preparation and transportation of the mixture : The provisions of Clauses 501.3 and 501.4 shall apply.

520.4.5. Spreading: The provisions of Clauses 501.5.2 to 501.5.4. shall apply. Mixing must be accomplished at the lowest temperature and in the shortest time that will produce a mixture with complete coating of the aggregate and at a suitable temperature to ensure proper compaction. The ideal mixing and compaction temperatures for the particular bitumen in use shall be obtained from the Bitumen Test Data Chart given in the Manual for Construction and Supervision of Bituminous Works and shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 Poise (0.3 Pa.s) respectively, based on the original (unaged) bitumen properties. For guidance, the ranges of acceptable mixing and rolling temperatures for some typical penetration grade bitumen are shown in Table 500-5.

520.4.6. Rolling : Clause 501.6 shall apply. Generally the initial or breakdown rolling shall be done with 8-10 tonne deadweight smooth-wheeled rollers. The intermediate rolling shall be done with 8 -10 tonne deadweight or vibratory rollers or with a pneumatic tyred roller of 12-15 tonne weight having a tyre pressure of at least 5.6 kg / sq.cm.. The finish rolling shall be done with 8 - 10 tonne deadweight smooth wheeled tandem rollers. The exact pattern of rolling shall be established at the laying trials.

520.5. Opening to Traffic

Traffic may be allowed alter completion of the final rolling when the temperature of the mixture at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature. When daytime

maximum ambient temperatures are in excess of 35°C, great care is needed to ensure that this criterion is met. particularly where slow moving heavy traffic is involved.

520.6. Surface Finish and Quality Control of Work

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

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

520.7. Arrangements for Traffic

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

520.8. Measurement for Payment

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

520.9. Rate

The contract unit rate for Sand Asphalt Basecourse materials shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2 (i) to (xi). The rate shall cover the provision of 5 per cent of bitumen by weight of the total mixture.

The variation from the actual percentage of bitumen approved by the Engineer and used will be assessed and the rate adjusted, plus or minus, using the rate for bitumen in the Bill of Quantities.

521. MODIFIED BINDER[1]

521.1. Scope

Modified binders comprise a base binder, to which is added either natural rubber, crumb rubber or a polymer such as Styrene- Butadiene-

[1]This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD). Ministry of Road Transport & Highways, Transport Bhavan, Parliament Street, New Delhi - 110 001. Fax No. # 3710236.

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.

521.2. Materials

521.2.1. Base Binder : The base binder into which the modifier is incorporated shall conform to IS:73. The choice of grade shall be such that it is compatible with the modifier and, when mixed shall have the properties described in Clause 521.3.

521.2.2. Modifier : The modifier shall be a natural rubber, crumb rubber or any other polymer which is compatible with >he base binder and which allows the properties given in Clause 521.3 to be achieved For further details, IRC:SP:53-1999 may be referred to. The modifier, in the required quantity shall be blended at the refinery or at the site plan: capable of producing modified binder.

521.3. Modifier Proportions

The quantity of modifier to be added shall be determined by tests on the base binder and the modified binder and the properties desired. A reference may be made to the Manual for Construction and Supervision of Bituminous Works for indicative dosage of different types of modifiers. The properties of the modified binder shall be as given in Table 500-44, 500-45 or 500-46 according to the requirements of the Contract.

521.4. Mixing

The modifier shall be blended with the base binder so that it disperses thoroughly prior to use. The type of mixing equipment used shall be suited to the modifier type. Further guidance is given in the Manual for Construction and Supervision of Bituminous Works.

521.5. Quality Control of Materials

521.5.1. Binder Properties : For control of the quality of the base binder, the relevant provisions of Section 900 shall apply. Additionally. the modified binder shall be tested for all the properties listed in Table 500-44, 500-45 or 500-46 as appropriate and certificates produced prior to use.

During use, the requirements for softening point, penetration and elastic recovery shall be tested regularly. If the modified binder is producer

TABLE 500-44. REQUIREMENTS OF POLYMER MODIFIED BINDERS (ELASTOMERIC THERMOPLASTICS AND RUBBER LATEX)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 25°C, 0. 1 mm, l00g, 5 sec.	90 to 1 50	50 In X9	30 to 49	IS:1203-1978
Penetration at 4°C, 0.lmm, 200°, 60 sec.. Minimum*	35	22	18	IS:1205-1978
Softening Point, (R&B), °C, Minim um	38	48	59	IS:1205-1978
Fraass Breaking Point, °C, Maximum	* -24	-16	-12	IS:9381-1978
Ductility at 27°C, cm. Minimum	75	50	50	IS:1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS:1209-1978
Elastic Recovery of Half Thread in	70	60	50	ASTM
Ductilo meter at 15°C, %, Minimum	(50)**	(40)**	(30)**	D5976-1996
Separation, Difference in Softening Point, R&B, °C, Maximum	4	4	4	ASTM D5976-1996
Viscosity at 150°C, Poise	1-3	2-6	4-8	15:1206-1978

Test on Thin Film Oven Test Residue, TFOT(IS:9382-1979)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 4°C, 0 1 mm, 200g, 60 sec , Minimum*	18	15	12	IS:1203-1978
Loss in Weight, %., Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS:1203-1978
Elastic Recovery of Half Thread in	60	40	35	ASTM
Ductilometer at 15°C, %, Minimum	(35)**	(30)**	(25)**	D5976-1996

* Relevant to snow bound cold climate areas
** Natural Rubber Modified Bitumen

on site then tests shall be carried out daily. If pre-blended modified binder is used tests shall be carried out weekly.

521.5.2. Storage Stability : Pre-blended modified binders which are to be stored without circulation or agitation facility shall be tested for storage stability prior to use, in accordance with Appendix 1 of IRC:SP:53-1999. The mean of the differences in softening point, top to bottom, of

TABLE 500-45. REQUIREMENTS OF POLYMER MODIFIED BINDERS (PLASTOMERIC THERMOPLASTICS)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 25°C, 0.lmm, l00g, 5 sec.	90 to 1 50	50 to 89	30 to 49	IS:1203-1978
Penetration at 4°C, 0.lmm, 200g, 60 sec.. Minimum*	35	*22*	18	IS:1205-1978
Softening Point, (R&B), °C, Minimum	38	48	59	IS:1205-1978
Fraass Breaking Point, °C, Maximum*	-20	-15	-10	IS:9381-1978
Ductility at 27°C, cm, Minimum	50	40	30	IS:1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS:1209-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60	50	40	ASTM D5976-1996
Separation, Difference in Softening Point, R&B, °C, Maximum	3	3	3	ASTM D5976-1996
Viscosity at 150°C, Poise	1-2	2-4	4-8	IS:1206-1978

Test on Thin Film Oven Test Residue, TFOT (9382-1979)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 4°C, 0. 1mm, 200g, 60 sec., Minimum*	18	15	12	IS:1203-1978
Loss in Weight, %, Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS:1203-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	45	35	30	ASTM D5976-1996

* Relevant to snow bound cold climate areas

not less than three pairs of samples shall not exceed 5°C.

Other pre-blended modified binders shall be stored with appropriate circulation or agitation facility, according to the manufacturer's instructions.

521.6. Measurement for Payment

Modified binder supplied for the Contract shall be paid for in Tonnes.

TABLE 500-46. REQUIREMENTS OK POLYMER MODIFIED BINDERS (TREATED WITH MODIFIED CRUMB RUBBER)

Designation	Grade			Method of Test
	CRMB 60	CRMB 55	CRMB 50	
Penetration at 25°C, 0.1mm, 100 g. 5 sec	50-70	50-60	40-60	IS:1203-1978
Softening Point. (R&B), °C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C. % Minimum	40	35	30	ASTM D5976-1996
Test on Thin Film Oven Test Residue (IS:9382-1979)				
Reduction in Penetration at 25°C, % Maximum	60	60	60	IS:1203-1978
Increase in Softening Point (R&B), °C, Maximum	5	5	5	IS:1205-1978
Elastic Recovery of Residue of Half Thread in Ductilometer at 15°C, %, Minimum	25	20	15	ASTM D 5976-1996

CRMB - Crumb Rubber Modified Bitumen

521.7 Rate

The contract rate for modified binder shall be as per contract agreement.

522. CRACK PREVENTION COURSES1

522.1. Scope

This clause covers the provision of Stress Absorbing Membrane (SAM) and Stress Absorbing Membrane Interlayer (SAMI) as measures to inhibit the propagation of cracks. A SAM is an elastomeric bitumen rubber membrane, which is laid over a cracked road surface, together with a covering of aggregate chips, in order to extend the life of the pavement before major treatment is carried out. SAM can be laid as a

[1]This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways, Transport Bhavan, Parliament Street, New Delhi - 110 001. Fax No. # 3710236.

single coat or a double coat. A SAMI is a layer which is applied to a cracked pavement surface but which is followed (within 12 months) by the application of an overlay course. A SAMI may be a material similar to that used for a SAM. It may alternatively consist of a bitumen impregnated geotextile.

522.2. Materials

522.2.1. Binder : Binder shall be a modified binder complying with the requirements of Clause 523, according to the requirements of the Contract, except that paving grade bitumen of 80-100 penetration complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

522.2.2. Aggregate : The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of a SAMI. Where required by the contract, aggregate shall be pre-coated using either of the techniques permitted by Clause 510.2.5.

522.2.3. Rates of spread of binder and aggregate : The rates of spread of binder and aggregate shall be according to one of the size alternatives in Table 500-47, as required by the Contract.

522.2.4. Geotextile: The use of geotextile as prescribed for SI. No. 7 in Table 500-47 shall conform to the requirements of Clause 704.3 of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

522.3. Construction Operations

522.3.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

522.3.2. 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.

522.3.3. Application of binder: The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 160-170°C. Binder for bitumen impregnated

TABLE 500-47. QUANTITY OK MATERIALS REQUIRED FOR 10 SQ.M. OK ROAD SURFACE FOR STRESS ABSORBING MEMBRANE

SI. No.	Type and Width of Crack	Specification of SAM lobe applied	Quantity of binder Kg/10m^2	Quantity of chipping
1.	Hair cracks and map cracks upto 3mm width	Single coal SAM or 2nd coat of two coal SAM	8 - 10	0. 10 m^3 of 5.6mm chips
2.	Map cracks or alligator cracks 3mm to 6mm width	Single coal SAM `	10- 12	0.11m^3 of 5.6mm chips
3.	Map cracks or alligator cracks 6mm to 9mm width	Two coat SAM 1 1st coat 2nd coat	12 – 14 8 – 10	0.12m^1 of 5.6mm and 11.2mm chips in 1:1 ratio 0.10^3 of 5.6mm chips
4.	Cracks above 9mm width and cracked area above 50%	Two coat SAM 1st coat 2nd coat	14- 16 8 – 10	0.12m^3 of 11.2mm chips 0.10^3 of 5. 6mm chips
5.	All types of cracks with crack width below 6mm	Single coat SAM as interlayer	8 – 10	0. 10 m^3 of 5.6mm chips.
6.	All types of cracks with crack width above 6mm	Single coat SAM as interlayer	10 - 12	0.10m^3 of 11.2mm chips.
7.	Bitumen Impregnated Geotextile			

Note: 1 Binder quantities for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 lures/nr. Binder quantities outside this range are permitted according to the geotextile manufacturer's instructions and subject to the agreement of the Engineer.

geotextile shall be applied according to Clause 502.4. The surface on which the binder is to be applied shall be dry.

522.3.4. 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.

522.3.5. Sweeping : The surface of SAMs and SAMIs shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

522.3.6. Two coat SAM or SAMI: Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first.

522.3.7. Geotextile placement: For bitumen impregnated geotextile,

the requirements of Clause 704.4.5 of the Ministry's Specification for Road and Bridge Works (third revision) shall apply.

522.4. 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.

522.5. Surface Finish and Quality Control of Work

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

522.6. Arrangements for Traffic

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

522.7. Measurement for Payment

Each application of SAM, SAMI or bitumen impregnated geotextile shall be measured as finished work, for the area specified, in square metres.

522.8. Rate

The contract unit rate for SAM, SAMI or bitumen impregnated geotextile shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2, (i) to (xi).

900

Quality Control of Road Works

903. QUALITY CONTROL TESTS DURING CONSTRUCTION

903.4. Tests on Bituminous Construction

903.4.1. Tests and Frequency : The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4. The Engineer may direct additional testing as required.

903.4.2. Acceptance criteria : The acceptance criteria for tests on density and Marshall stability shall be subject to the condition that the mean value is not less than the specified value plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of Samples})^{0.5}}\right] \text{times the standard deviation}$$

TABLE 900-4. CONTROL TESTS FOR BITUMINOUS WORKS, AND THKIR **MINIMUM FREQUENCY**

Sl. No.	**Type of Construction**	**Test**		**Frequency (min.)**
1.	Prime Coat/Tack Coat/ Fog Spray	(i)	Quality of binder	Number of samples per lot and tests as per 1S:73. IS:217and IS:8887 as applicable.
		(ii)	Binder temperature for application	At regular close intervals
		(iii)	Rate of spread of Binder	One test per 500m^2 and not less than two tests per day
2.	Seal Coat/Surface Dressing	(i)	Quality of Binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	One test per 50 m^3 of aggregate
		(iii)	Flakiness index and Elongation Index	-do-
		(iv)	Stripping value of aggregates (Immersion Tray Test)	Initially one set of 3 representative specimens for each source of supply Subsequently when warranted by changes in the quality of aggregates
		(v)	Water absorption of aggregates	-do-

		(vi)	water sensitivity of mix	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates (if required)
		(vii)	Grading of aggregates	One test per 25 m^3 of aggregate
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Initially, one determination by each method for each source of supply, then as warranted by change in the quality of the aggregates
		(ix)	Polished stone value	As required
		(x)	temperature of binder application	At regular close intervals at
		(xi)	Rate of spread of materials	One test per 500 m^2 of work, and, not less than two tests per day
		(xii)	Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
3	Open-graded Premix Surfacing/Close-graded Premix Surfacing	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Stripping value	Same as mentioned under Serial No.2
		(v)	Water absorption of aggregates	Same as mentioned under Serial No.2
		(vi)	Water sensitivity of mix	Same as mentioned under Serial No. 2
		(vii)	Grading of aggregates	Same as mentioned under Serial No.2
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Polished stone value	As required
		(x)	Temperature o I binder application	At regular close intervals at
		(xi)	Binder content	One test per 500m^3 and not less than two tests per day

		(vi)	Water sensitivity of mix	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates (if required)
		(vii)	Grading of aggregates	One test per 25 m^3 of aggregate
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Initially, one determination by each method for each source of supply, then as warranted by change in the quality of the aggregates.
		(ix)	Polished stone value	As required
		(x)	temperature of binder application	At regular close intervals at
		(xi)	Rate of spread of materials	One test per 500 m^2 of work, and, not less than two tests per day
		(xii)	Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
3.	Open-graded Premix Surfacing/Close-graded Premix surfacing	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2 5ef7[1>/f.
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Stripping value	Same as mentioned under Serial No.2
		(v)	Water absorption of aggregates	Same as mentioned under Serial No.2
		(vi)	Water sensitivity of mix	Same as mentioned under Serial No. 2
		(vii)	Grading of aggregates	Same as mentioned under Serial No.2
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Polished stone value	As required
		(x)	Temperature o I binder application	At regular close intervals at
		(xi)	Binder content	One test per 500m^3 and not less than two tests per day

		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	percentage of fractured faces	Same as mentioned under Serial No.2
4.	Bituminous Macadam	(i)	Quality of binder	Same as mentioned under Serial No 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	Same as mentioned under Serial No.2
		(iv)	Stripping Value	Same as mentioned under Serial No.2
		(v)	Water sensitivity of mix	-do-
		(vi)	Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii)	Water absorption of aggregates	Same as in Serial No. 2
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Percentage of fractured faces	Same as mentioned under Serial No.2
		(x)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xi)	Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close interval
		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	Density of compacted layer	One test per 250m^2 of area
5.	Bituminous Penetration Macadam/Built-up Spray-Grout	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	One test per 200 m^3 of aggregate
		(iii)	Flakiness Index and Elongation Index	-do-

		(iv)	Stripping value	Same as mentioned under Serial No. 2
		(v)	Water absorption of aggregates	Same as Serial No. 2
		(vi)	Water sensitivity of mix	Same as Serial No. 2
		(vii)	Aggregate grading	One test per 100 m^3 of aggregate
		(viii)	Soundness (Magnesium Sodium Sulphate)	Same as mentioned under and Serial No.2
		(ix)	Percentage of fractured faces	Same as mentioned under Serial No.2
		(x)	Temperature of binder application	At regular close intervals at
		(xi)	Rate of spread of binder	Same as mentioned under Serial No.2
6.	Dense Bituminous Macadam/Semi Dense Bituminous Concrete/ Bituminous Concrete	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Stripping Value	Same as mentioned under Serial No.2
		(v)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(vi)	Water absorption of aggregates	As in Serial No. 2
		(vii)	Sand equivalent test	As required
		(viii)	Plasiticity Index	As required
		(ix)	Polished stone value	As required, for Semi Dense Bituminous Concrete/ Bituminous Concrete
		(x)	Percentage of fractured) faces	Same as mentioned under Serial No. 2
		(xi)	Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day

		(xii)	Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day
		(xiii)	Water sensitivity of mix (Retained Tensile Strength)	Samc as mentioned under Serial No.2
		(xiv)	Swell test on the mix	As required for the Bituminous Concrete
		(xv)	Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close intervals
		(xvi)	Control of binder content and grading of the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
		(xvii)	Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness
		(xviii)	Density of compacted layer	One test per 250 m^2 area
7.	Mastic Asphalt	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Stripping Value	-do-
		(v)	Water sensitivity of mix	do-
		(vi)	Grading of aggregates	Two lefts per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii)	Water absorption of aggregates	Same as in Serial No. 2

		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Percentage of fractured faces	Same as mentioned under Serial No.2
		(x)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xi)	Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	Hardness number	One test for each 400 tonnes of mix subject to a minimum of two tests per day
8.	Slurry-seal	(i)	Quality of binder	Same as mentioned under Serial No. 1.
		(ii)	Film stripping test	Initially one set of 3 representative specimens for each source of supply, then as warranted by changes in the quality of aggregates
9.	Recycled material	(i)	Binder content and aggregate grading	Minimum of one test per 25 m^3 of recycled material
		(ii)	Recovered hinder penetration	Minimum of one test per $50m^1$ of recycled material
		(iii)	Mix stability (Remix/ Repave)	For each 400 tonnes of mix recycled, a set of 3 Marshall specimens to be prepared and tested for stability, flow, density and void content, subject to a minimum of two sets of tests per day
10.	Cold Mix	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angles Abrasion Value	Same as mentioned under Serial No. 2
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Striping Value	-do-
		(v)	Water sensitivity of mix	-do-

		(vi)	Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii)	Percentage minimum coaling	Two tests per day per plant
		(viii)	Water absorption of aggregates	Same as in Serial No. 2
		(ix)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(x)	Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
		(xi)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xii)	Mix stability	For each 400 tonnes of mix produced, one set of 3 Marshall specimens to be prepared and tested for stability, (low, density and void content, subject to a minimum of two sets of tests per plant per day
11.	Sand Asphalt Base Course	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Sand equivalent test	As required
		(iv)	Plasiticity Index	As required
		(v)	Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day
		(vi)	Stability of Mix	For each 400lonnesofmix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject lo a minimum of two sets being tested per plant per day

		(vii)	Control of temperature of binder in boiler, aggregate in the dryer and mix al the time of laying and rolling	At regular close intervals
		(viii)	Control of binder content and grading of the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
		(ix)	Rate of spread of mixed maternal	Regular control and through checks on the weight of mixed material and layer thickness
		(x)	Density of compacted layer	One test per 250 m- area
12.	Modified Binder	(i)	Softening Point	Initially on submission thereafter daily if site blended, weekly if pre - blended
		(ii)	Penetration at 25"C and 4℃	-do-
		(iii)	Elastic Recovery	-do-
		(iv)	Ductility	-do-
		(v)	Flash Point	-do-
		(vi)	Fraass Breaking	Initially on submission
		(vii)	Viscosity at 150℃	-do-
		(viii)	Thin film oven test, penetration, softening point, elastic recovery of residue, loss on heating	-do-
13.	Geotextiles	(i)	The requirements of Clause 704.3.1 of the Ministry's Specification for Road and Bridge Works (third revision) shall apply	

3000
Maintenance of Road

3004. BITUMINOUS WORK IN CONNECTION WITH MAINTENANCE AND REPAIRS

3004.1. General

The scope and type of maintenance work to be carried out shall be in accordance with the provisions of the Contract or as instructed by the Engineer.

In all instances it will have been necessary to identify the causes of defects in order to permit effective repair. Where investigation work into the causes of defects is included in the Contract it shall be carried out in accordance with the appropriate provisions of this Specification. Maintenance treatments required under the Contract or instructed by the Engineer may include pothole and patch repair, crack-sealing, fog spray, dusting, slurry sealing, surface dressing, overlays and specialist repairs.

When the pavement to be maintained is intended to carry volumes of traffic in excess of 1.5 million e.s.a. the constructed materials (particularly patching and overlay materials) used in maintenance operations shall be of a standard not less than those specified for the original construction. Traffic control during maintenance operations shall conform to the requirements of the Contract documents.

3004.2. Filling Pot-holes and Patch Repairs

3004.2.1. Scope : This work shall include repair of pot-holes and patching of all types of bituminous pavement.

The work shall include the removal of all failed material, in the pavement courses and, if necessary, below the pavement, until the root cause of the failure is removed; the trimming of the completed excavation to provide firm vertical faces; the replacement of material of at least as high a standard as that which was originally specified for the pavement layer; the painting of tack coat on to the sides and bases of excavations prior to placing of any bituminous materials and the compaction, trimming and finishing of the surfaces of all patches to form a smooth continuous surface, level with the surrounding road.

3004.2.2. Materials : All materials used for the pot-hole and patch repair of bituminous surface and underlying layers shall be in accordance

with this Specification and shall be of the same type as specified for the original construction. A mix superior to the one on the existing surface may also be used for repair work. An emulsified bitumen / modified bitumen mix compatible with the existing layer shall also be considered appropriate.

The bituminous mixture used for such patch repairs shall be in accordance with the appropriate Clause of these Specifications. Materials to be used for patching shall always be of the same type and standard of construction as, or better than, the material being patched at the same level of construction. Materials used for patching shall never be of lesser bearing capacity nor of a greater porosity than the adjacent previous construction. Non-bituminous material must not be used for patching bituminous materials. Where modified binder is to be used, Clause 521 of these Specifications shall apply.

The grading of aggregates and bitumen content of the mix used for such patch repair shall be in accordance with Clause 501.

3004.2.3. Preparation of the area for pot-hole and patch repair :

Each pot-hole and patch repair area shall be inspected and all loose material removed. The area shall be cut/trimmed either with jack hammers or with hand tools suitable for the purpose, such that the defective material responsible for the failure is all removed and such that the excavation is of a regular shape.

The edges of the excavation shall be cut vertically. The area shall be thoroughly cleaned with compressed air or any appropriate method approved by the Engineer to remove all dust and loose particles. Layers below the level of the bituminous construction shall be replaced using material of the equivalent specification to the original construction, which shall particularly include the specified standards of compaction. The area for bituminous construction shall be tacked or primed with cutback or emulsion depending upon whether the lower area is bituminous or granular in nature. The sides, however, are to be painted with hot tack coat material. The prime coat and tack coat shall conform to Clauses 502 and 503 of these Specifications, respectively.

3004.2.4. Backfilling operation : The mixture to be used in bituminous patching shall be either a hot mix or a cold mix in accordance with the appropriate Clauses of these Specifications. Mixing shall be

done in a plant of suitable capacity. The bituminous mixture shall be placed in layers of thickness not more than 100 mm (loose) and shall be compacted in layers with roller/plate compactor/hand roller/rammer to the compaction standards defined in the appropriate Clauses of these Specifications. While placing the final layer, the mix shall be spread slightly proud of the surface so that after rolling, the surface shall be flush with the adjoining surface. If the area is large, the spreading and levelling shall be done using hand shovels and wooden straight edges. During the process of compaction, the surface levels shall be checked using a 3m straight edge.

3004.2.5. Measurement for payment: Filling of pot-holes and patch repair shall be measured in sq.m.

3004.2.6. Rate : The contract unit rate for filling of pot-holes and patch repair shall be payment in full for:

(i) furnishing all materials required:

(ii) all works involved including excavation, trimming, back filling with any non-bituminous layers required, tacking, priming with cutback or emulsion, and back filling with bituminous materials;

(iii) all labour, tools, equipment and incidentals to complete the work in accordance with the Specifications.

3004.3. Crack Sealing

3004.3.1. Scope: Crack sealing shall consist of one or more of the following operations as instructed under the Contract:

(i) fog seal

(ii) filling cracks with a binder, or a combination of crusher dust and a binder

(iii) by treating the crack sealing as a patch repair.

3004.3.2. Fog Seal

3004.3.2.1. Scope : Fog seal for use in maintenance work shall conform to the requirements of Clause 518 of these Specifications, and shall consist of an application of emulsified bitumen, without any aggregate cover for sealing fine hair-cracks or for rejuvenating oxidised bituminous surfaces. Areas having cracks with less than 3mm width shall be considered for this treatment, unless otherwise instructed by the Engineer.

3004.3.2.2. Material: Bituminous emulsion for Fog Seal shall be of a slow setting type. Where modified binder is to be used, Clause 521 of these Specifications shall apply.

3004.3.2.3. Application : The area to be treated with fog seal shall be thoroughly cleaned using compressed air, scrubbers, etc. The cracks shall be cleaned with a compressed air jet to remove all dirt, dust, etc. The fog seal shall be applied at the rate of 0.5-1.0 litre/sq.m. of emulsion, or as otherwise instructed by the Engineer, using equipment such as a pressure tank, flexible hose and spraying bar or lance. Traffic shall be allowed on to the surface only after the seal has set to a non-tacky and firm condition so that it is not picked up by the traffic.

3004.3.2.4. Measurement for payment: The fog seal work shall be measured in sq.metres, calculated from the dimensions of work instructed in the Contract or by the Engineer.

3004.3.2.5. Rate : The contract unit rate for application of fog seal shall be payment in full for:

(i) supplying of fog seal material and all the operations for applying it; and

(ii) all the labour, tools, equipment and incidentals to complete the work in accordance with this Specification.

3004.3.3. Crack filling

3004.3.3.1. Scope: Crack filling shall be carried out using a binder of a suitable viscosity, normally a slow-curing bitumen emulsion, as instructed by the Engineer. For wider cracks, in excess of an average of 3 mm in width the application of emulsion may be preceded by an application of crusher dust, or other fine material acceptable to the Engineer.

3004.3.3.2. Materials: Bitumen for use in crack sealing shall be of a slow curing type as instructed by the Engineer. Dust for crack sealing, when used, shall be crusher dust or some other suitable fine material approved by the Engineer, passing the 4.75 mm sieve but with a maximum of 10% passing the 0.075 mm sieve.

3004.3.3.3. Construction: If dust is to be used it shall be placed in the cracks before the application of binder and the cracks filled to a level approximately 5 mm below road surface level. The surface of the road shall be swept clear of dust prior to the application of binder. Binder

shall be poured into the cracks, taking care to minimise spillage. If spillage onto the road surface does occur, dust shall be applied to the excess bitumen until it is blotted up.

3004.3.3.4. Measurement: Crack sealing shall be paid by the linear metre of crack as instructed by the Engineer.

3004.3.3.5. Payment: The contract rate for crack sealing shall be payment in full for:

(i) supplying all necessary materials and for the work of applying them;

(ii) all labour, tools, equipment and all incidentals necessary to complete the work according to these Specifications.

3004.3.4. Crack prevention courses: Clause 522 specifies crack prevention courses. These may be included in substantial maintenance treatments.

3004. 4. Dusting

3004.4.1. Scope: Dusting shall consist of the application of crusher dust or other fine graded material approved by the Engineer to areas of road where bleeding of excess bitumen is occurring.

3004.4.2. Material: Dust shall consist of crusher dust or other graded fine material acceptable to the Engineer, and shall generally be finer than 3.0 mm with not more than 10% passing the 0.075 mm sieve.

3004.4.3. Dust shall be spread by manual application, to the areas of road defined by the Engineer. Dust shall generally be applied during the hottest part of the day and, when so instructed by the Engineer, surplus dust displaced by passing traffic shall be manually swept back onto the area where further bleeding of excess bitumen is apparent. Dust shall be applied at a nominal rate of 2.5 kg per square metre.

3004.4.4. Measurement: Dusting shall be paid for by the square metre of road surface instructed to be dusted by the Engineer.

3004.4.5. Payment: The Contract unit rate for dusting shall be in payment in full for:

(i) supplying all necessary materials and for the work of applying them;
(ii) all labour, tools, equipment and all incidentals necessary to complete the work according to the Specifications.

3004.5. Slurry Seal

Slurry seal for use in maintenance work shall conform to the requirements of Clause 516. Manual methods of spreading and levelling may be used, subject to the prior agreement of the Engineer.

3004.6. Surface Dressing for Maintenance Work

Surface dressing for maintenance applications shall he carried out in conformity with the requirements of Clause 510, except that the use of small and portable equipment shall be permitted provided that it can be demonstrated, to the satisfaction of the Engineer, that it can produce work consistently in accordance with the requirements of these Specifications.

3004.7. Specialist Repairs

3004.7.1. Specialist repairs include repairs of localized areas of damage to materials for which repairs using normal hot-mix or cold-mix patching materials are inappropriate. Such specialist repairs will include repairs to mastic asphalt and stone mastic asphalt.

3004.7.2. In such cases, pot-hole and patch repairs shall be carried out in accordance with the provisions of Clause 3004.2 above, except that the construction to the mastic asphalt, stone mastic asphalt or other specialist material layer shall, subject to the instructions of the Engineer, be carried out in accordance with the provisions of the appropriate Clause of these Specifications.

List of Indian and Foreign Standards Referred to in the Specifications

(A) INDIAN STANDARDS

Number Designation		Title
IS:73-1992		Paving Bitumen-Specification
IS:2 17-1988		Cutback Bitumen-Specification
IS:454-1961		Cutback Bitumen from Waxy Crude-Specification
		Methods of Testing Tar and Bituminous Materials
IS: 1203-1978		Determination of Penetration
IS:1205-1978		Determination of Softening Point
IS: 1206-1978		Determination of Viscosity
IS:1208-1978		Determination of Ductility
IS: 1209-1978		Determination of Flash Point and Fire Point
IS: 1212-1978		Determination of Loss of Heating
IS:1216-1978		Determination of Solubility in Carbon Disuiphide or Trichoroethylene
IS: 1217-1978		Determination of Mineral Matter (Ash)
IS:1514-1959		Methods of Sampling and Test for Quicklime and Hydrated Lime
IS:2386-1963		Methods of Test for Aggregates for Concrete Particle Size and Shape
	Part 1	Specific Gravity, Density, Voids, Absorption and
	Part 3	Bulking
		Mechanic Properties
	Part 4	Soundness
	Part 5	Methods of Tests for Soils
IS:2720		Determination of Liquid and Plastic Limits
	Part 5-1985	

	Part 37-1976	Determination of Sand Equivalent Values of Soils and Fine Aggregates
IS:5317-1987		Specification for Bitumen Mastic for Bridge Decking and Roads
IS:5435-1969		General Requirements for Cold Bituminous Macadam Mixing Plants
IS:6241-1971		Methods of Test for Determination of Stripping Value of Road Aggregates
JS:8887-1995		Bitumen Emulsion for Roads (Cationic type)-Specification
IS:9381-1979		Methods of Testing Tar and Bituminous Materials: Determination of Fraass Breaking Point of Bitumen
IS:9382-1979		Methods of Testing Tar and Bituminous Materials: Determination of Effect of Heat and Air by Thin Film Oven .Tests

(B) FOREIGN STANDARDS

Number Designation	Title
ASTM:D977-9 1	Standard Specification for Emulsified Asphalt
ASTM: D979-89	Standard Practice for Sampling Bituminous Paving Mixtures
ASTM:D2026-72 (Reapproved 1993)	Standard Specification for Cutback Asphalt (Slow-Curing Type)
ASTM:D2027-76 (Reapproved 1992)	Standard Specification for Cutback Asphalt (Medium-Curing Type)
ASTM:D2041-95	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM:D2172-95	Standard Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures
ASTM:D2397-94	Standard Specification of Cationic Emulsified Asphalt
ASTM:D3203-94	Standard Test Method for Per cent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM:D3910-90 (Reapproved 1995)	Standard Practices for Design, Testing and Construction of Slurry Seal
ASTM:D5976-96	Standard Specification for Type I Polymer Modified Asphalt Cement for Use in Pavement Construction
AASHTO:M82	Equivalent to ASTM:D2027-76 or ASTM :D2026-72
AASHTO:M 140 AASHTO:T182-84	Equivalent to ASTM:D977-9 I Coating and Stripping of Bitumen Aggregate Mixtures

AASHTO:M208		Equivalent to ASTM:D2397-94
AASHTO:T283-89		Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
BS:434 :		Bitumen Road Emulsions (Anionic and
	- Part 2:1984	Cationic)
	- Part 2:1984	Specification for Bitumen Road Emulsion
		Code of Practice for Use of Bitumen Road Emulsions
BS:598		Sampling and Examination of Bituminous Mixtures for Roads and other Paved Areas
	- Part 104:1987	Methods of Test for the Determination of Density and Compaction
	- Part 107:1990	Method of Test for the Determination of the Composition of Design Wearing Course Rolled Asphalt
BS:812		Testing Aggregates
	- Part 114:1989	Method for Determination of the Polished-Stone Value
BS:2000		Methods of test for Petroleum and its products.
	- Part 397:1995	Recovery of Bitumen Binders Dichloromethane Extraction Rotary Film Evaporator Method
BS:DD232 1996		Method for Determination of the Maximum Binder Content of Bituminous Mixtures without excessive binder drainage.
Asphalt Institute		Manual Series No. 2 (MS-2)- Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.
		Manual Series No. 14 (MS-14)- Asphalt Cold Mix Manual.

517.7. Arrangement for Traffic

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

517.8. Measurements for Payment

The recycled pavement work shall be measured in cubic metres or tonnes of finished work as provided by the Contract,

517.9. Rate

The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for:

(i) Making arrangements for traffic to Clause 112;

(ii) Providing all materials to be incorporated in the work, including all royalties, fees, rents where necessary and all leads and lifts;

(iii) All labour, loots, equipment, plant and incidentals to complete the work to the Specification;

(iv) Carrying out the work in part width of the road where directed; and

(v) Carrying out tests to control the quality of the work.

600

Concrete Pavement

601. DRY LEAN CEMENT CONCRETE

SUB-BASE

601.1. Scope

601.1.1. The work shall consist of construction of dry lean concrete subbase for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer, The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.

601.1.2. The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the Contract drawings,

601.2. Materials

601.2.1. Source of Materials: The Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the Contractor later proposes to obtain the materials from a different source, he shall notify the Engineer for his approval at least 45 days before such materials are to be used.

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

(i)	Ordinary Portland Cement	IS : 269
(ii)	Portland Slag Cement	IS : 455
(iij)	Portland Poziolana Cemeni	IS : 1489

If the subgrade is found to consist of soluble sulphates in a concentration more than 0.5 per cent, cement used shall be sulphate resistant and shall conform to IS: 6909,

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

601.2.3. Aggregates:

601.2.3.1. Aggregates for lean concrete shall be natural material complying with IS: 383. The aggregates shall not be alkali reactive. The limits

of deleterious materials shall not exceed the requirements set out in IS: 383. In case the Engineer considers that the aggregates are not free from din, the same may be washed and drained for at least 72 hours before batching, as directed by the Engineer.

601.2.3.2. Coarse aggregate: Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of the coarse aggregate shall he 25 mm. The coarse aggregate shall comply with Clause 602.2.4.2.

601.2.3.3. Fine aggregate: The fine aggregate shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS : 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregate shall comply with Clause 602.2.4.3.

601.2.3.4. The coarse and fine aggregates may be obtained in either of the following manner:

(i) In separate nominal sizes of coarse and fine aggregates and mixed together intimately before use.

(ii) Separately as 25 mm nominal single size, 12.5 mm nominal size graded aggregates - and Tine aggregate of crushed stone dust or sand or a combination of these two.

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

TABLE 600-1. AGGREGATE GRADATION FOR DRY LEAN CONCRETE

Sieve Designation	Percentage passing the sieve by weight
26.50 mm	100
19.00 mm	80-100
9.50 mm	55-75
4.75 mm	35-60
600.00 micron	10-35
75.00 micron	0-8

601.2.4. Water: Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS : 456.

601.2.5. Storage of materials: All materials shall be stored in accordance with the provisions of Clause 1014 of these Specifications and

other relevant IS Specifications. All efforts must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for use in the work. The storage place must also permit easy inspection, removal and storage of materials. All such materials even though stored in approved godowns must be subjected to acceptance lest immediately prior to their use. The requirement of storage yard specified in Clause 602.2.9 shall also be applicable.

601.3. Proportioning of Materials for the Mix

60L3.1. The mix shall be proportioned with a maximum aggregate cement ratio of 15 : 1. The waiter 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 Clause 601.6 by making trial mixes.

601.3.2. Moisture content: The right amount of water for the lean concrete in the main work shall be decided so as to ensure full compaction under rolling and shall be assessed at the time of rolling the trial length. Too much water will cause the lean concrete to be heaving up before the wheels and picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ strength and an open-textured surface.

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

601.3.3. Cement content: The minimum cement content in the lean concrete shall not be less than 150 kg/cu.m. of concrete. If this minimum cement content is not sufficient to produce concrete of UK specified strength, it shall be increased as necessary without additional cost compensation to the Contractor.

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

shall be got approved from the Engineer and demonstrated in the trial length construction.

601.4. Subgrade

The subgradc shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these Specifications and Specification stipulated in the Contract, The lean concrete subbase shall not be laid on a subgrade softened by rain after its final preparation; surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise loose surface. If Engineer feels it necessary, another fine spray of water may be applied just before placing sub-base.

601.5. Construction

601.5.1. General: The pace and programme of the lean concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The sub-base shall be overlaid with cement concrete pavement only after 7 days after sub-base construction.

601.5.2. Batching and mixing: The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with Clause 602.9.3.2. The cement from the bulk stock shall be weighed separately from the aggregates. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity for the laying arrangements. The batching and mixing shall be carried out preferably in a forced action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. Other types of mixers shall be permitted subject to demonstration of their satisfactory performance during the trial length. The type and capacity of the plant shall be got approved by the Engineer before commencement of the trial length. The (weighing balances shall be calibrated by weighing the aggregates, cement, water and admixtures physically either by weighing with large weighing machine or in a weigh bridge. The accuracy of weighing scales of the batching plant shall be within ± 2 per cent in the case of aggregates and ±1 per cent in the case of cement and water.

The design features of Batching Plant should be such that the shifting operations of the plant will not take very long time when they are to be shifted from place to place with the progress of the work.

601.5.3. Transporting: Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tippers/ dumpers with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to paving site shall be such that the travel time available from mixing to paving as specified in Clause 601.5.5.2 will be adhered to.

601.5.4. Placing: Lean concrete shall be laid/placed by a paver with electronic sensor. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base.

The laying of the two-lane road subbase may be done either in full width or lane by lane. Preferably the lean concrete shall be placed and compacted across the full width of the road, by constructing it in one go or in two lanes running forward simultaneously. Transverse and longitudinal construction joints shall be staggered by 500-1000 mm and 200-400 mm respectively from the corresponding joints in the overlaying concrete slabs.

601.5.5. Compaction

601.5.5.1. The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction which is essential, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is closed. The minimum dry density obtained shall be 97 per cent of that achieved during the trial length construction vide Clause 601.7. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 95 per cent of that achieved during the trial construction vide Clause 601.7.

601.5.5.2. 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 concrete temperature is above 25 and below 30 degree Celsius and 120 minutes if less than 25 degree Celsius, This period may be reviewed by the Engineer in the light of the results of the trial run but in no case snail it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30 degree Celsius. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35°C. After compaction has been completed, roller shall not stand on the compacted surface for the duration *of* the curing period except during commencement of next day's work near the location where work was terminated the previous day.

601.5.5.3. Double drum smooth-wheeled vibratory rollers of mini mum 80 to 100 kN static weight are considered to be 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 i he thickness of the lean concrete, the compactibility of the mix, and the weight and type of the roller etc., and the same as well as the total requirement of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

601.5.5.4. In addition to the number of passes required for compaction there shall be a preliminary pass without vibration to bed the lean concrete down and again a final pass without vibration to remove roller marks and to smoothen the surface.

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

601.5.5.5. The final lean concrete surface on completion of compact-tion and immediately before overlaying, shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defec-tive areas shall be corrected by using fresh lean concrete material laid and compacted as per Specification. For repairing honeycombed surface, concrete with aggregates of size 10 mm and below shall he spread and compacted. It is necessary to check the level of the rolled

surface for compliance. Any level/thickness deficiency should be corrected after applying concrete with aggregates of size 10 mm and below after roughening the surface. Similarly the surface regularity also should be checked with 3m straight edge. The deficiency should be made up wilh concrete with aggregates of size 10 mm and below.

601.5.5.6. Segregation of concrete in the dumpers shall be controlled by premixing each fraction of the aggregates before loading in the bin of the batching plant, by moving the dumper back and forth while discharging the mix on it and other means. Even paving operation shall be such that the mix does not segregate.

601.5.6. Joints: Contraction and longitudinal joints shall be provided as per the drawing.

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

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

(a) The initial curing shall be done by spraying with liquid curing compound. The curing compound shall he white pigmented or transparent type with water Mention index of 90 per cent when tested in accordance with BS 7542. Curing compound shall be sprayed immediately after rolling is complete. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days.

(b) Curing shall be done by covering the surface by gunny bags/hessian, which shall be kept continuously moist for 7 days by sprinkling water.

601.6. 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 cement content specified and the specified aggregate grading but without violating the requirement of aggregate-cement ratio specified in Clause 601.3.1. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot as described in Clause 903.5,1.1. After establishing the optimum moisture, a set of six cubes shall be cast at that moisture for the determination of compressive strength on the 3rd and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory either by

increasing cement content or using higher grade of cement. After the mix design is approved, the Contractor shall construct a trial section in accordance with Clause 601.7.

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 a satisfactory mix. The cube specimens prepared with the changed moisture content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in ravelling of surface.

601.7. Trial Length

601.7.1. The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a "Method Statement" giving detailed description of the proposed materials, plant, equipment, mix proportion, and procedure for batching, mixing, laying, compaction and other construction procedures. The Engineer shall also approve the location and length of trial construction which shall be a minimum of 60 m length and for full width of the pavement. The trial lenglh shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid sub-base. The construction of trial length will be repealed till the Contractor proves his ability to satisfactorily construct the subbasc.

601.7.2. In order to determine and demonstrate the optimum mois ture content which results in the maximum dry density of the mix compacted by the rolling equipment and the minimum cement content that is necessary to achieve the strength stipulated in the drawing, trial mixes shall be prepared as per Clause 601.6.

601.7.3. After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method with 20 cm dia density cone. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length; average of these densities shall be determined. These main density-holes shall not be made in the strip 50 cm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 per cent. The field density of regular

work will be compared with this reference density in accordance with Clauses 601.5.5.1 and 903.5.1.2. A few cores may be cut as per the instructions of the Engineer to check segregation or any other deficiency.

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

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

601.8. Tolerances for Surface Regularity, Level, Thickness, Density and Strength

The tolerances for surface regularity, level, thickness, density and strength shall conform to the requirements given in Clause 903.5. Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

601.9. Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the lean concrete sub-base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the Engineer.

601.10. Measurements for Payment

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

601.11. Rate

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

602. CEMENT CONCRETE PAVEMENT

602.1. Scope

602.1.1. The work shall consist of construction of unreinforced, 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 trie Engineer.

602.1.2. The design parameters, viz,, thickness of pavement slab, grade of concrete, joint details etc. shall be as stipulated in the drawings.

602.2. Materials

602.2.1. Source of materials: The Contractor shall indicate to the Engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the Contractor later proposes to obtain materials from a different source, he shall notify the Engineer for his approval, at least 45 days before such materials are to be used with relevant test data.

602.2.2. Cement: Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but the preference should be to use at least the 43 Grade or higher.

(i) Ordinary Portland Cement, *33* Grade. IS : 269

(ii) Ordinary Portland Cement, 43 Grade IS : 8112,

(iii) Ordinary Portland Cement, 53 Grade, IS : 12269.

If the soil around has soluble salts like sulphates in excess of 0.5 per cent, the cement used shall be sulphate resistant and shall conform to IS: 12330.

Guidance may be taken from IS: SP: 23, Handbook for Concrete Mixes for ascertaining the minimum 7 days strength of cement required to match with the design concrete strength. Cement to be used may preferably be obtained in bulk form. If cement in paper bags are proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them of suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in

accordance with Clause 1014. The cement shall be subjected 10 acceptance test just prior to its use.

602.2.3. Admixtures : Admixtures conforming to IS:6925 and IS: 9103 shall be permitted to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved boih on the laboratory concrete trial mixes and in trial paving works. If air entraining admixture is used, the total quantity of air in air-entrained concrete as a percentage of the volume of the mix shall be 5 ± 1.5 per cent for 25 mm nominal size aggregate.

602.2.4. Aggregates

602.2.4.1. Aggregates for pavement concrete shall be natural material complying with IS : 383 but with a Los Angeles Abrasion Test result not more than 35 per cent The limits of deleterious materials shall not exceed the requirements set out in IS : 383.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalies in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 per cent by weight and the total sulphate content expressed as sulphuric anhydride (S03) shall not exceed 0.25 per cent by weight.

602.2.4.2, Coarse aggregate: Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 25 mm for pavement concrete. Continuously graded or gap graded aggregates may be used, depending on the grading of the fine aggregate. No aggregate which has water absorption more than 2 per cent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS : 2386 (Part-5). After 5 cycles of testing the loss shall not be more than 12 per cent if sodium sulphate solution is used or 18 per cent if magnesium sulphate solution is used.

Dumping and stacking of aggregates shall be done in an approved manner. In case the Engineer considers that the aggregates are not free

from din, the same may be washed and drained for at least 72 hours • before batching as directed by the Engineer.

602.2.4.3. Fine aggregate: The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS : 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following :

Clay lumps	4.0 per cent
Coal and lignite	10 per cent
Material pissing IS Sieve No. 75 micron	4.0 per cent

602.2.5. Water: Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, sail, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS: 456.

602.2.6. Mild steel bars for dowels and tie bars : These shall conform to the requirements of IS : 432, IS : 1139 and IS : 1786 as relevant. The dowel bars shall conform to Grade S 240 and tie bars to Grade S 415 of I.S.

602.2.7. Premoulded joint filler: Joint filler board for expansion joints which are proposed for use only at some abutting structures like bridges and culverts shall be of 20-25 mm thickness within a tolerance of ± 1.5 mm and of a firm compressible material and complying with the requirements of IS: 1838, or BS Specification Clause No. 2630 or Specification for Highway Works, Vol. I Clause 1015. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not be less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

602.2.8. Joint sealing compound: The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide type having flexibility, resistance to age hardening and durability. If the sealant is of hot poured type it shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

602.2.9. Storage of materials: All materials shall be stored in accordance with the provisions of Clause 1014 of the Specifications and other relevant IS Specifications. Ail efforts must be made to store the materials in proper places so as to prevent their deterioration or

contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The platform where aggregates are stock piled shall be levelled with 15 cm of watered, mixed and compacted granular sub-base material. The area shall have slope and dram to drain off rain water. The storage space must also permit easy inspection, removal and storage of the materials. Aggregates of different sizes shall be stored in partitioned stack-yards. All such materials even though stored in approved godowns must be subjected to acceptance test as per Clause 903 of these Specifications immediately prior to their use.

602.3. Proportioning of Concrete

602.3.1. After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer. The mix design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per 15:10262 (Recommended Guidelines for Mix Design) or on the basis of any other rational method agreed to by the Engineer, Guidance in this regard can also be obtained from IS:SP:23 Handbook on Concrete Mixes. The target mean strength for the design mix shall be determined as indicated in Clause 903.5.2. The mix design shall be based on the flexural strength of concrete.

602.3.2. Cement content: The cement content shall not be less than 350 kg per cu.m.of concrete. If this minimum cement content is not sufficient to produce in the field, concrete of the strength specified in the drawings/design, it shall be increased as necessary without additional compensation under the Contract. The cement content shall, however, not exceed 425 kg per cu.m. of concrete.

602.3.3. Concrete strength

602.3.3.1. While designing the mix in the laboratory, correlation between flexural and_ compressive strengths of concrete shall be established on the basis of at least thirty tests on samples. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means approved by the Engineer and the maximum free water cement ratio shall be 0.50.

602.3.3.2. The ratio between the 7 and 28 day strengths shall be established for die 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 normal working, die average value of any four consecutive 7 day test results falls below the required 7 day strength as derived from the value of'R', then the cement content of the concrete shall, without extra payment, be increased by 5 per cent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for its conformity with the requirements as per Clause 602.3.1. Whenever the cement content is increased, die concrete mix shall be adjusted to maintain the required workability.

602.3.4. Workability

602.3.4.1. The workability of the concrete at the point of placing shall be adequate for die 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,

602.3.4.2. The workability requirement at the Batching 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 plant site to the paving site changes. The workability shall be established for the type of paving equipment available. A slump value in the range of 30 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the Engineer. These tests shall be carried out on every truck/dumper at Plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate trucks or as per the instructions of the Engineer.

602.3.5. Design mix

602.3.5.1. The Contractor shall carry out laboratory trials of design mixes with die materials from the approved sources to be used. Trial

mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer. They shall be repeated if necessary until the proportions that will produce a concrete which complies in all respects with this Specification, and conforms to the requirement of the design/drawings have been determined.

602.3.5.2. 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.

602.3.5.3. Any change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length unless approval is given by the Engineer for minor adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

602.4. Sub-base

The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and Specifications contained in Clause 601. If the sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired with fine cement concrete or bituminous concrete before laying separation layer. Prior to laying of concrete it shall be ensured that the separation membrane as per Clause 602.5 is placed in position and the same is clean of dirt or other extraneous materials and free from any damage.

602.5. Separation Membrane

A separation membrane shall be used between the concrete slab and the subbase. Separation membrane shall be impermeable plastic sheeting 125 microns thick laid flat without creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails.

602.6. Joints

602.6.1. The location and type of joints shall be as shown in the drawing. Joints shall be constructed depending upon their functional

requirement as detailed in the following paragraphs. The location of the joints should be transferred accurately at the site and mechanical saw cutting of joints done as per stipulated dimensions. It should be ensured that the full required depth of cut is made from edge to edge of the pavement. Transverse and longitudinal joints in the pavement and sub-base shall be staggered so that they are not coincident vertically and are at least 1m and 0.3 m apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load of the sawing machine and personnel without damaging the texture of the pavement. Sawing operation could start as early as 6-8 hours depending upon the season.

602.6.2. Transverse joints

602.6.2.1. Transverse joints shall be contraction and expansion joints constructed at the spacing described in the Drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints which is the straight line transverse to the longitudinal axis of the carriageway at the position proposed by the Contractor and agreed to by she Engineer, except at road junctions or roundabouts where the position shall be as described in the drawings:

(i) Deviations of the filler board 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 602.11.

602.6.2.2. Contraction joints : Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and 1/4 to 1/3 depth of .he slab ± 5 mm or as stipulated in the drawings and dowel bars complying with Clause 602,6.5 and as detailed in the drawings.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab.

602.6.2.3. Expansion joints: The expansion joints shall consist of a joint filler board complying with Clause 602.2.7 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. and at such depth below the surface as will not impede the passage of the finishing straight edges or oscillating beams of the paving machines. The adjacent slabs shall be completely separated from each other by providing joint filler board. Space around the dowel bars, between the sub-base and the filler board shall be packed with a suitable compressible material to block the flow of cement slurry.

602.6.3. Transverse construction joint: Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than 30 minutes. These joints shall be provided at the regular location of contraction joints using dowel bars. The joint shall he made butt type. At all construction joints, steel bulk heads shall be used to retain the concrete while the surface is finished. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulk head/ stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be formed and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened,

602.6.4. Longitudinal joint

602.6.4.1. The longitudinal joints shall be saw cut as per details of the joints shown in the drawing. The groove may be cut after the final set of the concrete. Joints should be sawn to at least 1/3 the depth of the slab ± 5 mm as indicated in the drawing.

602.6.4.2. Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with Clause 602.6.6.

602.6.5. Dowel bars

602.6.5.1. Dowel bars shall be mild steel rounds in accordance with Clause 602.2.6 with details/dimensions as indicated in the drawing and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placemen of the bars besides full re-compaction of the concrete around the dowel bars.

602.6.5.2. 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 hereunder, the compliance of which shall be checked as per Clause 602.10.7,

(i) For bars supported on cradles prior to the laying of the slab:

(a) All bars in a joinl shall be within ± 3 mm pet 300 mm lenglh of bar

(b) 2/3rd of the bars shall be within ± 2 mm per 300 mm length of bar

(c) No bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm lenglh of bar in either the horizontal or vertical plane

(d) Cradles supporting dowel bar shall nol extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joinl.

(ii) For all bars inserted after laying of the slab:

(a) Twice the tolerance for alignment as indicated in (i) above

602.6.5.3. 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 both directions horizontally) shall conform to be within the following limits:

(i) Two-thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar

(ii) The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

602.6.5.4. The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position:-

(i) For expansion joints, the deflection of [he lop 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 bat or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection after removal of the load shall be not more than 3 mm.

(ii) The joint assembly fixings to sub-base shall not fail under the 1.3kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.

(iii) The fixings for contraction joint shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or limber packing placed as near to the level of the line of fixings as practicable.

(iv) 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 lo the centre of the bar or limber packing.

602.6.5.5. Dowel bars shall be covered by a thin plastic sheath for at least two-thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of an average thickness not greater than 1.25 mm. The sheathed bar shall comply with the following pull-out tests:

(i) 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 n 150 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,

602.6.5.6. For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using comp ressible sponge. To block the entry of cement slurry between dowel and cap it may be taped.

602.6.6. Tie bars

602.6.6.1. Tie bars in longitudinal joints shall be deformed steel bars of strength 415 MPa complying with 15:1786 and in accordance with the requirements given below. The bars shall be free from oil, dirt, loose rust and scale.

602.6.6.2. Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75mrn 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 tic bars are used,

602.6.6.3. Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placement of the bars and recompaction of the concrete around the tie bars.

602.6.6.4. Tie bars shall be positioned to remain within the middle third of the slab depth as indicated in the drawings and approximately parallel to die 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 ± 50mm, and with a minimum cover of 30 mm below the joint groove,

602.7. Weather and Seasonal Limitations

602.7.1. Concreting during monsoon months: When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other water proof cloth shall be provided along the line of the work. Any lime when it rains, all freshly laid concrete which had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directives of die Engineer,

602.7.2. Concreting in hot weather: No concreting shall be done when the concrete temperature is above 30 degree Centigrade, Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., if so desired by the Engineer, tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. The temperature of the concrete mix on reaching the paving site shall not be more than 30° C, To bring down the temperature, if necessary, chilled water or ice flakes should be made use of.

No concreting shall be done when the concrete temperature is below 5 degree Centigrade and the temperature is descending.

602.8. Side Forms, Rails and Guidewires

602.8.1. Side forms and rails: All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface regularity of the sub-base. The forms can be placed on series of steel packing plates or shims to take care of irregularity of subbase. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment. Sideforms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rails shall be firmly secured in position by not less than 3 stakes/pins per each 3 m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 m and when in place shall

not settle in excess of 1.5 mm in 3 m while paving is being done. Forms shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances ± 10 mm and ± 3 mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected from the Engineer for his approval before 12 hours on the day before the construction of the slab and shall not be removed until at least 12 hours afterwards.

602.8.2. At all times sufficient forms shall be used and set to the required alignment for at least 200 m length of pavement immediately in advance of the paving operations, or the anticipated length of pavement to be laid within the next 24 hrs whichever is more,

602.8.3. Use of guidewires

602.8.3.1. Where slip form paving is proposed, a guidewire shall be provided along both sides of the slab, Each guidewire shali be at a constant height above and parallel to the required edges of the slab as described in the contract/drawing within a vertical tolerance of ± 3mrn. Additionally, one of the wires shall be kept al a constant horizontal distance from the required edge of the pavement as indicated in the contract/drawing within a lateral tolerance of ± 10 mm.

602.8.3.2. The guidewires shall be supported on stakes not more than 8 mm apart by connectors capable of fine horizontal and vertical adjustment. The guidewire shall be lensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20 mm when suspended at the mid point between any pair of stakes. The ends of the guidewires shall be anchored to fixing point or winch and not on the stakes.

602.8.3.3. The stakes shall be positioned and the connectors maintained at their correct height and alignment from 12 hours on the day before concreting takes place until 12 hours after finishing of the concrete. The guidewire shall be erected and tensioned on the connectors at any section for al least 2 hours before concreting that section.

602.8.3.4. The Contractor shall submit to the Engineer for his approval of line and level, the stakes and connectors which are ready for use in the length of road to be constructed by 12 hours on the working

day before the day of construction of slab. Any deficiencies noted by the Engineer shall be rectified by the Contractor who shall then re-apply for approval of the affected stakes. Work shall not proceed until the Engineer has given his approval. It shall be ensured that the stakes and guidewires are not affected by the construction equipment when concreting is in progress.

602.9. Construction

602.9.1. General: A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities including indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work, The above shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of atleast 300 m in one day.

602.9.2. Batching and mixing: Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationary water tanks. This shall be, however, situated at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor.

602.9.3. Equipment for proportioning of materials and paving

602.9.3.1. Proportioning of materials shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume. Wherever properly graded aggregate of uniform quality cannot be maintained as envisaged in the mix design, the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity of the laying/paving equipment.

602.9.3.2. Batching plant and equipment:

(1) General- The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. The weighing hoppers shall

be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non-resetnble batch counter which will correctly indicate the number of batches proportioned.

(2) Bins and hoppers - Bins with minimum number of four adequate separate compartments shall be provided in the batching plant.

(3) Automatic weighing devices-Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells.

(4) Mixers - Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specific mixing period, and of discharging the mixture, without segregation. Each 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 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.

The mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at midpoint of each blade are recommended. Batching Plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.

(5) Control cabin - An air-conditioned centralised control cabin shall be provided for automatic operation of the equipment.

602.9.3.3. Paving equipment : The concrete shall be placed with an approved fixed form or slip from 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 controls to control/sensor line and grade from either or both sides of the machine.

Vibrators shall operate at a frequency of 8300 10 9600 impulses per minute under load at a maximum spacing of 60 cm. The variable vibration setting shall be provided in the machine,

602.9.3.4. Concrete saw : The Contractor shall provide adequate number of concrete saws with sufficient number of diamond-edge saw blades. The saw machine shall be either electric or petrol/diesel driven type, A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

602.9.4. Hauling and placing of concrete

602.9.4.1. Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of trucks/tippers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Covers shall be used for protection of concrete against the weather. The trucks/tippers shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that the paving is done in an uninterrupted manner with a uniform speed throughout the days work.

602.9.4.2. Placing of concrete

Concrete mixed in central mixing plant shall be transported to the site without delay and the concrete which, in the opinion of the Engineer, has been mixed too long before laying will be rejected and shall be removed from the site. The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing

shall not exceed 120 minutes when concrete temperature is less than 25°C and 90 minutes when the concrete temperature is between 25°C to 30°C. Trucks/tippers delivering concrete shall not run on plastic sheeting nor shall they run on completed slabs until after 28 days of placing the concrete. The Paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

602.9.4.3. Where fixed form pavers are to be used, forms shall be fixed in advance as per Clause 602.8. of the Specifications. Before any paving is done, the site shall be shown to the Engineer, in order to verify the arrangement for paving besides placing of dowels, tie-bars etc., as per the relevant Clauses of this Specification. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

602.9.4.4. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.
602.9.4.5. The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the Engineer when it shall be applied as a mist by means of approved equipment.

602.9.4.6. If considered necessary by the Engineer, the paving machines shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight and rain or hot wind.

602.9.4.7. While the concrete is still plastic, its surface shall be brush textured in compliance with Clause 602.9,8 and the surface and edges of the slab cured by the application of a sprayed liquid curing membrane in compliance with Clause 602.9.9. After the surface texturing, but before the curing compound is applied, the concrete slab shall be marked with the chainage at every 100 m interval.

602.9.4.8. As soon as the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of one part of cement to 3 parts of fine chips and fine aggregate under the supervision of the Engineer.

602.9.4.9. If the requirement of Clause 902.4, for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

602.9.5. Construction by fixed form paver

602.9.5.1. The fixed form paving train shall consist of separate

powered machines which spread, compact and finish the concrete in a continuous operation.

602.9.5.2. The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the subbase. 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 cross fall. 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 overworking.

602.9.6. Construction by slip form paver

602.9.6.1. The slip form paving train shall consist of power machine which spreads, compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across the whole width and to a height which at all times is in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the whole width of the slab. The equipment for striking-off the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by change in slab thickness or crossfall.

602.9.6.2. The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires installed as per Clause 602.8 by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative

to the guide wire or to the surface and edge of the slab.

602.9.6.3. Slip-form paving machines shall have vibrators of variable output, with a maximum energy output of not less than 2.5 KW per metre width of slab per 300 mm depth of slab for a laying speed upto 1.5 m per minute or pro-rata for higher speeds. The machines shall .be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete in all situations.

602.9.6.4. If the edges of the slip formed slab slump to the extent that the surface of the top edge of the slab does not comply with the requirements of Clause 602.14, then special measures approved by the Engineer shall be taken to support the edges to the required levels and work shall be stopped until such time as the Contractor can demonstrate his ability to slip form the edges to the required levels.

602.9.7. Construction by hand-guided method: Areas in which hand-guided methods of construction become indispensable shall be got approved by the Engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths. Work shall be carried out by skilled personnel as per methods approved by the Engineer. The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures shall be the same as in the case of machine laid work.

602.9.8. Surface texture

602.9.8.1. After the final regulation of the slab and before the application of the curing membrane, the surface of concrete slab shall be brush-textured in a direction at right angles to the longitudinal axis of the carriageway.

602.9.8.2. The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide but longer brushes are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10 mm centres. The tufts shall contain an average of 14 wires and initially be 100 mm long. The brush shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in 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.

602.9.8.3. The texture depth shall be determined by the Sand Patch Test as described in 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.

602.9.8.4. Texture depths shall not be less than the minimum required when measurements are taken as given in Table 600-2 nor greater than a maximum average of 1.25 mm.

TABLE : 600-2. Texture Depth

Time of Test	Number of Measurements	Required Texture Depth (mm)	
		Specified Value	Tolerance
1. Between 24 hours and 7 days after the constn., of the slab or until (he dab is first used by vehicles.	An average of 5 measurements	1.00	±0.25
2. Not later than 6 weeks before the mad is opened to public traffic.	An average of 5 measurements	1.00	±0.25 ±0.35

602.9.8.5. After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

602.9.8.6. Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over length directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

602.9.9. Curing

602.9.9.1. Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin- based aluminised reflective curing compound which hardens into an impervious film or membrane with the help of a mechanical sprayer.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index of 90 per cent in accordance with BS Specification No. 7542.

602.9.9.2. The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks after application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer's instructions checked during the construction of the trial length and subsequently whenever required by the Engineer. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying.

602.9.9.3. In addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavement with tents as described in Clause 602.7.2, during adverse weather conditions as directed by the Engineer. After three hours, the pavement shall be covered by moist hessian and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis.

602.9.9.4. The Contractor shall be liable at his expense to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint.

602.10. Trial Length

602.10.1. The trial length shall be constructed at least oil • month in advance of the proposed start of concrete paving work. At least one month prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a detailed method statement giving description of the proposed materials, plant, equipment and construction methods. All the major equipments like paving train, batching plant, tippers etc., proposed in the construction are to be approved by the Engineer before their procurement. No trials of new materials, plant, equipment or construction methods, nor any development of them shall be permitted either during the construction of trial length or in any subsequent paving work, unless they form part of further, approved trials. These trial lengths shall be constructed away from the carriage way but with at least a subbase layer below it.

602.10.2. The Contractor shall demonstrate the materials, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 60 m but not more than 300 m long for mechanised construction and at least 30 m long

for hand guided methods. If the first trial is unsatisfactory, the Contractor shall have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

602.10.3 The trial length shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 30 m constructed each day for mechanised construction and a minimum of 15 m on each clay for hand guided construction. The trial length shall be constructed at a similar rate (speed, around lm/hr) to that which is proposed for the main work.

602.10.4. Transverse joints and longitudinal joints of each type that are proposed for dowel-jointed unreinforced concrete slabs in the main work shall be constructed and assessed in the trial length. If in the trial length the construction of expansion joint and longitudinal joint is not demonstrated, the first 2 expansion joints and at least the first 150 m of longitudinal construction joint for mechanised paving in the main work, shall be considered as the trial length for these joints.

602.10.5. The trial length shall comply with the Specification in all respects, with the following additions and exceptions;

602.10.5.1. Surface levels and regularity

(i) In checking for compliance with Clause 903.5 the levels shall be taken at intervals at the locations specified in this Clause along any line or lines parallel to the longitudinal centre line of the trial length.

(ii) The maximum number of permitted irregularities of pavement surface shall comply with the requirements of Clause 902.4. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.

602.10.5.2. Joints

(iii) Alignment of dowel bars shall be inspected as described in Clause 602.10.7 in my two consecutive transverse joint. If the position or alignment of the dowel bars at one of these joints does not comply with Clause 602.6.5. if that joint remains the only one that does not comply after the next 3 consecutive joints of the same typo have been inspected, then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without Extending the trial length unduly, the Contractor may, by agreement with the Engineer, construct joints at more frequent joint intervals than the normal spacing required in the Contract.

(iv) If there arc deficiencies in the first expansion joint that is constructed as a trial, the next expansion joint shall be a trial joint. Should this also be deficient, further trial expansion joints shall be made as pan of the trial length which shall not form part of die permanent works, unless agreed by the Engineer.

602.10.5.3. Density

(v) Density shall be assessed as described in Clause 602.3.3. from at leasl 3 cores drilled from each part of the trial length.

602.10.5.4. Position of tie bars

(vi) Compliance with Clause 602.6.6 for the position and alignment of tie bars shall be checked by drilling additional cores from the slab unless they can be determined from cores taken for density.

602.10.6. Approval and acceptance

602.10.6.1 Approval of the materials, plant, equipment and construction methods shall be given when a trial length complies with the Specification. The Contractor shall not proceed with normal working until the trial length has been approved and any earlier defective trial lengths have been removed, unless that can be remedied to the satisfaction of the Engineer. If the Engineer does not notify the Contractor of any deficiencies in any trial length within 10 days after the completion of that trial length, the Contractor may assume that the trial length, and the materials, plant, equipment and construction methods adopted are acceptable.

602.10.6.2. When approval has been given, the materials, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, without the approval of the Engineer. Any changes in materials, plant, equipment, and construction methods shall entitle the Engineer to require the Contractor to lay a further trial length as described in this Clause to demonstrate that the changes will not adversely affect the permanent works.

602.10.6.3. Trial lengths which do not comply with the Specification, with the exception of areas which are deficient only in surface texture and which can be remedied in accordance with Clause 602.9.8.6 shall be removed immediately upon notification of deficiencies by the Engineer and the Contractor shall construct a further trial length.

602.10.7. Inspection of dowel bars

602.10.7.1. Compliance with Clause 602.6,5, for the position and alignment of dowel bars at construction and expansion joints shall be checked by measurements relative to the side forms or guide wires.

602.10.7.2. When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them in the plastic concrete across die whole width of the slab. When the joint is an expansion joint, the top of the filler board

shall first be exposed sufficiently in the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working, these measurements shall be carried out in the pavement section at the end of day's work by extending slab length by 2 m. After sawing the transverse joint groove, the extended 2 m slab shall be removed carefully soon after concrete has set to expose dowels over half the length. These dowels can be tested for tolerances,

602.10.7.3. If the position and alignment of the bars in a single joint in the slab is unsatisfactory then the next two joints shall be inspected. If only one joint of the three is defective, the rate of checking shall be increased to one joint per day until the Engineer is satisfied that compliance is being achieved. In the event of non-compliance in two or more successive joints, the Contractor shall revert to the construction of fresh trial lengths and make any necessary alteration to concrete mix, paving plant or methods until the dowel bar position and alignment are satisfactory.

602.10.7.4. After the dowel bars have been examined, the remainder of the concrete shall be removed over a width of 500 mm on each side of the line of the joint and reinstated to the satisfaction of the Engineer. The dowels shall be inserted on both sides of the 1m wide slab by drilling holes and grouting with epoxy mortar. Plastic sheath as per Clause 602.6.5.5'shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per Clause 602.11.

602.11. Preparation and Sealing of Joint Grooves

602.11.1. General

All transverse joints in surface slabs shall be sealed using sealants described in Clause 602.2.8. Joints shall not be sealed before 14 days after construction.

602.11.2. Preparation of joint grooves for sealing

602.11.2.1. Joint grooves usually are not constructed to provide the minimum width specified in the drawings when saw cut joints are adopted. They shall be widened subsequently by sawing before sealing. Depth/width gauges shall be used to control the dimension of the groove.

602.11.2.2. If rough arrises develop when grooves are made, they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle upto 10 degree from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn

or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degrees, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects upto a maximum width, including any chamfer, of 35 mm for transverse joints and 20 mm for longitudinal joints. If the spalling cannot be so eliminated then the arrises shall be repaired by an approved thin bonded arris repair using cementitious materials.

602.11.2.3. All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. If need arises the Engineer may instruct cleaning by pressurised water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves may have to be sand blasted to increase the bondage between sealant and concrete.

602.11.2.4. The groove shall be cleaned and dried at the time of priming and sealing.

602.11.2.5. Before sealing the temporary seal provided for blocking the ingress of dirt, soil etc., shall be removed. A highly compressible heat resistant paper-backed debonding strip as per drawing shall be inserted in the groove to serve the purpose of breaking the bond between sealant and the bottom of the groove and to plug the joint groove so that the sealant may not leak through the cracks. The width of debonding strip shall be more than the joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat resistant tapes may be inserted to block the leakage through bottom of the joint.

602.11.3. Sealing with sealants

602.11.3.1. When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with their recommendation. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 7° C.

602.11.3.2. If hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer having recirculating pump and extruder. For large road projects, sealant shall be applied with extruder having flexible hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature and not for a period

longer than the safe heating period, as specified by the manufacturer. The dispenser shall be cleaned our at the end of each day in accordance with the manufacturer's recommendations and reheated material shall not be used.

602.11.3.3. Cold applied sealants with chemical formulation like polysulphide may be used. These shall be mixed and applied within the lime limit specified by the manufacturer. If primers are recommended they shall be applied neatly with an appropriate brush. The Movement Accommodation Factor (MAP) shall be more than 10 per cent.

602.11.3.4. The sealants applied at contraction phase of the slabs would result in bulging of the sealant over and above the slab. Therefore, the Contractor in consultation with the Engineer, shall establish the right temperature and time for applying the sealant. Thermometer shall be hung on a pole in the site for facilitating control during the sealing operation.

602.11.3.5. Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 5 ± 2 mm.

602.11.3.6. During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the sealing process.

602,11.4. Testing of applied sealants: Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard as in Clause 602.2.8. The samples shall meet the requirement of AASHTO M 282 for hot applied sealant or BS 5212: (Part-2) for cold applied sealant.

602.12. Measurement of Texture Depth - Sand Patch Method

602.12.1. The following apparatus shall be used:

(i) A cylindrical container of 25 ml internal capacity

(ii) A flat wooden disc 64 mm diameter with a hard rubber disc. 1,5mm thick, *slack* to one face, the reverse face being provided with a handle

(iii) Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

602.12.2. Method: The surface to be measured shall be dried, any extraneous mortar and loose material removed and the surface swept clean using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times on the surface to ensure compaction, and

striking off the sand level with the top of the cylinder. The sand shall be poured into a heap on the surface to be treated. The sand shall be spread over the surface, working The disc with its face kept flat in a circular motion so that the sand is spread into a circular patch with the surface depressions filled with sand to the level of peaks.

602.12.3. The diameter of the patch shall be measured to the nearest 5 mm. The texture depth of concrete surface shall be calculated from 31000/(D×D) mm where D is the diameter of the patch in mm,

602.13. Opening to Traffic

No vehicular traffic shall be allowed to run on the finished surface of a concrete pavement within a period of 28 days of its construction and until the joints arc permanently sealed. The road may be opened to regular traffic after completion of the curing period of 28 days and after scaling of joints is completed including the construction of shoulder, with the written permission of the Engineer.

602.14. Tolerances for Surface Regularity, Level, Thickness and Strength

The tolerances for surface regularity, level, ^thickness and strength shall conform to the requirements given in Clause 903.5. Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

602.15. Measurements for Payment

602.15.1. Cement Concrete pavement shall be measured as a finished work in square metres with specified thickness. The volume to be paid for will be calculated on the basis of thickness and plans shown on the project drawings and adjusted for the deficiency in thickness. No additional payment shall be made for extra thickness of the slab. The full payment will be made to this item after 28 days strength of the concrete is found to be satisfactory.

The unit for measurement for concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas for the specified thickness shown on the Drawings or directed by the Engineer. The rate shall include all provisions of this Specification and shall include the provision of all materials including polythene film, concrete, stock piling, mixing, transport, placing, compacting, finishing, curing together with all formwork, and including testing and submission of test certificates and records. No deduction shall be made in measurement for openings provided that the area of each is less than 0.5 sq. m. The unit rate

as entered in the Bill of Quantities shall also include the full costs of contraction, expansion, construction, and longitudinal joints. It shall also include joint filler, keys, caulking rod, debonding strip, sealant primer, joint sealant, dowel bar and tie rod.

602.15.2. Pavement thickness

All precautions and care shall be taken to construct pavement having uniform thickness as called for on the plans.

Thickness of the cement concrete pavement shall be calculated on the basis of level data of the cement concrete-pavement and the underlying sub-base taken on a grid of 5 m x 3,5 m or 6,25 rri x 3.5 m, the former measurement being in longitudinal direction.

A day's work is considered as a 'lot' for calculating the average thickness of the slab. In calculating the average thickness, individual measurements which are in excess of the specified .thickness by more than 10 mm shall be considered as the specified thickness plus 10 mm.

Individual areas deficient by more than 25 mm shall be verified by the Engineer by ordering core cutting and it in his opinion the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the plans.

When the average thickness for the lot is deficient by the extent shown in Table 600-3, the Contract unit price will be adjusted as per this Table.

TABLE 600-3. PAYMENT ADJUSTMENT FOR DEFICIENCY IN THICKNESS

Deficiency in the average thickness of day's work	Per cent of Contract unit price payable
Up to 5 ram	100
6 - 10 mm	87
11 - 15 mm	SI
16 - 20 mm	75
21 - 25 mm	70

In the stretch where deficiency of average thickness is more than 25 mm, the section whose thickness is deficient by 26 mm or more is identified with the help of cores. Such slabs shall be removed and reconstructed at the cost of the Contractor, During such rectification work, care shall be taken to replace full slab and to the full depth.

602.16. Rate

The Contract unit rate for the construction of the cement concrete shall be payment in full for carrying out the operations required for the different items of the work as per these Specifications including full compensation for all labour, tools, plant, equipments, testing and incidentals to complete the work as per Specifications, providing all materials to be incorporated in the work including all royalties, fees, storage, rents where necessary and all leads and lifts.

603. ROLLED CEMENT CONCRETE BASE

603.1. Scope

603.1.1. The work shall consist of construction of rolled concrete base course for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, material and labour and performing all operations in connection with the work, as approved by the Engineer.

603.1.2. The design parameters of rolled cement concrete base course viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the contract drawings.

603.2. Materials

603.2.1. Source of materials: The Contractor shall indicate to the Engineer the source of all materials to be used in the lean concrete work with relevant test data sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 50 days before the scheduled commencement of the work. If the Contractor later proposes to obtain the materials from a different source, he shall notify the Engineer for his approval at least 60 days before such materials are to be used.

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

(i)	Ordinary Portland Cement	IS : 269. 8112 or 12269
(ii)	Portland Slag Cement	IS : 455
(iii)	Portland Pozzolana Cement	IS : 1489

If the subgrade is found to consist of soluble sulphates in a concentration more than 0.5 per cent, cement used shall be sulphate resistant and shall conform to IS : 12230, 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.

603.2.3. Aggregates :

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

603.2.3.2. Coarse aggregate : 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 maxi mum size of the coarse aggregate shall be 25 mm. The coarse aggregate shall comply with the Clause 602.2.4.2.

603.2.3.3. Fine aggregate : The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383, Fine aggregate shall be free from soft panicles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregate shall comply with the Clause 602.2.4.3.

603.2.3.4. The coarse and fine aggregates may be obtained in either of the following manner:-

(i) In separate nominal sizes of coarse and fine aggregates and mixed together intimately before use.

(ii) Separately as 25 mm nominal single size, 12.5 mm nominal size graded aggregate and fine aggregate of crushed stone dust or sand or a combination of these two.

The material after blending shall conform to the grading as indicated in Table 600-4 below:

TABLE 600-4. AGGREGATE GRADATION FOR DRY LEAN CONCRKTE

Sieve Designation	Percentage Passing the sieve by weight
37.5 mm	100
19.0 mm	80-100
9,5 mm	55-80
4.15 mm	35-60
600 micron	10-35
75 micron	0-8

603.2.4. Water: Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS: 456.

603.2.5. Storage of materials: Air materials shall be stored in accordance with the provisions of Clause 1014 of these Specifications, and other relevant IS Specifications. All efforts must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage place must also permit easy inspection, removal and storage of materials. All such materials even though stored in approved godowns must be subjected to acceptance test immediately prior to their use. The requirement of storage yard specified in Clause 602.2.9 shall be applicable.

603.3. Proportioning of Materials for the Mix

603.3.1. The mix shall be proportioned with a maximum aggregate: cement ratio of 15:1. After the approval of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportion of all ingredients for the approval of the Engineer, The mix design shall be submitted at least 30 days prior to the paving of trial, length and design shall be done based on the laboratory trials using approved materials and methods. The water content shall be adjusted to the optimum as per Clause 603.3.2. for facilitating compact-tion by rolling. The target mean strength for the design mix as well as acceptance Specification of concrete shall be in accordance with Clause 903.5.2. The mix design shall be based on the flexural strength of concrete.

603.3.2. Moisture content: The right amount of water for the rolled concrete in the main work shall be decided for ensuring full compaction under roiling and shall be assessed at the time of rolling the trial length. Too much water will cause the concrete to be picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ strength and an open textured surface. The optimum water content shall be determined in accordance with Clause 603.7, and demonstrated by rolling during trial length construction; and the optimum moisture content and degree of compaction shall be got approved by the Engineer. While laying, in the main work, the rolled concrete shall have a moisture content between die optimum and optimum + 2 per cent,

keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

603.3.3. Cement content: The minimum cement content in the rolled concrete shall not be less than 150 kg/cu.m. of concrete. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary without additional compensation under the Contract.

603.3.4. Concrete strength: The flexural strength as specified shall be the governing criteria for approval of the mix. While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of tests^ on samples for use at a later date to verify the in situ flexural strength of rolled concrete through testing of cores.

At least a batch of two beam and cube specimens, one each for 3 day and 7 day strength testing shall be cast for every 100 cum or part thereof of concrete placed during construction. On each day's work not less than four beams and four cubes shall be made.

A ratio between the 3 and 7 day strengths shall be established for the mix to be used. This will help in assessing the fall in strength, if any in advance so that corrective action can be taken for the future work.

603.4. Subgrade

The subgrade shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these Specifications and the Specification stipulated in the Contract. The rolled concrete base shall not be laid on a subgrade softened by rain after its final preparation; any surface trenches, soft spots etc., must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise the loose surface. If the Engineer feels it necessary, another fine spray of water may be applied just before placing she base course.

603.5. Construction

Clause 601,5 shall apply.

603.6. Trial Mix

Using the specified cement content and proportioned aggregates, the Contractor shall make trial mixes at water contents ranging from 5 per cent to 7 per cent by weight of dry materials at 0.5 per cent intervals using an aggregate /cement ratio of not greater than 15.0. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. The compaction of mould shall be done in three layers as explained in Clause 903.5.2.1, The optimum moisture content determined normally gives an indication about the moisture content which after minor adjustment may provide satisfactory mix which could be rolled.

After determining the moisture content from the above trial mix, a set of six beams and cubes shall be prepared for testing them on 3rd and 7th day. If the flexural strength achieved is lower than the desired strength, the above trial shall be repeated after increasing the cement content and adjusting the mix appropriately.

During the construction of trial length as per Clause 603.7 minor modifications may have to be carried out to the moisture content of the mix. But such modified mix shall have to satisfy the flexural strength requirement. Flexural strength to be achieved ""Shall be the governing criteria for the design -of mix.

603.7. Trial Length

Clause 601.7 shall apply.

603.8. Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the rolled concrete base after its construction. Light vehicles may be, however, allowed after 7 days of its construction with prior approval of the Engineer,

603.9. Tolerances for Surface Regularity, Level, Thickness and Strength

The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in Clause 903.5. Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

603.10. Measurements for Payment

The unit of measurement for concrete and rolled concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas

for the specified thickness shown on the drawings as directed by the Engineer.

603.11. Rate

The Contract unit rate payable for rolled cement concrete for base course shall be payment in full for carrying out the required operations including full compensation for all labour, materials and equipment, mixing, transport, placing, compacting, finishing, curing, testing and incidentals to complete the work as per Specifications, all royalties, fees, storage and rents where necessary and all leads and lifts.

_____

Geosynthetics

700

Geosynthetics and Reinforced Earth

701. GEOSYNTHETICS IN ROAD AND BRIDGE WORKS

701.1 Scope

This specification covers the various applications of Geosymhetic materials in road and bridge works including supplying and laying as per special provisions.

"Geosynihetic is a general classification for all synthetic materials used in geotechnical engineering application. It includes geotextiles, geogrids, geonets, geomembranes and geocomposites.

(i) **Geotextile:** Any permeable textile natural or Synthetic, used with foundation, soil, rock, earth, or any other geotechnical engineering related material. In the present chapter, it is related to synthetic material only.

(ii) **Geogrid: A** deformed or non-deformed grid of polymeric material used primarily for reinforcement purposes with foundation, soil, rock, earth, or any other geolechnical engineering related material.

(iii) **Geonets :** These are net made of polymeric material used for drainage of foundation, soil, rock, earth or any other geotechnical engineering related material.

(iv) **Geomembrane** : An essentially impermeable membrane of polymeric material used with foundation, soil, rock, earth or my olher geotechnical engineering related material, to control fluid migration.-

(v) **Geocompositt :** A manufactured material using geoiexliles, geogrids, geoneu and/ or geomembrane in laminated or composite form,"

701.2 Material Testing and Acceptance

Unless otherwise stated, these Geosynthetic materials shall conform to the requirements as under :

701.2.1. Geotextile : Geotextile shall be made of polyethylene or polypropylene or polyester or similar fibres, either woven or nonwoven in variety, through machine made process of heatbonding or needle punching or weaving techniques. These fabrics are required to pass water through but retain the soil particles, which require specific cross-plane permeability or permittivity and apparant opening size or equivalent opening size or 095. The above two requirements alongwith the requirement of strength and durability denote general characteristics of geotextiles to be used. The type of geotextile to be used in a particular application shall be decided on the basis of design.

701.2.2. Geogrid : Geogrid shall be made from integrally jointed, mono or bi-directionally orientated or stretched meshes made from poly ethylene or polypropylene or polyester or similar polymer, with high

secant modulus, in square, rectangular, hexagonal or oval mesh form. Their junction strength shall be high with high creep resistance, and dimensional stability. Their open structure shall permit effective interlocking with soil, aggregates, rock etc., they shall be used as a tensile member or reinforcement. Characteristics strength of such Geogrids varies from 40 kN/m to 200 kN/m peak strength at a maximum elongation of 15 per cent in the direction of the length of the roll.

701.2.3. Geonet : Geonet shall be made from a single extruded unoriented process from polyethylene or polypropylene or similar polymer. It shall have square or rectangular net shape aperture when used for protective works like gabions and mattresses. While in polygonal aperture it shall be used as a separator. It shall not be used as soil reinforcement due to its high creep characteristics, neither as a slope reinforcement or soil retaining wall or asphaltic reinforcement. Geonets used in protective works for highway structures shall be atleast 650 gm/ sq.m. in unit weight. It shall be black in colour, available in roll form in suitable width.

701.2.4. Geomembrane : Geometnbrane shall be made from PVC or polyethelene sheets of atleast 0.8 mm thickness, duly protected from ultra violet exposure with 2.5 per cent carbon black, in black colour, supplied in roll form with 3 m or above width. The joints of these sheets shall be heatbondeti or seamed for effective permeation cut off, at site using standard equipment as part of Ihe laying process. While fixing on to a slope, they shall not be punctured or stappled to impair their use.

701.2.5. Geocomposite : Geocomposites shall be made from combination of geonets, geogrids or geomembrancs of above description using heat bonded, seamed stitched or wrap techniques. Their principal use shall be to regulate drainage in cross-plane or in-plane directions. Minimum unit weight of such material shall conform to the special provisions or as per Contract drawing.

701.2.6. Testing and acceptance : Geosymhetics shall be tested in accordance with tests prescribed by BIS. In absence of IS Codes, tests prescribed either by ASTM or British Standards or International Standards Organisation, shall be conducted.

701.3 Application Areas

Some of the application areas for geotextiles and related materials and

their functions are given below in table 700-1,

Table 700-1. Applications and Functions of Geosynthctics

S. No.	Application Area	Geosynthetics Involved	Functions for Performance
1.	Embankments on soft soils	GT. GG	R, S
2.	Retaining walls	GG. GT	R
3.	Drainage and Filtration	GT	F, S
4.	Drain age- prefab, composite	GC, GN	D, F, S, B
5.	Erosion Control rip rap	GT	F, S
6.	Sediment control-sill fence	GT	B, R, S
7.	Asphalt overlay	GT. GC	B, R, S
	Note : GT = geotextile GG = geogrid GC = geocomposite GN = geonet	S = separation R = reinforcement F = filtration D = drainage B = barrier	

702. GEOTEXTILES IN SUB-SURFACE DRAINS

702.1. Scope

The work covers the use of geotextiles in subsurface drains, such as fin drains or narrow, filter drains. The fin drain shall mean a planar geocomposite structure designed to perform the same function as a narrow filler drain. The work shall be carried out as per design drawings,

702.2. Materials

702.2.1. The geotextile fabric shall be a woven or non-woven fabric consisting of long-chain polymeric filaments or yams 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,

702.2.2. The geosynthetic material of which the drain is made shall be treated with carbon black so that they are protected from the deleterious effects of short term exposure to ultraviolet light, and shall be resistant to degradation by acid, alkalis, common chemicals, bacteria, fungi and moulds occurring in soils and highway construction materials, in case of exposure to ultraviolet light, the Engineer may require evidence that the geosynthetic material still complies with the requirements of this Clause. Where necessary, the side intended for entry of water and direction of m-plane flow shall be identified.

702.2.3. The geotextile shall :

(a) Sustain a load of not less than 10 kN/rn at break and have *3* minimum Failure strain

of 10 per cent when determined in accordance with BS;6906 (Part 1) or shall have a grab tensile strength more than 0,4 kN/m and grab elongation corresponding to this limit in accordance with ASTM D 4632.

(b) The Apparent opening size, shall satisfy the following :

(i) Soil with 50 per cent or less particles by weight passing IS sieve 75 microns, apparent opening size less than 0.6 mm.

(ii) Soil more than 50 per cent particles by weight passing IS sieve 75 microns, apparent opening size less than 0.927 mm.

The test should he as per TF 25 # 6

(c) allow water lo flow through it at right angles to its principal plane, in either direction at a rate of not less than 10 litres/ml/sec, under a constant head of water of 100 mm, determined in accordance with BS:6906 (Part 3) or ASTM D 4491 or as slated in the design drawing. The flow rate determined in the lest shall be corrected lo that applicable to a temperature of 15°C using published data on variation in viscosity of water with temperature.

(d) have a minimum puncture resistance of 200 N when determined in accordance with DS:6906 (Part 4) or ASTM D 4833

(e) have a minimum tear resistance of 150 N when determined in accordance with ASTM Standard D 4533.

702.2.4. The composite drain shall have a flow rate through each face of the drain of more than 75 per cent of the value specified in sub-Clause 702.2.3 (c), determined by direct measurement of the composite drain using BS:6906 (Part 3). The composite drain shall have values of long-term in-plane flow rates as stated in the design drawing.

702.3. Installation

702.3.1. The installation of fin drains shall be as per the design drawings. Where fin drains are assembled on site, the assembly area shall be clean and dry and free of any wind-borne pollutants. No geotextile or core material shall be exposed to daylight (or any source of ultraviolet radiation) for a period exceeding a cumulative total of 50 hours. Where fin drains are laid in trench, the bottom of the trench shall be free of irregularities and shall be brought to the required level. Rock and other hard protrusions shall be removed and any excess cut in the trench bottom tilled and compacted back to the required grade with suitable excavated or imported material as directed by the Engineer. Fin drains shall be capable of being jointed longitudinally or laterally into pipe systems or chambers for inflow and outflow purposes. Joints parallel to the direction of flow and any exposed edged shall be protected from the ingress of soil by a geotextile wrapping with a minimum overlap of 150 mm or other measures as agreed by the Engineer.

702.4. Narrow filter drains consisting of a porous or perforated pipe

laid in a narrow trench surrounded by a layer of geotextile filter shall have the same properties of geotextile as specified in Clause 702.2. The spicing of lengths of geotextile and minimum overlap shall be as per the design drawing or as approved by the Engineer. Such drains shall be installed as per the design drawing to Clauses 702.3 and 309.3.5.

702.5. Measurements for Payment

Measurement for fin drain/narrow filter drains shall be per running metre length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cu.m.

702.6. Rates

The Contract unit rates for subsurface drains shall be payment in full for all items such as excavation, dressing the sides and bottom, providing geotextile composites, laying and jointing pipes etc. including full compensation for alt materials, labour, tools, equipment incidental to complete the work as shown on drawings with all leads and lifts except for removal of unsuitable material for which the lead shall be 1000 m. Provision of inlets, outlet pipes, bedding etc., wherever required shall be incidental to construction of drain. The Contract unit for disposal of surplus and unsuitable material beyond the initial 1000 m lead shall be in accordance with Clause 301.3.11.

703. REINFORCED EARTH

703.1. Scope

The work covers the construction of reinforced earth structures, together with the construction of earthwork in layers, assembly and erection of reinforcing elements and placement of facing panels and all associated components.

703.2. Reinforcing Element

703.2.1. The reinforcing clement shall be of Geotexiile, aluminium alloy strip, copper strip, carbon steel strip, mals of metal or synthetic grids, or any other proprietary material which may be approved by the Engineer and indicated on the drawings.

703.2.2. Geotextile : The material shall conform to Clause 701.2.6,

703.2.3. Aluminium alloy strip shall comply with BS:1470 quality 5454 in the H 24 condition.

703.2.4. Copper strip shall comply with BS:2870 quality C 101 or C 102 in the 1/2 H condition and shall have 0.2 per cent proof stress of not less than 580 N/mm^2.

703.2.5. Carbon steel strip which shall be galvanized shall comply with BS:1449 (Pan 1), either quality KHR 34/20 P or quality 50/35 P, each having a silicon content of not less than 0.25 per cent and not mo than 0.40 per cent. The fabricated element shall be galvanized accordance with BS:729, and the average zinc coating weight for any individual test area shall not be less than 1000 gm/sq.m.

703.2.6. Stainless steel strip shall comply with BS:1449 (Part 2 quality 316 S 31 or 3/6 S 33 except that the material shall be cold rolled to provide a 0.2 per cent proof stress of not less than 400 N/sq. mm and the tensile strength s hall not be les s than 540 N/sq. m.

703.2.7. All metallic components buried in soil shall be of electrolytically compatible materials.

703.2.8. Geogrids : The supply of geogrids shall carry a certification of BIS or ISO 9002 for all works. While the reinforcing element for wall or slope portion shall be with mono oriented Geogrid. the reinforcement for the foundation of a reinforced earth wall or slope shall be with bi-directionally oriented Geogrid. For mono oriented Geogrid. the characteristic design tensile strength at a strain not exceeding 10 per cent in 100 years shall be at least 40 kN/m when measured as per GRI:GG3. The strength for bi-directionally oriented Geogrid in the longitudinal direction shall be at least 40 kN/m at a maximum elongation of 15 per cent. The Geogrid shall be inert to all naturally occurring chemicals, minerals and salts found in soil.

703.3. Earth Fill

The fill material for reinforced earth structures shall have an angle of interface friction between the compacted fill and the reinforcing element of not less than 25°C, measured in accordance with IS:13326 (Part 1). The soil should be predominantly coarse grained; not more than 10 per cent of the particles shall pass 75 micron sieve. The soil should have properties such that the salts in the soil should not react chemically or electrically with the reinforcing elements in an adverse manner.

703.4. Facia Material

703.4.1. The facing shall comprise of one of the following:

(i) Reinforced concrete (Cast in situ or precast) slabs:
(ii) Plain cement concrete form fill bellow block (Precast).
(iii) Masonry construction,.Rubble facia
(iv) Other proprietary and patented proven system.

The facing shall be sufficiently flexible to withstand any deformation of the fill.

703.4.2. Facia unit joint filler should be durable, resistant to the effect of air pollution and water/saline water.

703.4.3. Bedding material shall consist of either cement mortar or a durable gasket sealing such as resin bonded cork strip.

703.4.4. Connection between the facia and the reinforcing clement shall be by using polyethylene strips/rods, fibre glass dowels or any other material shown in the drawing. Any other material used shall be tested to provide 100 per cent joint strength as of parent element in continuity,

Overlapping in principal reinforcement or in the joint shall ensure load transfer through joints, perpendicular to the direction of laying.

703.5. Construction Details

703.5.1. The plan area of the reinforced earth structure shall be excavated to provide a nominally level base which may be stepped at the back as required to receive the horizontal reinforcing element grid,

The depth of the foundation below the finished ground level at the foot of the slope or wall shall not be less than 1000 mm.

Additional strip footing, trough guide made of concrete or anchor key pad shall be provided at founding level to receive the facia or the bottom most reinforcement connection. This shall have adequate soil cover against erosion and scour in particular cases.

703.5.2. Orientation : The reinforcing elements shall be placed at right angles to the face of the wall, with greater cross sectional dimension in the horizontal plane. The placement of the elements including their vertical/horizontal spacing and length shall be as in the drawing,

703.5.3. Facing batter : It may be necessary to set facing unit at an additional batter than as provided in the drawing *as* 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 rectify this phenomenon.

703.5.4. Drainage : Drainage shall be provided as per drawing given in detail. The retained fill shall have a suitably designed drainage bay to allow free draining of the reinforced fill.

703.5.5. Laying and compacting : The reinforcing elements shall be laid free from all kinks, damage and displacement during deposition, speading, levelling and compaction of the fill. The programme of filling shall be such that no construction plant runs directly on the reinforcement.

All construction plant having a mass exceeding 1000 Kg shall be kept at least 1.5 m away from the face of slope or wall. In this area (upto 1.5 m from the face of slope or wall), following compaction plant shall be used :

(i) Vibratory roller having a weight per metre width of roll not exceeding 1300 kg. with total weight not exceeding 10,000 kg.

(ii) Vibratory plate compactor of maximum weight 1000 kg.

(iii) Vibro tamper having a weight not exceeding 75- kg.

Compaction by any other method like using dozer or back blade compaction by dozer or excavator bucket shall be permitted with due approval from the Engineer after ascertaining the level of compaction so achieved.

During construction of reinforced fill, the retained material beyond the reinforcement at the rear or the structure shall be maintained at the same level as reinforced fill.

The compacted layer shall not be more than 200 mm, to achieve compaction of 95 per cent of maximum laboratory density where measured as per IS : 2720 (Part 8). Temporary formwork shall be used to support the construction as per specified details given in the drawing. The forms, scaffolding and props shall be sufficient in numbers to allow taking up of a sectoral construction schedule specified in the design.

703.6. Measurements for Payment

Measurement for reinforcing elements shall be in linear metre for anchor strips or in sq.m. for geogrid/geotextile etc.

The measurement for facia shall be in sq. metres. The measurement for foundation for facia and capping beam shall be in linear metres. Measurement for compacted earthfill shall be in cubic metres for compacted soil.

703.7. Rates

Rate shall include cost of labour, plant hire, material storage and handling expenses, for completing the works,

Rate for providing reinforcing elements shall include material cost, all

transportation costs and storage of the same as per special provisions. The rate shall also include cost of laying of the reinforcing elements including all overlaps, jointing or stitching, heat bonding or extension.

Rate for facia fixing shall include cost of joints, all necessary temporary formwork, scaffolding and all lifts and leads, if any, as shown in the drawing, unless otherwise specified to the treated separately along with foundation or slope/wall kerb at the top of slope or wall. Rate for bed block and capping beam shall include all items of excavation, concrete, reinforcing steel, formwork, labour and equipment.

Rate for soil fill shall include compaction as desired in requisite layers through mechanical means, cost of hire or labour for plant operations, dressing and levelling slopes, including special measures for edge reinforcements as shown in the drawing.

704. GEOSYNTHETICS FOR HIGHWAY PAVEMENTS

704.1. Scope

This work shall consist of laying geosynthctic materials over existing bituminous surface, including preparation of surface and joining, stitching or overlapping of geosynthetic fabric etc., as pan of highway pavement strengthening in layers as shown on drawings.

704.2. Paving Fabrics

704.2.1. Description : This work shall consist of furnishing and placing as asphalt/bitumen overlay textile (paving fabric) beneath a pavement overlay or between pavement layers to provide a water resistant

704.3. Material Requirements

704.3.1. Paving fabric : The paving fabric will be a nonwoven heat set material consisting of at least *85* per cent by weight 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 of Table 704-2. Heavy duty paving fabrics should be used in areas experiencing unusually high impact forces or heavy loads such as airport runways and taxiways :

Table 704.2. Physical Requirements-Paving Fabrics

Property	Units	Standard Requirements	Test Method
Tensile Strength	Kg	36.3 50	ASTM 13 4632
Elongation Asphalt	% Kg/10 sq.m.	 10	ASTM D 4632
Retention			Texas DOT 3<m
Melting Point	℃	150	ASTM D 276
Surface Tenure	—	Heal bonded on one side only	Visual Inspection

Notes:

1 Certification of conformance from paving fabric manufacturer may he required.

2 All numerical values represent minimum average roll values (average of test results from any sampled roll in a lot shall meet or exceed the minimum values) in weaker principal direction. Lot shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing".

3. Conformance of paving fabrics to specification property requirements shall he determined as per ASTM D <l75Ui.--"Practice for Determining the Specification Conformance of Geosynthetics

704.3.2. Tack Coat: The tack coat/used to impregnate the fabric and bond the fabric to the pavement shall be a paving grade Bitumen of 80-100 penetration. A cationic or anionic Emulsion may be used as approved by the engineer. The use of cutbacks of emulsions which contain solvents shall not be used.

704.4. Construction and Installation Requirements

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

704.4.2. Weather limitations : Minimum air and pavement temperature shall be at least 10°C and rising for placement of bitumen and shall be at least 15℃ and rising for placement bitumen emulsion. Neither bitumen tack coat nor paving fabric shall be placed when weather conditions, in the opinion of the engineer, arc not suitable.

704.4.3. Surface preparation : The pavement surface shall be thoroughly cleaned of all dirt, water, and oil to the satisfaction of the engineer. Cracks 3 mm wide or greater shall be cleaned and filled with suitable bituminous material or by a method approved by the engineer. Crack filling material shall be allowed to cure prior to paving fabric placement. Potholes and other pavement distress shall be repaired. Repairs shall be performed as directed by the engineer.

704.4.4. Tack coat application : The tack coat shall be spread by means of a calibrated distributor spray *bar.* Hand spraying and brush application may be used in locations of fabric overlap. Every effort shall be made to keep hand spraying to a minimum. The tack coal shall be applied, uniformly to the prepared dry pavement surface at the rate of 1 kg/sq.m. or as recommended by the paving fabric manufacturer and approved by the engineer. When using emulsions, the application rate must be increased as directed by the engineer to offset the water content of the emulsion. Within street intersections, on steep grades, or in other zones where vehicle speed changes are common place, the normal application rate shall be reduced by about 20 per cent as directed by the engineer. The lack coat application rate must be sufficient to saturate the fabric and to bond the fabric to the existing pavement surface.

The temperature of the lack coat/shall be sufficiently high to permit a uniform spray pattern. For bitumen the minimum temperature shall be 140°C. To avoid damage to the fabric, distributor tank temperatures shall not exceed I60°C, For bitumen emulsions, the distributor tank temperatures shall be maintained between 55°C and 70°C.

The target width of tack coal application shall be equal to the paving fabric width plus 150 mm. The tack coat shall be applied only as far in advance of paving fabric installation as is appropriate to ensure a tacky surface at the time of paving fabric placement. Traffic shall not be allowed on the tack coat. Excess tack coat shall be cleaned from the pavement.

704.4.5. Paving fabric placement: The paving fabric shall be placed onto the tack coal using mechanical or manual laydown equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. The paving fabric shall be placed prior to the tack coat cooling and losing tackiness. Paving fabric shall not be installed in areas where the overlay asphalt 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 essentially no water moisture remains prior to placing the paving fabric. Wrinkles or folds in excess of 25 mm shall be slit and laid flat. All transverse joints and slit folds or wrinkles shall be shingle-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 with paving fabrics placed will 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 shingled - 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.

704.4.6. Overlay placement : Bituminous overlay construction shall closely follow fabric placement. All areas in which paving fabric[1] has been placed will be paved during the same day. Excess tack coat which bleeds through the paving fabric shall be removed. Excess tack coat can be removed by broadcasting hot mix or sand on the paving fabric.

705. PROTECTION WORKS WITH GEOSYNTHETICS

705.1. Scope

This work shall consist of laying boulder Gabions/Mattresses in wraps of Geosynthctics in the form of bolsters, on slopes of embankments or in apron. Gabions or Mattresses are also used for stone spurs. Geotcxtifes are used for prevention of migration of fine soil particles.

705.2. Gabions/Mattresses with Geogrids and Geonets

Mattresses constructed with Geogrids or Geonets shall be used for thickness of 300 mm or above as shown in the drawings. While adopting a particular size for gabions or mattresses width of the roll of geogrid/ geonet may be kept in view to minimise wastage of the geosyntheiic in cutting off pieces. The mesh opening may very depending on functional requirement but shall have aperture between 35 mm and 100 mm. The

mesh/net shall have following characteristics"':

Aperture	:	Rectangular, square or oval shaped (and not in diamond, round or polygonal shape).
Colour	:	Black
Mechanical Properties	:	Peak strength not less than 10 kN/m at maximum elongation of 15 per cent. Not more than 5 per cent elongation at half peak load.
Stands/Fabric Form	:	Integral joints with junction strength of 100 per cent of plain strands as measured by[1] GRI-GG3 standards. Material shall have ISO 9002 certification,'
Life	:	Atleast 8 years in case of continuous exposure and 5 years for burned applications (defined as capable of retaining atleast 75 per cent of its origin*! strength after the life span slated.

705.3. Construction

705.3.1. Assembly : Gabion and mattress boxes shall be assembled in situ, on a level surface. After fabrication is done in situ they shall be correctly filled in layers in dense packed state.

The bottom, sides and end panels shall be erected after removal of all kinks, kept in an upright position to form rectangular boxes by joining the sides with connectors of 40 mm x 6 mm size, or by ring staples. The top corners shall be tie tensioned from sides to keep it erect for filling. For gabions of 600 mm or more height, suitable cross internal ties shall be placed in layers of 300 mm connecting opposite sides in lateral braces tied with polymer braids of ultra-violet stabilised variety so as to ensure protection against bulging of the gabions during filling with stones.

705.3.2. Construction and installation : The filling of the gabion/ mattress shall be done by hand in layers so as to minimise viods and achieve specified density. The stones in contact with the surface of the geogrids/geonets shall be placed in such a way that their sharp edges are kept turned inside so that they do not damage the material of the geogrids/ geonets. The opposite panels of the boxes shall be firmly secured with lateral ties to withstand the design forces. The bottom of the gabion mesh shall be secured in a key type excavation for preventing slide. The space between the gabion and earthen sides shall be filled with sand and the filling compacted. In most of the cases design shall be supplemented with a layer of geotextile under the gabion/mattress to prevent migration of fines.

705.3.3. Laying boulder apron in crates ; Mattresses of minimum height 300 mm shall be used. The typical size of a single continuous unit shall be 1 m x 5 m size with baffles at 1 m centres. The size of boulders shall be at least 100 mm or double the size of the aperture whichever is

larger. The density of boulder filling shall be as stated in me drawing and the specific gravity of stones not less than 2.65. Methodology of laying boulders shall be as per Clause 2503.3. Gabions if placed in the apron shall be of size 1 m x 5 m in plan with height at least 600 mm, with baffles in 1 m centres.

Gabions or mattresses made with polymer geogrids/geonets shall always be laid in situ and shall not be performed, filled and transported to be dropped in deep waters. Where depth of water is low or dry bed is available, the boxes shall be filled in situ. In streams or water body having running boulders in the bed, the gabions/mattresses shall be armoured with placement of loose large boulders alongside the gabion wall to protect against impact hit of stray boulders.

Stakes or keying shall always be provided in the founding recess, where the gabion be located, especially in case the ground is assessed to be sloping or yielding type.

705.3.4. Groynes or spurs with crates : Groynes or spurs of gravity retaining variety shall be constructed using geogrid/geonet gabions placed in a stable configuration one over the other to form a well. They shall be filled in situ on a shallow depth of water or dry bed with firm founding and level strata. The provision of a layer of geotextile/geocomposiie shall be made while placing the structure if resting over a bed of fine soil to prevent passage of fines and sinking.

705.3.5. Measurements for payment : The fabric of geotextile/ geocompostte shall be measured in sq, metres of plan area of actual use (as per drawing).

The connecting rods or polymer braids shall be measured in metres. Ring staples shall be measured in number provided per linear metre.

The boulder fill shall be measured in cubic metres.

The excavation for keying of gabions in the ground trenches shall be measured in cubic metres.

The backfilling in side trenches shall be deemed part of the excavation work.

705.3.6. Rate : The cost of Geosynthetic material for fabrication of Gabions/Mattresses shall be all inclusive of supply, transportation and storage.

The contract rate per cubic metre of crate fill shall consist of cost of boulders and their transportation.

The contract rate for excavation and backfilling of trenches, seating trench upto 15 cm (included in rate), shall include cost of labour, tools and plant for completion of the work.

The cost of making a crate shall include preparation of box of geognd/geonet, tensioning and staking arrangements, tying, internal crossbraids, etc., for forming of the crates in an engineered manner and filling the crate by laying boulders. The cost shall include transportation of material from store to site.

Wherever composite system using Geosynthetics with natural material like stone revetment etc. shall be used, the provision of measurement and rate as per Clauses 2509 and 2510 are applicable.

800

Traffic Signs, Markings and Other Road Appurtenances

801. TRAFFIC SIGNS

801.1. General

801.1.1. The colour, configuration, size and location of all traffic signs for highways other than Expressways shall be in accordance with the Code of Practice for Road Signs, IRC: 67 or as shown on the drawings. For Expressways, the size of the signs, letters and their placement shall be as specified in the Contract drawings and relevant Specifications. In the absence of any details or for any missing details, the signs shall be provided as directed by the Engineer.

801.1.2. The signs shall be either reflectorised or non-reflectorised as shown on the drawings or as directed by the Engineer. When they are of reflectorised type, they shall be of retro-reflectorised type and made of encapsulated lens type reflective sheeting vide Clause 801.3, fixed over aluminium sheeting as per these Specifications.

801.1.3. In general, cautionary and mandatory signs shall be fabricated through process of screen printing. In regard to informatory signs with inscriptions, either the message could be printed over the reflective sheeting, or cut letters of non-reflective black sheeting used for the purpose which must be bonded well on the base sheeting as directed by the Engineer.

801.2. Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

801.2.1. Concrete : Concrete shall be of the grade shown on the Contract drawings or otherwise as directed by the Engineer.

801.2.2. Reinforcing steel : Reinforcing steel shall conform to the requirement of IS: 1786 unless otherwise shown on the drawing.

801.2.3. Bolts, nuts, washers: High strength bolts shall conform to IS : 1367 whereas precision bolts, nuts, etc., shall conform to IS: 1364.

801.2.4. Plates and supports : Plates and support sections for the sign posts shall conform to IS: 226 and IS: 2062 or any other relevant IS Specifications.

801.2.5. Aluminium: Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS : 736-Material designation 24345 or 1900.

801.2.6. Signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick. All others shall be at least 2 mm thick. 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 the prevailing wind and other loads.

801.2.7. In respect of sign sizes not covered by IRC67, the structural details (thickness, etc.) shall be as per the approved drawings.

801.3. Traffic Signs Having Retro-reflective Sheeting

801.3.1. General requirements: The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface. It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure facing the sun for two years and its having passed these tests shall be obtained from a reputed laboratory, by the manufacturer of the sheeting. The reflective sheeting shall be either of Engineering Grade material with enclosed lens or of High Intensity Grade with encapsulated lens. The type of the sheeting to be used would depend upon the type, functional hierarchy and importance of the road.

801.3.2. High intensity grade sheeting : This sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent water-proof plastic having a smooth surface. 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 Standard E : 810) as indicated in Table 800-1.

TABLE 800-1. ACCEPTABLE MINIMUM COEFFICIENT OK RETRO-REFLECTION FOR HIGH INTENSITY GRADE SHEETING (CANDELAS PER LUX PER SQUARE METRE)

Observation angle (in degrees)	Entrance Angle (in degrees)	White	Yellow	Orange	Green/ Red	Blue
0.2	- 4	250	170	100	45	20
0.2	+ 30	150	100	60	25	11
0.5	- *6*	*95*	62	30	15	73
0.5	+ 30	65	45	25	10	5.0

When totally wet, the sheeting shall not show less than 90 per cent of the values of retro-reflectance indicated in Table 800-1. At the end of 7 years, the sheeting shall retain at least 75 per cent of its original retro-reflectance.

801.3.3. Engineering grade sheeting : This sheeting shall be of enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. 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 Standard : E-830) as indicated in Table 800-2.

TABLE 800-2. ACCEPTABLE MINIMUM COEFFICIENT OF RETRO-REFLECTION FOR ENGINEERING GRADE SHEETING (CANDELAS PER LUX PER SQUARE MFJTRE)

Observation angle in degree	Entrance angle in degree	White	Yellow	Orange	Green	Red	Blue
0.2	- 4	70	50	25	9.0	14.5	4.0
0.2	+30	30	22	7.0	3.5	6.0	1.7
0.5	- 4	30	25	13.5	4.5	7.5	2.0
0.5	+30	15	13	4.0	2.2	3.0	0.8

When totally wet, the sheeting shall not show less than 90 per cent of the values, of retro-reflection indicated in Table 800-2. At the end of 5 years, the sheeting shall retain at least 50 per cent of its original retro-reflectance.

801.3.4. Messages/borders: The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut-outs. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. Cut-outs shall be of materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer.

801.3.5. For screen-printed transparent coloured areas on white sheeting, the co-efficient of retro-reflection shall not be less than 50 per cent of the values of corresponding colour in Tables 800-1 and 800-2, as applicable.

801.3.6. Cut-out messages and borders, wherever used, shall be made out of retro-reflective sheeting (as per Clause 801.3.2 or 801.3.3 as applicable), except those in black which shall be of non-reflective sheeting.

801.3.7. Colour: Unless otherwise specified, the general colour scheme shall be as stipulated in IS : 5 "Colour for Ready Mixed Paints", viz.

Blue	-	IS	Colour	No. 166: French Blue
Red	-	IS	Colour	No. 537: Signal Red
Green	-	IS	Colour	No. 284: India Green
Orange.	-	IS	Colour	No. 591: Deep Orange.

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

801.3.8. Adhesives : The sheeting shall either have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface, or a lack free adhesive activated by heat, applied in a heat-vacuum applicator, 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. In case of pressure-sensitive adhesive sheeting, the sheeting shall be applied in accordance with the manufacturer's Specifications. Sheeting with adhesives requiring use of solvents or other preparation for adhesive shall be applied strictly in accordance with the manufacturer's instructions.

801.3.9. Refurbishment: Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

801.3.10. Fabrication :

801.3.10.1. 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.

801.3.10.2. 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. Sheeting with heat-activated adhesives may be spliced with an overlap not less than 5 mm or butted with a gap not exceeding 0.75 mm. Where screen printing with transparent colours is proposed, only butt jointing shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

801.3.11. Warranty and durability : The Contractor shall obtain from the manufacturer a seven-year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of high intensity grade and a five year warranty for the adhesive sheeting of engineering grade, and submit the same to the Engineer. In addition, a seven year and a five year warranty for satisfactory in-field performance of the finished sign with retro-reflective sheeting of high intensity grade and engineering grade respectively, inclusive-of the screen printed or cut out letters/legends arid their bonding to the retro-reflective sheeting shall be obtained from the Contractor/supplier and passed on to the Engineer, The Contractor/supplier shall also furnish a certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty.

Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discolouration, cracking, blistering or dimensional change and shall not have less than 50 per cent of the specified minimum reflective intensity values (Tables 800-1 and 800-2) when subjected to accelerated weathering for 1000 hours, using type E or EH Weatherometer (AASHTO Designation M 268).

801.4. Installation

801.4.1. Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind toads or displacement by vandalism. Normally, signs with an area upto 0.9 sq. m. shall be mounted on a single post, and for greater area two or more supports shall be provided. Sign supports may be of mild steel, reinforced concrete or galvanised iron (G.I). Post-

end(s) shall be firmly fixed to the ground by means of property designed foundation. The work of foundation shall conform to relevant Specifications as specified.

801.4.2. All components of signs and supports, other than the reflective portion and G.I. posts shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. Any part of mild steel (M.S.) post below ground shall be painted with three coats of red lead paint.

801.4.3. The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size in the case of reinforced concrete or G.I. posts. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

801.5. Measurements for Payment

The measurement of standard cautionary, mandatory and information signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

801.6. Rate

The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site and incidentals to complete the work in accordance with the Specifications.

802. OVERHEAD SIGNS

802.1. General

802.1.1. Overhead signs may be used in lieu of, or as an adjunct to, ground signs where the situation so warrants for proper information and guidance of the road user .The following conditions may be considered while deciding about the provision of overhead signs:

(1) Traffic volume at or near capacity

(2) Complex interchange design

(3) Three or more lines in each direction

(4) Restricted sight distance

(5) Closely spaced interchanges

(6) Multi-lane exits

(7) Large percentage of commercial vehicles

(8) High speed traffic

(9) Consistency of sign message location through a series of interchanges

(10) Insufficient space for ground mounted signs

(11) Background of street lighting

(12) Distances of important places enroute highways at suitable intervals,

802.1.2. From safety and aesthetic standpoints, overhead signs shall be mounted on overhead bridge structures wherever possible. Where these are required to be provided at some other locations, the support system should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m1 normal to the face of the sign and 30 kg/m1 transverse to the face of the sign. In addition to the dead load of the structure, walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.

802.2. Height

Overhead signs shall provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 300 mm in excess of the minimum design clearance of other structures.

802.3. Lateral Clearance

802.3.1. The minimum clearance outside the usable roadway shoulder for expressway signs mounted at the road side or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 1.80 m shall also apply outside of an uncountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lane. Large guide signs should be farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified. Lesser clearances, but not generally less than 1.80m, may be used on connecting roadways or ramps at inter-changes.

802.3.2. Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimise the impact forces or protect motorists adequately by a physical barrier or guard rail of suitable design.

802.4. Number of Signs at an Overhead Installation

In no case should there be more than three signs displayed at any one location. including regulatory or warning signs, either on the on the over head structure or on its support.

802.5. Materials for Overhead Sign and Support Structure

802.5.1. Aluminium alloy or galvanized steel to be used as truss design supports shall conform to relevant IS. These shall be of sections and type as per structural design requirements as shown on the plans.

802.5.2. After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss unites and the vertical and support units, they shall be galvanized in accordance with IS Specifications.

802.5.3. Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS 736. Material Designation 24345 or 1900. The thickness of sheet as 1.5mm.

802.5.4. High Strength bolts shall conform to IS: 1367 whereas precision bolts, nuts etc, shall conform to IS: 1364.

802.5.5. Plates and support sections for sign posts shall conform to IS: 266 and IS: 2062.

802.5.6. The overhead signs shall be reflectorised with high intensity retro-reflective sheeting preferably of encapsulated lens type.

802.6. Size, Locations, etc. of Signs

802.6.1. The size of the signs, letters and their placements shall be as specified in the Contract Drawings and Specifications.

802.6.2. In the absence of details or for any missing details in the Contract documents, the signs shall be provided as directed by the Engineer.

802.7. Installation

802.7.1. The supporting structure and signs shall be fabricated and erected as per details given in the plans.

802.7.2. Sign posts, their foundations and sign mountings shall be as constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism.

802.7.3. The work of construction of foundation for sign supports including excavation and backfill, forms, steel reinforcement, concrete and its placement shall conform to the relevant Specifications given in these Specifications.

802.7.4. The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement.

802.7.5. Brackets shall be provided for mounting signs of the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degree from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the heights of the signs being supported.

802.7.6. Before erecting support structures, the bottom of each base plate shall he protected with an approved material which will adequately prevent any harmful reaction between the plate and the concrete.

802.7.7. The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall he completely filled with an anti-shrink grout.

802.7.8. Anchor bolts for sign supports shall be set to proper locations and elevation with templates arid carefully checked after construction of the sign foundation arid before the concrete has set.

802.7.9. All nuts on aluminium trusses, except those used on the flanges, shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut.

802.7.10. All nuts o galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition.

802.7.11. Field welding shall not be permitted.

802.7.12. After installation of signs is complete, the sign shall be inspected by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor to eliminate or minimize this condition.

802.8. Measurements for Payment

802.8.1. Aluminium or steel overhead sign structure will be measured for payment by the specific unit (each) complete in place or for each

component of the overhead sign structure as indicated in the Bill of Quantities and the detailed drawing(s).

802.8.2. Flat sheet aluminium signs with retro-reflective sheeting thereon shall be measured for payment by the square metre for each thickness, complete in place.

802.9. Rate

802.9.1. The structural steel part of the overhead sign shall be measured in tonnes while the sign board shall be measured in sq. m. Other items like excavation for foundation and concrete in foundation to be measured and paid in cu. m. separately. The Contract unit rate for overhead sign structure shall be payment in full compensation for furnishing all labour, materials, tools, equipment, excavation, fabrication and installation and all other incidental costs necessary to complete the work to the Specifications.

802.9.2. The Contract unit rate for aluminium sheet signs shall include the cost of making the sign including all materials and fixing the same in position and all other incidental costs necessary to complete the work to the Specifications.

803. ROAD MARKINGS

803.1. General

The colour, width and layout of road markings shall be in accordance with the Code of Practice for Road Markings with paints, IRC : 35, and as specified in the drawings or as directed by the Engineer.

803.2. Materials

Road markings shall be of ordinary road marking paint, hot applied thermoplastic compound, or reflectorised paint as specified in the item and the material shall meet the requirements as specified below.

803.3. Ordinary Road Marking Paint

803.3.1. Ordinary paint used for road marking shall conform to Grade I as per IS: 164.

803.3.2. The road marking shall preferably be laid with appropriate road marking machinery.

803.3.3. Laying thickness of road marking paint shall be as specified by the Engineer.

803.4. Hot Applied Thermoplastic Road Marking

803.4.1. General :

(i) The work under this section consists of marking traffic stripes using a thermoplastic compound meeting the requirements specified herein.

(ii) The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic,

(iii) The colour of the compound shall be white or yellow (IS colour No. 556) as specified in the drawings or as directed by the Engineer.

(iv) Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

803.4.2. Thermoplastic Material

803.4.2.1. General : The thermoplastic material shall be homo geneously composed of aggregate, pigment, resins and glass reflectorizmg beads.

803.4.2.2. Requirements :

(i) Composition : The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 800-3.

TABLE 800-3. PROPORTIONS OF CONSTITUENTS OF MARKING MATERIAL (Percentage by weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-40	30-40
Titanium Dioxide	10.0 min.	—
Calcium Carbonate and Inert Fillers	42.0 max.	See Note
Yellow Pigments	—	

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

(i) **Properties:** The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3 262-(Part 1), shall be as below:

(a) Luminance :

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

Yellow: Daylight luminance at 45 degrees-45 per cent min. as per AASHTO M 249

(b) Drying time : When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set LO bear traffic in not more than 15 minutes.

(c) Skid resistance : not less than 45 as per BS 6044.

(d) Cracking resistance at low temperature : The material shall show i-o cracks on application to concrete blocks.

(e) Softening point : 102.5 ± 9,5° C as per ASTM D 36.

(f) How resistance : Not more than 25 per cent as per AASHTO M 249.

(g) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

(iii) Storage life : The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted panicles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/ supplier/Contractor.

(iv) Reflectorisation : Shall be achieved by incorporation of beads, the grading and other properties of the beads shall be as specified in Clause 803.4.3.

(v) Marking : Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:

1. The name, trade mark or other means of identification of manufacturer
2. Batch number
3. Date of manufacture
4. Colour (white or yellow)
5. Maximum application temperature and maximum safe heating temperature.

(vi) Sampling and testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification,

803.4.3. Reflectorising glass beads

803.4.3.1. General : This Specification covers two types of glass beads 10 be used for the production of reflectorised pave ment markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-3 and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6,3.

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

These shall conform to the requirements spelt out in Clause 803.4.3.3,

803.4.3.3. Specific requirements

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

GRADATION REQUIREMENTS FOR GLASS BEADS

Sieve size	Per cent retained	
	Type 1	Type 2
1.18 mm	0 to 3	
850 micron	5 to 20	0 to 5
600 -do-	-	5 to 20
425 -do-	65 to 95	-
300 -do-	-	30 to *75*
ISO -do-	0 to 10	10 to 30
below 180 micron	-	0 to 15

B. Roundness: The glass beads shall have a minimum of 70 per cent true spheres.

C. Refractive index: The glass beads shall have a minimum refractive index of 1.50.

D. Free flowing properties : The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

803.4.3.4. Test methods: The specific requirements shall be tested with the following methods:

(i) Free-flow test- Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter desiccator which is filled within 25 mm of the lop of a desiccator plate with sulphuric acid water solution { specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 20 lo 29 degree C. Remove sample from desiccator, transfer beads to a pan aid inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stern and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be essentially free of lumps and clusters and shall flow freely through the funnel.

(ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per B3 6088 and BS 3262 (Part I).

(iii) The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing

results of all tests specified herein mid shall certify that the material meets all requirement of this Specification. However, if so required, these tests may be carried out as directed by the Engineer.

803.4.4. Application properties of thermoplastic material

803.4.4.1. The thermoplastic material shall readily get screeded/ extruded at temperatures specified by the manufacturers for respective method of application to produce a tine of specified thickness which shall be continuous and uniform in shape having clear and sharp edges. 803.4.4.2. The material upon heating to application temperatures, shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

803.4.5. Preparation:

(i) The material shall be melted in accordance with the manufacturer's instructions in a healer filled with a mechanical stirrer to give a smooth consistency to the thermoplastic material lo avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed lo 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 lo prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

(ii) After transfer lo the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

803.4.6. Properties of finished road marking :

(a) The stripe shall not be slippery when wet.

(b) The marking shall not lift from the pavement in freezing weather.

(c) After application and proper drying, the stripe shall show no appreciable deformation or discolouration under traffic and under road temperatures upto 60°C.

(d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil drippings from traffic.

(e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.

(f) The colour of yellow marking shall conform 10 IS Colour No. 356 as given in IS: 164.

803.5. Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirement of Clause 803.4,3.

803.6. Application

803.6.1. Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

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

803.6.3. The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

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

803.6.5. The finished lines shall be free from ruggedncss 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

803.7. Measurements for Payment

803.7.1. The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any).

803.7.2. In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

803.8. Rate

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

804. HECTOMETRE/KILOMETRE STONES

804.1. General

The work covers the supply, painting, lettering and fixing of distance measurement stones and shall include:

(i) Heciometre siones

(ii) Kilometre stones

(iii) 5th Kilometre siones

804.2. The dimensions of the stones and the size, colour, arrangement of letters and script shall be as per IRC : 26 "Type Designs for 200 Metre Stones" and IRC: 8 "Type Designs for Highway Kilometre Stones",

804.3. The hectometre/kilometre stones may be made of local stones, concrete or any other material available locally and approved by the Engineer. The stones shall be bedded into the ground with adequate foundations as indicated in the drawings or in the relevant I.R.C. Specifications or as directed by the Engineer. The orientation and location of the stones shall be as indicated in the drawings or in the relevant I.R.C. Specifications or as directed by the Engineer.

804.4. Measurements for Payment

The measurement will be in numbers of 200 metre, kilometre and 5th kilometre stones fixed at site.

804.5. Rate

The Contract unit rate for hectorneu-e/kilornetrc/5ih kilometre stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment and making the stones, painting and lettering and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

805.1. General

The work covers supplying and fixing roadway indicators, hazard markers and object markers.

805.2. The design, materials to be used and the location of the road delineators shall conform to Recommended Practice for Road Delineators, IRC: 79, and to relevant drawings or as otherwise directed by the Engineer.

805.3. Measurements for **Payment**

The measurement shall be made in numbers of delineators fixed at site.

805.4. Rate

The Contract unit rate for Road Delineators shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing at site and all oilier incidental costs necessary to complete the work to these Specifications.

806. BOUNDARY STONKS

806.1. General

The work comprises of supplying and fixing boundary stones as per designs and Specifications given in IRC: 25 "Type Designs for Boundary Stones" and at locations indicated in the drawings or-as directed by the Engineer.

806.2. Measurements for Payment

The measurement shall be made in numbers of boundai y stones 1'ixeu at site.

806.3. Rate

The Contract unit rate for boundary stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing and all other incidental costs necessary to complete the work to these Specifications.

807. FENCING

807.1. General

The work comprises of fixing Mild Steel (M.S.) posts and providing barbed wire fencing including necessary stays and entry gates as shown in the drawing (s) and as directed by the Engineer.

807.2. The M.S. posts shall conform to IS:226 and shall be of angle iron of size indicated in the drawings. The angle iron shall be embedded in concrete to a sufficient depth below ground as indicated in the drawings. The steel shall be fabricated and painted to conform to Section 1900 of these Specifications,

807.3. The barbed wire shall be of galvanised iron and shall conform to 15:278.

807.4. Entry gate(s) shall be made of M.S. rods or other metal as per the design shown in the drawing(s).

807.5. Measurements for Payment

The measurement shall be in running metre of fencing including the entry gates.

807.6. Rate

The Contract unit rate for fencing shall be payment in full compensation for furnishing all labour, materials, tools, equipment for fabrication and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

808. TUBULAR STEEL RAILING

808.1. General

The work shall consist of supplying, fixing and erecting tubular steel railings as shown on the drawings and as directed by the Engineer.

808.2. The railings shall be of tubular steel in conformance to IS:1239. The fabrication and painting except for the final coat shall be completed before despatch to the site. Prior to the painting, all surfaces shall be grit blasted to the satisfaction of the Engineer and pickled. The priming coat of paint shall be applied as soon as the steel has dried,

808.3. The posts shall be vertical and of the type as shown in the drawing with a tolerance not exceeding 6 mm in a length of 3 m. The railing shall be erected true to line and grade.

808.4. Measurements for Payment

The railing shall be measured in linear metre from end to end along the face of the railing, including end and intermediate posts, with no deductions for gaps as shown on the drawings.

808.5. Rate

The Contract unit rate for Tubular Steel Railing shall be payment

in full compensation for furnishing alllabour, materials, tools, equipment and plant required for fabrication, connection, oiling, painting, temporary erection, inspection, test and final erection at site and a!l other incidental costs necessary to complete the work to these Specifications.

809. CONCRETE CRASH BARRIER

809.1. General

809.1.1. This work shall consist of construction, provision and installation of concrete crash barrier at the edges of the road and median at locations and of dimensions as shown on the drawings or as directed by the Engineer.

809.1.2. Concrete barrier shall generally be located on approaches to bridge structures, at locations where the embankment height is more than 3 metres and at horizontal curves,

809.2. Materials

809.2.1. All materials shall conform to Section 1000-Materials for Structures as applicable, and relevant Clauses in Section 1600 shall govern the steel reinforcement. The concrete barriers shall be constructed either 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 "extrusio n or slip form" method is adopted, full details of the method and literature shall be furnished.

809.2.2. Concrete barriers shall be constructed with M'20 grade concrete and with High Yield Strength deformed reinforcement conforming to IRC: 21.

809.2.3. An expansion joint with pre-moulded asphalt filler board shall be provided at the junction 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.

809.3. Construction Operations

809.3.1. The location of crash barrier shall be strictly adhered to as shown on the drawing and as directed by the Engineer. Concrete crash barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the plans or as ordered by the Engineer and shall be free of lumps, sags or other irregularities. The top and exposed faces of the barriers shall conform to the specified tolerances, as defined in Clause 809.4, when tested with 3 m straight edge, laid on the surface.

809.3.2. When concrete barriers are to be constructed on recently completed bridges, the height of the barriers shall be adjusted to compensate for die camber and dead load deflection of the superstructure. The amount of adjustment shall be determined by the Engineer and shall be ordered before the concrete is placed. Such barriers shall be placed after form work has been released and as long after the superstructure construction as possible without hampering the progress of the work.

809.3.3. Backfilling to the concrete barriers shall be compacted in layers to the compaction of the surrounding earthwork.

809.4. 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 die plans above the edge of the nearest adjacent carriageway or shoulder, within a tolerance of ± 30 mm.

809.5. Measurements for Payment

All barriers will be measured by linear metres of completed and accepted length \n place, corresponding end to end along the face of concrete barriers including approach and departure ends.

809.6. Rate

The Contract unit rate shall include full compensation for furnishing all labour, materials, tools, equipment and incidental costs necessary for doing all the work involved in constructing the concrete barrier complete in place in all respects as per these Specifications.

810. METAL BEAM CRASH BARRIER

810.1. General

810.1.1. This work shall consist of furnishing and erection of metal beam crash barrier of dimensions and at locations as shown on the drawing (s) or as directed by the Engineer,

810.1.2. Metal beam crash barrier shall generally be located on approaches to bridge structures, at locations where the embankment height is more than 3 metres and at horizontal curves,

810.2. Materials

810.2.1. Metal beam rail shall be corrugated sheet steel beams of

the class, type, section and thickness indicated on the plans. Railing posts shall be made of steel of the section, weight and length as shown on the plans. All complete steel rail elements, terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised. All elements of the railing shall be free from abrasions, rough or sharp edges and shall not be kinked, twisted or bent.

810.2.2. Steel beam elements and terminal sections shall be galvanised (zinc coated, 0.55 kg per square metre, minimum single spot) unless otherwise specified. The galvanising on all other steel parts shall conform tp 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.

810.2.3. Concrete for bedding and anchor assembly shall conform to Section 1700 of these Specifications.

810.3. Construction Operations

810.3.1. 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 ens ure proper matching at abutting joints arid 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.

810.3.2. 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 galvanised. Any part of assembly below ground shall be painted with three coats of red lead paint.

810.3.3. 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.

810.4. Installation of Posts

810.4.1. 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.

810.4.2. All post holes that are dug or drilled shall be of such size s will permit proper setting of the posts and allow sufficient room or backfilling and lapping.

810.4.3. 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 tamp are completed, the posts or anchors shall be held securely in place.

810.4.4. Post holes that are drilled in rock and holes for anchor posts shall be back filled with concrete.

810.4.5. Posts for metal beam guardrails on bridges shall be ed to the structure as detailed on the plans. The anchor bolts shall be set to proper location and elevation with templates and carefully checked.

810.5. Erection

810.5.1. All guardrail anchors shall be set and attachments made rand placed as indicated on the plans or as directed by the Engineer.

810.5.2. 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 atleast 6 mm through and beyond the full nut, except which such extensions might interfere with or endanger traffic in which case the bolts shall be cut off flush with the nut.

810.5.3. All railings shall be erected, drawn and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

810.6. Tolerance

The posts shall be vertical with a tolerance not exceeding 6 mm in a length of 3 metre. The railing barrier shall be erected true to line and grade.

810.7. Measurements for Payment

810.7.1. Metal beam railing barriers will be measured by linear metre of completed length as per plans and accepted in place. Terminals/ anchors of various types shall be paid for by numbers.

810.7.2. No measurement for payment shall be made for projections or anchors beyond the end posts except as noted above. Furnishing and placing anchor bolts and/or devices for guard rail posts on bridges shall be Considered incidental to the construction and the costs thereof shall be included in the price for other items of construction.

810.7.3. No measurement for payment will be made for excavation or backfilling performed in connection with this construction.

810.8. Rate

The Contract unit rate shall include full compensation for furnishing

of labour, materials, tools, equipments and incidental costs necessary for doing all the work involved in constructing the metal beam rating barrier complete in place in all respects as per these Specifications.

811. ROAD TRAFFIC SIGNALS

811.1. General

The traffic signal, its configuration, size and location shall be in accordance with IRC: 93 and IS: 7537 and as shown in the drawings or as directed by the Engineer. Prior to installation of signals, the Contractor shall submit to the Engineer, for approval, detailed proposals showing the signal type, sizes, paint and structural details of the signal posts including control system.

811.2. The traffic signals shall have a complete electronic mechanism for controlling the operation of traffic with an auxiliary manual controller. The time plan of signals shall be as per drawing and shall be modified as directed by the Engineer.

811.3. Materials

The various materials and fabrication thereof shall conform to the following:

811.3.1. Signal foundation: The signal foundations shall be constructed as per Specifications given in Clause 13 of IRC : 93 or as shown in the drawings.

811.3.2. Constructional requirements: The constructional requirements for post, signal head assembly, signal head, optical system, lamp and holder, visor, post, supports for overhead mounted signals, equipment housing, locks, inter-connecting cables, earthing, mains termination, controller electrical components, etc., shall conform to IS: 7537 unless otherwise staled in IRC: 93. The post shall be painted and protected as per Clause 3.7. of IS: 7537.

811.3.3. Optical requirements: The shape of all signal lenses shall be circular and shall be of specified colour and size and as shown in the drawing. Quality of lenses, arrangement of lenses, illuminations, visibility and shielding of signals shall be as per relevant Clauses of IRC : 93 and 15:7537.

811.4. Tests

Tests shall be carried out on all components of traffic signal including tests on complete system for its performance as per relevant Clauses of IRC : 93 and IS: 7537.

811.5. Maintenance of Traffic Signals

It shall be the responsibility of the Contractor to provide for maintenance of the signal section system throughout the warranty period for at least five (5) years after installation and as per Clause 18 of IRC : 93.

811.6. Measurements for Payment

The measurement for traffic signalisation system shall be by unit for complete work as specified and as per drawing for complete road junction.

811.7. Rate

The Contract unit rate for the traffic signalisation system as a whole shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying, fixing at site, testing and maintenance throughout warranty period and all other incidental costs necessary to complete and maintain the work to these Specifications.

900

Quality Control for Road Works

901. GENERAL

901.1. All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order 10 carry out all required tests and Quality Control work as per Specifications and/or as directed by the Engineer, The internal layout of the laboratory shall be as per Clause 121 and/or as directed by the Engineer. The list of equipment and the facilities to be provided shall be got approved from the Engineer in advance.

901.2. The Contractor's laboratory should be manned by a qualified Materials Engineer/Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.

901.3. The Contractor shall carry out quality control tests on the materials and work to the frequency stipulated in subsequent paragraphs. In the absence of clear indications about method and or frequency of tests for any item, the instructions of the Engineer shall be followed.

901.4. For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer.(by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth hereinunder. Additional tests may also be conducted where, in the opinion of the Engineer, need for such tests exists.

901.5. The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This may include provision of labour, attendants, assistance in packing and despatching and any other assistance considered necessary in connection with the tests.

901.6. For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

901.7. The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer during inspection. Works falling short of quality shall be rectified/redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.

901.8. The cost of laboratory building including services, essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same. If, however, there is a separate item in the Bill of Quantities for setting up of a laboratory and installing testing equipment, such work shall be paid for separately.

901.9. For testing of samples of soils/soil mixes, granular materials, and mixes, bituminous materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied to the Engineer by the Contractor at his own cost.

901.10. For cement, bitumen, mild steel, and similar other materials where essential tests are to be carried out at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also furnish the test certificates to the Engineer.

901.11. For testing of cement concrete at site during construction, arrangements for supply of samples, sampling, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests specified in the Handbook of Quality Control for Construction of Roads and Runways (IRC :SP: 11) and relevant IS Codes or relevant clauses of these Specifications, the cost of which shall be borne by the Contractor.

901.12. The method of sampling and testing of materials shall be as required by the "Handbook of Quality Control for Construction of Roads and Runways" (IRC : SP: 11), and these MOST Specifications. Where they are contradicting, the provision in these Specifications shall be followed. Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor.

901.13. The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

Similarly, the supply of aggregates for construction of road pavement shall be from quarries approved by the Engineer, Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

901.14. Defective Materials

All materials which the Engineer/his representative has determined as not conforming to the requirements of the Contract shall be rejected whether in place or not; they shall be removed immediately from the site as directed. Materials, which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any order of the Engineer/his representative, given under this Clause, the Engineer/his representative shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

901.15. Imported Materials

At the time of submission of tenders, the Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor's responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/finished products are not covered by the Specifications in the Contract, the details of Specifications proposed to be followed and the testing procedure as well as laboratories/ establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified to the lot of materials shall be furnished at the Contractor's cost.

902. CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

902.1. General

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after.

902.2. Horizontal Alignment

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 10 mm there from. The

corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 25 mm.

902.3. Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 900-1,

TABLE 900-1. TOLERANCES IN SURFACE LEVELS

1.	Subgrade	+ 20mm
		-25 mm
2.	Sub-base + 10mm	
	(a) Flexible pavement	- 20mm
	(b) Concrete pavement	+ 6 mm
	[Dry lean concrete or Rolled concrete]	- 10mm
3.	Base-course for flexible pavement	
	(a) Bituminous course	+ 6 mm
		- 6mm
	(b) Other than bituminous	+ 10 mm
	(i) Machine laid	- 10mm
		+ 15 mm
	(ii) Manually laid	- 15 mm
4.	Wearing course for flexible pavement	
	(a) Machine laid	+ 6 mm
		- 6 mm
	(b) Manually laid	+ 10mm
		- 10mm
5.	Cement concrete pavement	+ 5 mm
		- 6mm *

* This may not exceed - 8 mm at 0 - 30 cm from the edges.

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than 6 mm for flexible pavements and 5 mm for concrete pavements.

For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of (he surface levels shall be taken on a grid of points placed at 6.25m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversly, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the

permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

902.4. Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straight-edge as desired by the Engineer at the middle of each traffic lane along a line parallel to the centre line of the road.

The maximum permitted number of surface irregularities shall be as per Table 900-2.

TABLE 900-2. MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES

	Surfaces of carriageways and paved shoulders				**Surfaces oflajbjs, service areas and ail bituminous base courses**			
Irregularity	4 mm		7 mm		4 mm		7 mm	
Length(m)	300	75	300	75	300	75	300	75
National Highways/ Expressways	20	9	2	1	40	18	4	3
Roads of lower category*	40	18	4	2	60	27	6	3

*Category of each lection of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous and cement concrete) 3 mm

for bituminous base courses 6 mm

for granular sub-base/ base courses 8 mm

for sub-bases under concrete pavements 10 mm

902.5. Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

(i) Subgrade; Where the surface is high, it shall be trimmed and suitably compacted Where the same is low, the deficiency shall he corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to t>e used shall conform to the requirements of Clause 305.

(ii) Granular Sub-base: Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401.

(iii) Lime/Cement Stabilized Soil Sub-base: For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care (hat the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.

For cement treated material, when the time elapsed between detection of irregularity and the lime of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm supplemented with freshly mixed materials as necessary and recompacted to the relevant specification. When this time is more than 2hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

(iv) Water Bound Macadam/Wet Mix Macadam Sub-base/Base: Where the surface is high or low, the lop 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 404. This shall also apply to wet mix macadam to Clause 406.

(v) Bituminous Constructions: For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat if needed and recompacting to specifications. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications, in all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less than 3.5 m in width.

(vi) Dry Lean Concrete Sub-base/Rolled Cement Concrete; The defective length of the course shall be removed Lo full depth and replaced with material conforming to Clauses 601 or 603, as applicable. The area treated shall be at least 3 m long, not less than 1 lane wide and ex lend to the full depth. Before relaying the course, the disturbed sub grade or layer below shall be corrected by levelling, watering and compacting.

(vli) Cement concrete pavement; The defective areas having surface irregularly exceeding 3 mm but not greater than 6 mm may be rectified by bump cutting or scrabbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured

in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. *IS* high areas in excess 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed at the Contractor's expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances shall be demolished and reconstructed at the Contractor's expense.

903. QUALITY CONTROL TESTS DURING CONSTRUCTION

903.1. General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the preceding Clauses.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. When; no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

903.2. Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

903.2.1. Borrow material. : Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out:

(a) Sand Content [IS: 2720 (Part4)]: 2 tests per 3000 cubic metres of soil,

(b) Plasticity Test [IS:2720(Part 5)]:Each type to be tested, 2 tests per 3000 cub.metres of soil.

(c) Density Test (IS:2720 (Part 5)]: Each soil type to be tested, 2 tests per 3000 cubic metres of soil.

(d) Deleterious Content Test [15:2720 (Part -27)]: As and when required by the Engineer.

(e) Moisture Content Test [IS :2720 (Part-2)]: One test for every 250 cubic metres of soil.

(f) CBR Test on materials to be incorporated in the subgrade on suaked/unsoaked samples [IS : 2720 (Part-16)]: One CBR lest for every 3000 cu. m. atleast or closer as and when required by the Engineer.

903.2.2. Compaction Control: Control shall be exercised on each layer by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28), Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of anyone test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

$$1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}$$ times the standard deviation.

However, for earthwork in shoulders (earthen) and in the subgrade, atleast one density measurement shall be taken for every 500 square metres for the compacted area provided further that the number of tests in each set of measurements shall be atleast 10. In other respects, the control shall be similar to that described earlier.

903.2.3. Cut formation : Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903,2.2.

903.3. Tests on Sub-bases and Bases (excluding bitumen bound bases)

The tests and their frequencies for the different types of bases and sub-bases shall be as given in Table 900-3.Theevaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2,2.

903.3.1. Acceptance criteria: The acceptance criteria for tests on the strength of cernent/lime stabilised soil and distribution of stabiliser content shall be subject to the condition that the mean value is not less than the

specified value plus :

$1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}$ times the standard deviation.

TABLE 900-3. CONTROL TESTS AND THEIR MINIMUM FREQUENCY FOR SUB-BASES AND BASES (EXCLUDING BITUMEN BOUND BASES)

SI. No.	Type of Construction	Test	Frequency (min)
1.	Granular	(i) Gradation	One test per 200 m^3
		(ii) Atterberg limits	One test per 200 m^3
		(iii) Moisture content prior to compaction	One test per 250m^3
		(iv) Density of compacted layer	One test per 500 m^3
		(v) Deleterious constituents	As required
		(vi) C.B.R.	As required
2.	Lime/Cement Stabilised Soil Sub-base	(i) Quality of lime/ cement	One test for each consignment subject to a minimum of one test per 5 tonnes
		(ii) Lime/Cement content	Regularly, through procedural checks
		(iii) Degree of pulverization	Periodically as considered necessary
		(iv) CBR or Unconfined Compressive Strength test on a set of 3 specimens	As required
		(v) Moisture content prior to compaction	One lest per 250 sq. m.
		(vi) Density of compacted layer	One test per 500 m^2
		(vii) Deleterious constituents	As required
3.	Water Bound Macadam		One test per 200 m^3 of aggregate
		(i) Aggregate Impact Value	One test per 100 m^3
		(ii) Grading	One test per 200 m^3 of aggregate
		(iii) Flakiness Index and Elongation Index	One test per 25 m^3 of binding material
		(iv) Atterberg limits of binding material	

SI. No.	Type of Construction	Test		Frequency (min)
		(v)	Alterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 cubic metre of aggregate
4.	Wet Mix Macadam	(i)	Aggregate Impact Value	One test per 200 m^3 of aggregate
		(ii)	Grading	One test per 100m^3 of aggregate
		(iii)	Flakiness and Elongation Index	One test per 200 m^3 of aggregate
		(iv)	Atierberg limits of portion of aggregate passing 425 micron sieve	One test per 100m^3 of aggregate
		(v)	Density of compacted layer.	One test per 500 m^2

903.4. Tests on Bituminous Constructions

903.4.1. The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4.

903.4.2. Acceptance criteria : The acceptance criteria for tests on density and Marshall stability shall be subject to the condition that the mean value is not less than the specified value plus:

$$1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}$$ times the standard deviation.

TABLE 900-4. CONTROL TESTS AND THEIR MINIMUM FREQUENCY FOR BITUMINOUS WORKS

SI. No.	Type of Construction	Test		Frequency (min)
1.	Prime Coat/Tack Coal	(i)	Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer
		(ii)	Binder temperature for application	At regular close intervals
		(iii)	Rate 'of spread of Binder	Two tests per day
2.	Seal Coat/Surface Dressing	(i)	Quality of binder	Two samples per loi Dressing to be subjected to all or

Sl. No.	Type of Construction	Test	Frequency (min)
			some tests as directed by the Engineer
		(ii) Aggregate Impact Value	One test per 50m5 of aggregate
		(iii) Flakiness Index and Elongation Index	-do-
		(iv) Stripping value of " aggregates	Initially one set of 3 representative specimens for each "source of supply. Subsequently when warranted by changes in the quality of aggregates
		(v) Water absorption of aggregates	-do-
		(vi) Grading of aggregates	One test per 25 m3 of aggregate
		(vii) Stone polishing value	As required
		(viii) Temperature of binder at application	At regular close intervals
		(ix) Rate of spread of materials	One test per 500 m1 of work
3.	Open-graded Premix Carpet/Mix-Seal Surfacing	(i) Quality of binder	Two samples per lot to be subjected to all or some tests as directed by Engineer
		(ii) Aggregate Impact Value	One test per 50 ms of aggregate
		(iii) Flakiness Index and Elongation Index of aggregates	-do-
		(iv) Stripping value	Same as mentioned under Serial No, 2
		(v) Water absorption of aggregates	Same as mentioned under Serial No, 2
		(vi) Grading of aggregates	One test per 25 m1 of aggregates
		(vii) Stone polishing value	As required
		(viii) Temperature of binder at application	At regular close intervals
		(ix) Binder content	Two tests per day
		(x) Rate of spread of mixed material	Regular control through checks on materials and layer thickness
4.	Bituminous Macadam	(i) Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer

Sl. No.	Type of Construction	Test	Frequency (min)
		(ii) Aggregate Impact Value	One lest per 50 m3 of aggregate
		(iii) Flakiness Index and Elongation Index of aggregates	-do-
		(iv) Stripping value	Same as mentioned under Semi No. 2
		(v) Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vi) Water absorption of aggregates	Same as in Serial No. 2
		(vii) Binder content	Periodic, subject to minimum of two tests per day per plant
		(viii) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		(ix) Rate of spread of mixed material	Regular control through checks of layer thickness
5.	Bituminous Penetration Macadam/ Built-up Spray-Grout	(i) Quality of binder	Two samples per lot to be subjected to alt or some tests as directed by the Engineer.
		(ii) Aggregate Impact Value	One test per 200m! of aggregate
		(iii) Flakiness Index and Elongation Index	-do-
		(iv) Stripping value	Same as mentioned under Serial No 2
		(v) Water absorption of aggregates	Same as in Serial No. 2
		(vi) Aggregate grading	One test per 100 m! of aggregate
		(vii) Temperature of binder at application	At regular close intervals
		(viii) Rate of spread of binder	One test per 500 m^2 of area
6.	Dense Bituminous Macadam/Semi Dense Bituminous Concrete/ Bituminous Concrete	(i) Quality of binder	Two samples per lot lo be subjected lo all or some tests as directed by the Engineer
		(ii) Aggregate Impact Value	One test pet 50 m1 of aggregate

Sl. No.	Type of Construction	Test	Frequency (min)
		(iii) Flakiness Index and Elongation Index of aggregates	--do-
		(iv) Stripping Value	As in Serial No. 2
		(v) Water absorption of aggregates	As in Serial No. 2
		(vi) Sand equivalent test	As required
		(vii) Stone Polishing Value	As required for Semi Dense Bituminous Concrcle/Bituminous Concrete
		(viii) Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject ID a minimum of two tests per plant per day
		(ix) Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being vested per plant per day
		(x) Water sensitivity of mix (Retention of Marshall Stability)	As required for Bituminous Concrete
		(xi) Swell lest on the mix	-do-
		(xii) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	Al regular close intervals
		(xiii) Control of binder content and gradation in the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
		(xiv) Rate of spread of mixed material	Regular control and through checks on the weight of mixed material and layer thickness
		(xv) Density of compacted layer	One lest per 250 m1 area

903.5, Quality Control Tests for Concrete Road Construction

903.5.1. Dry lean concrete sub-base :

903.5.1.1. Sampling and testing of cubes: Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 sq. m. or part thereof laid each day. The sampling of mix shall be done from the paving site,

Test cubes of 150mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 sq.mm. The compaction shall be uniformly applied for 60± 5 seconds with a downward force of between 300N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be scarified before the next layer is added to give key for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete cubes shall be cured m accordance with lS:516.

903.5.1.2. In-situ density: The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 60l.5.5.1. This ra le of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges,

903.5.1.3. Thickness: The average thickness of the subbase layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 10mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.5.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

903.5.1.4. Frequency of quality control tests: The frequency of quality control tests for levels, alignment and materials shall be as in Table 900-6.

903.5.2. Pavement concrete

903.5.2.1. Sampling and testing of beam and cube specimens: Atleast two beam and two cube specimens, one each for 7-day and 28 day strength testing shall be cast for eve; 150 cu.m (or part thereof) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered to the paving plant. Each pair shall be from a different delivery of concrete and tested at a place to be designated by the Engineer in accordance with the testing procedure as outlined in Clause 602.3.3. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the strength requirements. The specimens shall be transported in an approved manner to prevent sudden impact causing fractures or damage to the specimen. The flexural strength test results shall prevail over compressive strength tests for compliance.

A quality control chart indicating the strength values of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut from the hardened concrete at such locations. The cores shall be cut at the rate of 2 cores for every 150cu. m.of concrete. The results of crushing strength tests on these cores shall not be less than 0.8 times the corresponding crushing strength of cubes, where the height to diameter ratio of the core is two. Where height to diameter ratio is varied, then the necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$f = 0.11\,n + 0.78$$

where f = correction factor and

n = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm. If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to

the area from which the cores were cm should be replaced, i.e., atleast over an area extending between two transverse joints where the defects could be isolated or over larger areas, if necessary, as assessed by additional cores and their test results. The equivalent flexural strength at 28 days shall be estimated in accordance with Clause 602,3.3.2.

In order to ensure that the specified minimum strength at 28 days is attained in 99 per cent of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 2.33 limes the standard deviation calculated first from the flexural strengths of test beams made from the trial mix and subsequently from the accumulating result of flexural strengths of job control test beams.

The standard deviation shall be re-calculated from the test results obtained after any change in the source or quality of materials and the mix shall be adjusted as necessary to comply with the requirements. An individual 28 day test strength below the specified strength shall not be evidence for condemnation of the concrete concerned if the average 28 day strength of this beam plus the preceding 5 and succeeding 4 beams exceeds the specified strength by 2.33 times the standard deviation and provided that there is no other evidence that the concrete mix concerned is substandard.

Beams shall be made each day in pairs at intervals, each pair being from a different batch of concrete. At the start of the work, and until such time as the Engineer may order a reduction in the number of beams required, at least six pairs of beams and cubes shall be made each day, one of each pair for testing at 28 days for determination of the minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix. When the first thirty number of 28-day results are available, and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall-be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the28 day flexural strengths to detect any deterioration in the quality of the! concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence

of non-compliance of the concrete from which they were taken.

Concrete shall not comply with the Specification when more than one test beam in a batch has a 28 day strength less than the specified strength and the average 28 day flexural strength of the batch, of beams is less than the specified strength plus 2.33 times the standard deviation of the batch.

Should the concrete fail to pass the Specification for strength as described above, the Contractor may, all at his own expense, elect to cut cores from the suspect concrete as the Engineer shall direct. From the relation between cube strength and flexural strength, the core strength shall be converted to flexural strength.

The equivalent flexural strength at 28 days shall be the estimated insitu strength multiplied by 100 and divided by the age-strength relation obtained from Table 900-5.

Any concrete that fails to meet the strength specification -shall be removed and replaced at Contractor's expense.

TABLE 900-5. AGE - STRENGTH RELATION OF CONCRETE (RELATED TO 100 PER CENT AT 28 DAYS)

DAYS	0	2	4	6	8
0	-	41.0	60.0	71.0	77.5
10	81.5	85.0	87.5	90.0	92.0
20	94.0	96.0	97.5	98.5	100.0
30	101.0	102.0	103.5	104.5	105.5
40	106.5	107.0	108.0	109.5	110.0
50	I10.5	111.0	112.0	112.5	113.0
60	114.0	114.5	115.0	115.5	116.0
70	116.5	117.0	117.5	118.0	118.5
80	119.0	119.5	119.5	120.0	120.5
90	121.0	121.5	122.0	122.0	122.5
100	123.5	123.5	123.5	124.0	124.5
110	125.0	125.0	125.5	125.5	126.0
120	126.0	126.5	127.0	127.0	127.5
130	127.5	128.0	128.5	128.5	129.0
140	129.0	129.5	129.5	130.0	130.0
150	130.5	130.5	131.0	131.0	131.5
160	131.5	131.5	132.0	132.0	132.5
170	132.5	132.5	133.0	133.0	1J3.5
180	133.5	134.0	134.0	134.5	134.5
190	135.0	135.0	135.0	135.5	135.5
200	135.5	135.5	136.0	136.0	136.5

210	136.5	136.5	137.0	137.0	137.0
220	137.0	137.5	137.5	137.5	138.0
230	138.0	138.5	138.5	138.5	138.5
240	139.0	139.0	139.0	139.5	139.5
250	139.5	140.0	140.0	140.0	140.0
260	140.5	140.5	140.5	140.5	141.0
270	141.0	141.0	141.5	141.5	141.5
280	142.0	142.0	142.0	142.0	142.0
290	142.5	142.5	142.5	142.5	142.5
300	143.0	143.0	143.0	143.0	143.5
310	143.5	143.5	144.0	144.0	144.0
320	144.0	144.5	144.5	144.5	144.5
330	144.5	145.0	145.0	145.0	145.0
340	145.0	145.5	145.5	145.5	145.5
350	146.0	146.0	146.0	146.0	146.0
360	146.0	146.0	146.5	146.5	146.5

903.5.2.2. In-situ density : The density of the compacted concrete shall be such that the total air voids are not more than 3 per cent. The air voids shall be derived from the- difference between the theoretical maximum dry density of the concrete calculated from the specific gravities of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the vibratory effort imparted i.e., the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. Incase of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculating the density, allowance shall be made for any steel in cores.

Cores removed from the main carriageway shall be reinstated with compacted concrete with mix proportions of 1 part of portland cement: 2 parts of fine aggregate : 2 parts of 10 mm nominal size single sized coarse aggregate by weight. Before filling the fine mix, the sides shall be hacked and cleaned with water. Thereafter cement-sand slurry shall be applied to the sides just prior to filling the concrete mix.

903.5.2 3. Thickness : Thickness shall be controlled by taking levels as indicated in Clause 9023. Thickness of the slab at any point checker) as mentioned above shall be within a tolerance of -5 mm to + 25 mm of the specified thickness as per Drawing. Thickness deficiency more than 5 mm may be accepted and paid for at a reduced rate given in Clause 602.15.2. In no case, however, thickness deficiency shall be more than 25 mm.

903.5.2.4. Summary of control tests : Table 900-6 gives a summary of frequency of testing of pavement quality concrete.

TABLE 900-6 . FREQUENCY OF QUALITY CONTROL TESTS FOR PAVING QUALITY CONCRETE

1.	**Levels, alignment and texture**				
	(i) Level tolerance				Clause 902.3
	(ii) Width of pavement and position of paving edges				Clause 902.2
	(iii) Pavement thickness				Clauses 902.3 and 903.5,13
	(iv) Alignment of joints, widths. depths of dowel grooves				To be checked® one Joint per 400m length or a day's work whichever is more.
	(v) Surface regularity both transversely and longitudinally				Once a day orone day's work, without disturbing the curing operation.
	(vi) Alignment of dowel bars and their accuracy/tie bars				To be checked in trial length as per Clause 602. 10.5.2 and once on every *2* km.
	(vii) Texture depth				Clause 602,9.8
2.	**Quality of Materials and Concrete**				
	Control tests for materials and concrete shall be as under				
1.	Cement		Physical and chemical tests	IS ; 269 IS : 455 IS : 14S9 IS : 8112 IS : 12269	Once for each source of supply and occasionally when called for in case of long/improper storage, Besides, the Contractor also will submit daily data on cement released by the Manufacturer.
2.	Coarse and Fine aggregates	(i)	Gradation	IS : 2386 (Pt. 1)	One use test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; may be relaxed later at the discretion of the Engineer.
		(ii)	Deleterious constituents	IS : 2386 (Pt. 2)	-do-

		(iii)	Water absorption	13:2386 (Pt. 3)	Regularly as required subject to a minimum of one lest a day for coarse aggregate & two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix on daily basis.
3.	Coarse Aggregate	(i)	Los Angeles Abrasion value or Aggregate Impact lest	IS:2386 (Pt. 4)	Once for each source of supply and subsequently on monthly basis.
		(ii)	Soundness	IS:23S6 (Pt.5)	Before approving the aggregates and every month subsequently
		(iii)	Alkali aggregate reactivity	IS:2386 (Pt. 7)	-do-
4.	Water		Chemical Tests	IS:456	Once for approval of source of supply, subsequently only in case of doubt,
5.	Concrete	(i)	Strength of concrete	IS:516	2 cubes and 2 beams per 150 in' or part thereof (one for 7day and other for 28 day strength) or minimum 6 cubes and 6 beams per day's work whichever is more.
		(ii)	Core strength on hardened concrete	IS:516	As per the requirement of the Engineer; only in case of doubt.
		(iii)	Workability of fresh concrete-Slump Test	IS:1199	One lest per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumper.
		(iv)	Thickness determination		From the level data of concrete pavement surface and sub-base at grid points of S/ 6.25 m x 3.5 m
		'(v)	Thickness measurement for trial length		3 cores per trial length.
		(vi)	Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving		String line or steel forms shall be checked for level at an interval of 5.0m or 6.25 m. The level tolerance allowed shall be ± 2mm. These shall be got approved 1-2 hours before the commemcement of the concreting activity.

903.5.3. Rolled Concrete Base

903.5.3.1. Sampling and testing of beams and cubes: Clause 903,5.2.1 shall apply

903.5.3.2. Thickness : Thickness shall be controlled by taking levels as indicated in Clause 903.5.1.3.

903.5.3.3. In-situ density : The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 601.5.5,1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non compliance. Density holes at random may be made to check the density at edges.

903.5.3.4. Summary of control tests liable 900-6 gives the summary of tests for levels, alignment and materials.

903.5.4. Summary of rate of sampling and testing:

(i)	Strength	:	3 beams and 3 cubes for each 100 sq. m. or part thereof laid each day.
(ii)	Density	:	3 density holes for each 2000 sq.m. or part thereof bid each day
(iii)	Cotes	:	Only when Engineer instructs. They shall not be cut on regular basis.

A relation between flexural strength and compressive strength may be developed by regression analysis using the available data. This may be updated from time to time.

1000

Materials for Structures

1001. GENERAL

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

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

1002. SOURCES OF MATERIAL

The Contractor shall notify the Engineer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

1003. BRICKS

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

1004. STONES

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

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

The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

1005. CAST IRON

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

1006. CEMENT

Cement to be used in the works shall be any of the following types with the prior approval of the Engineer :

a) Ordinary Portland Cement, 33 Grade, conforming to IS:269.

b) Rapid Hardening Portland Cement, conforming to IS:8041.

c) Ordinary Portland Cement, 43 Grade, conforming to IS:8112.

d) Ordinary Portland Cement, 53 Grade, conforming to IS:12269.

e) Sulphate Resistant Portland Cement, conforming to IS:12330.

Cement conforming to IS:269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cu,m. of concrete.

Cement conforming to IS:8112 and IS:12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28-day range can be achieved by finer grinding and higher constituent ratio of C_3S/C_2S, where C_3S is Tricalcium Silicate and C_2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

Cement conforming to 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 per cent in soil substrata or 300 ppm (0.03per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to 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 540 kg/ cu.m. of concrete,

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

Total chloride content in cement shall in no case exceed 0.05 per cent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO3) shall in no case exceed 2.5 per cent and 3.0 per cent when tri-calcium aluminate per cent by mass is upto 5 or greater than 5 respectively.

1007. COARSE AGGREGATES

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other approved inert material. They shall not consist 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 aggregate having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS:383 and tests for conformity shall be carried out as per 15:2386, Parts I to VIII.

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

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

The maximum value for flakiness index for coarse aggregate shall not exceed 35 per cent. The coarse aggregate shall satisfy the following requirements of grading :

TABLE 1000-1 REQUIREMENTS OF COARSE AGGREGATE

IS Sieve Size	Per cent by Weight Passing the Sieve		
	40 mm	**20mm**	**12.5mm**
63 mm	100	—	—
40 mm	95-100	100	—
20 mm	30-70	95-100	100
12.5 mm	—	—	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

1008. SAND/FINE AGGREGATES

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

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

Sand/fine aggregate for structural concrete shall conform to the following grading requirements :

TABLE 1000-2

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone 1	Zone II	Zone 111
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	S-30	12-40
150 micron	0-10	0-10	0-10

1009. STEEL

1009.1. Cast Steel

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

1009.2. Steel for Prestressing

The prestressing steel shall conform to either of the following :

(a) Plain hard drawn steel wire conforming to IS:1785 (Part I) and IS:1785 (Part II).

(b) Cold drawn indented wire conforming to IS.6003

(c) High tensile steel bar conforming to IS:2090

(d) Uncoated stress relieved strands conforming to IS:6006.

1009.3. Reinforcement / Untensioned Steel

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

TABLK 1000-3

Grade Designation	Bar Type conforming to governing IS Specification	Characteristic Strength fy MPa	Elastic Modulus GPa
S 240	IS:432 Part I Mild Steel Bar	240	200
S 415	IS:17B6 High Yield Strength Deformed Bars (I1YSD)	415	200

Other grades of bars conforming to IS:432 and IS:1786 shall not be permitted.

All steel shall be procured from original producers, no re-rolled steel shall be incorporated in the work.

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

Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS: 13620, Additional requirements for the use of such reinforcement bars have been given below :

(a) Patch up materials shall be procured in sealed containers with certificates from the agency who has supplied the fusion bonded epoxy bars.

(b) PVC coated G.I. binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.

(c) Chain for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.

(d) The cut ends and damaged portions shall be touched up repair patch up material.