APCRDA

TECHNICAL SPECIFICATIONS (DRAFT)

FOR CONSTRUCTION OF ROADS

NOTE

1. Relevant clause of Ministry of Road Transport & Highways (MORT&H) Specifications for Road & Bridges (5^{th} Edition, 2010) relevant to this tender only are reproduced.

2. In case of any variation between the technical specifications of the bid and the original specification of MORT&H publication, the technical specification of the bid shall prevail and shall be construed accordingly.

3. If MORT&H clauses referred to in the reproduced specifications herein are not included in the bid documents, the same shall be read from MORT&H specifications.

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 decided 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, measures for safety of workers and public and traffic arrangements during execution shall comply with the requirements set forth in succeeding sections. Where the drawings and Specifications describe a portion of the work only in general terms, and not in complete detail, it shall be understood that only the sound engineering practice is to prevail, materials and workmanship of the best quality are to be employed and the instructions of the Engineer are to be fully complied with.

A list of Indian Roads Congress (IRC) Specifications and recommended Codes of Practice which have been referred in these Specifications is given at Appendix-1. The latest edition of all Specifications/Standards/Codes of IRC till 60 (sixty) days before the final date of submission of the tender, shall be adopted.

In case of any conflict or inconsistency in the provisions of the applicable Specifications/ Standards/Codes of IRC, provisions contained in these Specifications shall apply.

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 the 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 Materials
BS	British Standard published by the British Standards Institution
BIS	Bureau of Indian Standards
BOQ	Bill of Quantities
CBR	California Bearing Ratio
IRC	Indian Roads Congress
IS	Indian Standard published by the Bureau of Indian Standards
QA	Quality Assurance

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 are included at Appendix-2.

104 SIEVE DESIGNATIONS

Table 100-1: Designation of Test Sieves IS Designation Conforming to IS: 460

(in mm)	(in Micron)
*125	850
106	
*90	*710
75	600
*63	*500
*53	425
	355
	300
*45	*250
37.5	212
*31.5	*180
26.5	150
*22.4	*125
19.0	106
*16.0	*90
13.2	75
*11.2	*63
9.50	53
*8.00	*45
6.70	
*5.60	5
4.75	2
*4.00	
3.35	
*2.80	
2.36	
*2.00	
1.70	
*1.40	
1.18	
*1.00	

Notes: 1)'*'are the principal sizes stated in ISO-565
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

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

Conformity with Drawings/Allowable Deviations

All works performed and all materials furnished shall be in conformity with the lines, grades, typical sections, dimensions, material requirements, and tolerances shown in the drawings or as indicated in the Specifications.

The works to be performed shall also include all general works preparatory to the construction of roads, bridges, structures, 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 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 compliance by the Contractor with all Conditions of Contract, whether specifically mentioned or not in the various Sections 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 include all works related to safety of road user. It shall also include safety of workers at construction site, 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 works, safety of the public and protection of the works and adjoining land/ structures.

The Contractor shall ensure that all actions are taken to build in quality assurance (QA) in the planning, management and execution of works. The quality assurance shall coverall 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 QA programme shall cover the details as per IRC:SP:47 and IRC:SP:57. These shall broadly cover quality assurance aspects of all services rendered, all items to be supplied and all activities to be performed under the contract including temporary structures and equipment which will influence the quality of the completed works or the progress of the contract.

As a minimum, it shall cover the following:

i) Organization and management responsibility,
ii) Document and data control,
iii) Construction programme,
iv) Method statement,
v) Process control,
vi) Working, inspection, testing and documentary procedures,
vii) Arrangement for smooth and safe traffic flow during construction and maintenance,
viii) Control and documentation of purchasing and handling of materials,
ix) Maintenance of records for non-conformity and timely corrective actions,
x) Internal quality audit,
xi) Training of staff,
xii) Environment Management Plan (EMP).

The QA plan shall be submitted to the Engineer for approval, not later than 28 days from the date of signing of the contract agreement. The work of building in quality assurance shall be deemed to be covered in the scope of the work.

The Contractor shall furnish, at least 7 days in advance, unless otherwise stipulated in the contract, his programme of commencement of each item of work, including the method statement including deployment of plant and equipment for the works included in the contract and any other work for which the Engineer may demand the method statement. He shall provide all information to the satisfaction of the Engineer to ensure its adequacy. 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.

Inspection of Materials before Incorporation

All materials shall be inspected, tested and accepted by the Engineer as per these specifications, before incorporation in the work. The frequencies and methods of sampling and testing materials, including those required for definite purpose and not covered by these specifications shall be in accordance to the relevant IRC or BIS or AASHTO/ASTM/ BS Standards in order of priority.

All materials or work not conforming to the requirements of the Specifications shall be considered unacceptable and rejected. The unacceptable materials or work that are rejected shall be immediately removed unless the defects are corrected and approved by the Engineer. If the Contractor fails to comply promptly with any order of the Engineer made under the provisions of this Clause, the Engineer has the authority to remove and replace unacceptable materials or work and to deduct from money due to the Contractor the cost of removal and replacement.

Inspection of Materials at Source

The Engineer may choose to inspect material at source. In the event, the following conditions shall be met.

i) The Contractor and the manufacturer of material shall assist and co-operate with the Engineer in carrying out the inspection.
ii) The Engineer shall have right to enter areas of plant where the manufacture or production of material is carried out.

Delivery, Storage and Handling of Materials

All materials shall be handled and stored in appropriate manner to preserve their quality and fitness for the work. During the handling of all aggregates or other construction materials, special care shall be taken to prevent contamination. Furthermore, aggregate shall be handled in such a manner as to prevent segregation.

Vehicles used in transporting construction material shall be kept clean and in proper working condition so as to prevent the loss of materials during transportation and meet the requirements of the Specifications.

The Contractor may be allowed to store materials and equipment within the right-of-way at location approved by the Engineer, but shall be responsible for the restoration and repair of any damage to plantation, signs, property or any assets resulting from such operations. Any additional space that may be needed for storage purposes and for placing of plant and equipment shall be provided by the Contractor at no additional cost to the Employer.

Materials Furnished by the Employer

When the Contract provides that certain materials required to complete the work will be supplied by the Employer, such material will be delivered or made available to the Contractor at the location(s) specified in the Contract.

The Contractor shall be responsible for all damages occurring to the materials furnished by the Employer while the materials are in his possession. Any demurrage or storage charges shall also be the responsibility of the Contractor.

The Contractor shall include the cost of handling, transportation and placing all Employer-furnished materials in the Contract unit price for the relevant pay item.

Laws to be Observed

The Contractor shall observe and comply with all Central and State laws, local laws and ordinance which affect those employed on the work or affect the conduct of the work.

The Contractor shall provide all safeguards, safety devices, and protective equipment and take any other actions necessary for safety and health of employees on the project.

Patented Devices, Materials and Processes

If the Contractor is required or desires with the approval of the Engineer to use any design, device, material or process covered by trademark, patent or copyright, the Contractor shall obtain the right for its use by legal agreement with the patentee or owner. A copy of the agreement shall be furnished to the Engineer. Contract prices shall include all royalties and costs arising from patents, trademarks and copyrights.

106 CONSTRUCTION EQUIPMENT

In addition to the 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 tolerances 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) Plants, equipment and instruments provided shall have adequate sensitivity, facility for calibration to desired level and shall be robust;
d) Plant, equipment and instrument provided shall have data logging arrangement and control systems to enable automatic feedback control of process;
e) Plants, equipment and instruments provided shall have adequate safety features and pollution control devices;
f) Plant, equipment and instruments provided shall be operated by skilled and qualified operators;
g) 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;
h) Any material or equipment not meeting the approval of the Engineer shall be removed from the site forthwith;
i) No equipment shall be removed from site without permission of the Engineer;
j) The Contractor shall also make available stand by equipment and spare parts; and
k) The Contractor shall also make available equipment for site quality control work as directed by the Engineer.

107 DRAWINGS

The drawings provided in the Tender Documents shall be used as reference only. The Contractor shall study the nature and type of work and ensure that the rates and prices quoted by him in the Bill of Quantities have due consideration of the site and complexities of work involved during actual execution/construction.

The Contractor based on his surveys and investigations, shall submit the working drawings (hard and soft copy) to the Engineer for each activity at least 45 days in advance of the scheduled date to the start of the activity as per his approved work programme. The working drawings shall clearly show the modifications, if any, proposed with reference to corresponding tender drawings. The Engineer shall review the working drawings including the modifications proposed, if any, revise the drawings, if required, approve and issue to the Contractor two copies of Good for Construction

(GFC) drawings at least 28 days in advance of the scheduled date of the start of the activity.

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

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 negatives which the Contractor is required to provide in accordance with the Contract.

108 SITE INFORMATION

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

The location of the works and the general site particulars are as shown in the Site plan/index plan enclosed with the Tender Documents.

Whereas the right-of-way to the bridge sites/road works shall be provided to the Contractor by the Employer, the Contractor shall have to make his own arrangement for the land required by him for site offices, field laboratory, site for plants and equipment, maintenance and repair workshop, construction workers' camp, stores etc.

109 SETTING OUT

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, in working bench marks/levels should be got approved from the Engineer. Checks must be made on these bench marks once every month and adjustments, if any, got approved from the Engineer and recorded. An up-to-date record of all bench marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Engineer for his record.

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.

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

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

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

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

The construction staking shall be done by personnel who are trained and experienced in construction layout and staking of the type and kind required in the Contract.

Field notes shall be kept in standard, bound field notebooks as approved by the Engineer. Field notes shall be subject to inspection by the Engineer and shall be the property of the Employer.

The Contractor shall correct any deficient staking or construction work which resulted from inaccuracies in the staking operations or from the Contractor's failure to report inaccuracies in the plans or survey data furnished by the Department.

After obtaining approval of the Engineer, work on earthwork can commence.

The profile and cross-sections as per Section 305, shall form the basis for measurements and payment. The Contractor shall be responsible for ensuring that all the basic traverse points are in place at the commencement of the contract and, if any, are missing, or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A "survey File" containing the necessary data will be made available for this purpose. If in the opinion of the Engineer, design modifications of the centre line or grade are advisable, the Engineer will issue detailed instructions to the Contractor and the Contractor shall perform the modifications in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required.

There will be no separate payment for any survey work performed by the Contractor. The cost of these services shall be considered as being included in the rate of the items of work in the Bill of Quantities.

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

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

110 PUBLIC UTILITIES

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

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.

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

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.

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

111 ARRANGEMENT FOR TRAFFIC DURING CONSTRUCTION

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 roads, the Contractor shall, in accordance with the directives of the Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement or along a temporary diversion constructed close to the highway. Before taking up any construction or

maintenance operation, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the Engineer for prior approval. This plan should include inter alia:

a) Provision of a qualified safety officer with support staff to serve as a site safety team
b) Provision of traffic safety devices and road signs in construction zones as per IRC: SP:55 and other relevant IRC Codes and para 112.4.
c) Safety measures for the workers engaged including personal protection equipment
d) First aid and emergency response arrangements
e) Details and drawings of arrangements in compliance with other sub Sections of this Section.

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/5.5m carriageway with earthen shoulders of m width on each side with the following provision for road crust in the 7 m width:

a) Earthwork
b) 200 mm (compacted) granular sub-base
c) 225 mm (compacted) granular base course
d) Priming and Tack Coat and
e) Premix carpet with Seal Coat/Mix Seal Surfacing

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

Traffic Safety and Control

The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, marking, flags, lights and flagmen as per the traffic management plan submitted by the Contractor and approved by the Engineer, referred to in Sub-Section 109.1. Before taking up any construction, an agreed phased programme for the diversion of traffic on the highway shall be drawn up in consultation with the Engineer.

All construction equipment working or parked on or within the traffic lanes or shoulders under ‑Traffic maintained‖ conditions shall be equipped with flashing yellow beacons. The Contractor shall conduct all operations to minimize any drop-offs (abrupt changes in roadway) exposed to traffic. Drop-offs in the travelled way shall be protected by a wedge of compacted stable material capable of carrying traffic (the wedge being 1 vertical to 4 horizontal or flatter).

The Engineer shall authorize other methods, to protect drop-offs when conditions do not allow a wedge of compacted, stable material. Warning signs, barricades, warning lights, and all other traffic control devices shall not be removed if the hazard has not been eliminated. Only upon receipt of specific written authorization from the Engineer, the Contractor may remove or cease to maintain warning signs, barricades, warning lights, and all other traffic control devices.

The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise. At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriageway) the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device to the directions of the Engineer. At night, the passage shall be delineated with lanterns or other suitable light source including solar energy bulbs. One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

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

Maintenance of Diversions and Traffic Control Devices

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

Measurements for Payment and Rate

All arrangements, as contained in this Section 112 for safety of road users, during construction including provision of temporary diversions/temporary cross drainage structures/treated shoulders shall be measured and paid as per the BOQ. However their maintenance, dismantling and clearing debris shall be considered as incidental to the Works and shall not be paid separately.

112 SCOPE OF RATES FOR DIFFERENT ITEMS OF WORK

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, over-head charges and profit as well as the general liabilities, performance of other obligations, insurance and risks arising out of the Conditions of Contract.

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

i) General works such as setting out, clearance of site before setting out and clearance of works after completion;
ii) A detailed programme using modern project management software for the construction and completion of the work 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 installation and testing, for all activities of the Engineer/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 Works for conducting tests thereon as required as per the provisions of the Contract;
iv) Design of mixes as per the relevant Sections of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant Sections of these Specifications to the submitted to the Engineer for his approval before use on the Works;
v) Cost of laying trial stretches;
vi) Detailed drawings as per Clause 107.
vii) Detailed design calculations and drawings for all Temporary Works (such as form-work, staging, centering, specialized constructional handling and launching equipment and the like);
viii) Detailed drawings for templates, support and end anchorage, details for pre-stressing cable profiles, bar bending and cutting schedules for reinforcement, material lists for fabrication of structural steel, etc.;
ix) Mill test reports for all mild and high tensile steel and cast steel as per the relevant provisions of the Specifications;
x) Testing of various finished items and materials including bitumen, cement, concrete, bearings as required under these Specifications and furnishing test reports/certificates;
xi) Inspection Reports in respect of formwork, staging, reinforcement and other items of work as per the relevant Specifications;

xii) 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;
xiii) Any other item incidental to work which is necessary for complying with the provisions of the Contract;
xiv) All temporary works, formwork and false work not included as separate item in the BOQ;
xv) Establishing and running a laboratory with facilities for testing for various items or works as specified in Section 900 and other relevant Sections;
xvi) Cost of in-built provisions for Quality Assurance;
xvii) Cost of safeguarding the environment; and
xviii) Cost of providing ‗as-built drawings‖ in original and two sets of prints.

113 METHODOLOGY AND SEQUENCE OF WORK

Prior to start of the construction activities at site, the Contractor shall, within 28 days after the date of the agreement unless otherwise stipulated in the Contract, submit to the Engineer for approval, the detailed method statement. The method statement shall be submitted in two parts.

The general part of the method statement shall describe the Contractor's proposals regarding preliminary works, common facilities and other items that require consideration at the early stage of the contract. The general part shall include information on:

i) Sources of materials like coarse aggregates and fine aggregates, quantity and quality of materials available in different sources;
ii) Sources of manufactured materials like bitumen, cement, steel reinforcement, pre-stressing strands and bearings etc. He shall also submit samples/test certificates of materials for consideration of the Engineer;
iii) Locations of the site facilities such as batching plant, hot mix plant, crushing plant, etc.;
iv) Details of facilities available for transportation of men/material and equipment;
v) Information on procedure to be adopted by the Contractor for prevention and mitigation of negative environmental impact due to construction activities;
vi) Safety and traffic arrangement during construction;
vii) Implementation of activities provided in the Environmental Management Plan;
viii) Any other information required by the Engineer.

The general part of the QA programme under Section 105.3 shall accompany the method statement.

Special part of the method statement shall be submitted to the Engineer by the Contractor for each important item of work as directed by the Engineer. The statement shall be submitted at least 4 weeks in advance of the commencement of the activity of item of work unless otherwise stipulated in the contract. The statement shall give information on:

i) Details of the personnel both for execution and quality control of the work;
ii) Equipment deployment with details of the number of units, capacity, standby arrangement;
iii) Sequence of construction and details of temporary or enabling works like diversion, cofferdam, formwork including specialized formwork for superstructure, details of borrow areas, method of construction of embankment, sub-grade and pavement, pile concreting, proprietary processes and products and equipment's to be deployed. Wherever required technical literature, design calculations and drawings shall be included in the method statement;
iv) Testing and acceptance procedure including documentation;
v) The special part of the QA programme under Sub-Section 105.3 for the particular item of work shall accompany the method statement for the concerned activity.
vi) The Engineer shall examine and approve the method statement with the required modifications. The modified method statement if required shall be submitted within 14 days of the receipt of the Engineer's approval. The sole responsibility for

adequacy and safety of the method adopted by the Contractor shall rest on the Contractor irrespective of any approval given by the Engineer.

114 SUPPLY OF QUARRY SAMPLES

Raw and processed samples of the mineral aggregates from the approved quarry shall be submitted by the Contractor at his cost.

115 APPROVAL OF MATERIALS

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

116 USE OF SURFACES BY TRAFFIC

Ordinarily, no construction traffic shall be allowed on pavement under construction unless authorized 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 sub-grade 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.

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

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/binder course shall be that engaged in laying and compacting the wearing course or that engaged on such surface treatment where the base/binder course is to be blinded and/or surface dressed. Should the base/binder course or tack coat on the base/binder course become contaminated, the Contractor shall make good by cleaning it to the satisfaction of the Engineer, and if this is impracticable, by removing the layer and replacing it to Specifications without any extra cost to the employer.

117 FIELD LABORATORY

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.

Description

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

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

Ownership

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

Maintenance

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

The contractor shall furnish to the Engineer, the items of laboratory equipments that shall be provided in the field laboratory along with layout drawings and get the approval of Engineer/Owner in charge of the project before commencing the construction work.

118 SUPPLY OF PROJECT RECORD

Scope

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

Description

The Contractor shall provide the following project records in digital format (DVD/Flash Drive) as directed by the Engineer:

Record of work in each work front : It shall cover the status of each work front before start of work, during various stages of construction and after completion duly including the arrangements made (day & night) for traffic during construction (This shall be need based or as directed by the Engineer);

Record of quarry sites, plant sites, camp sites including labour camps, haul roads, access roads, etc. on quarterly basis;

Record of all accidents on project road/various sites (quarry, plant, camp, etc.)

The record shall be taken by a professional with a digital camera capable of taking still as well as video images having the facility to record the date and the background commentary. The Contractor shall keep separate discs/drives, one with the Engineer and the other with the Employer and update the data in these discs/drives on monthly basis. Separately, a video (in digital format) of maximum one hour duration covering interesting and novel features of the work duly editing the above master disc/drive shall also be maintained, one copy each kept with the Engineer and the Employer and updated on monthly basis. All recording shall be done in the presence of the Engineer's Representative who will certify in writing the recording.

Measurements for Payment

Supply of two copies of all digital records as above and colour record photographs both in digital format as well as mounted in the albums project shall be measured as one item for the project.

Supply of additional prints of colour record photograph if requested shall be measured in number of additional prints supplied.

The supply of -as-built‖ drawings in digital format and in hard copies is incidental to the work and shall not be a payable item.

Rate

Supply of project record in digital format in two copies (one for the Engineer and the other for the Employer) including video recordings updated on monthly basis throughout the construction period shall be measured as one single item.

200 SITE CLEARANCE

201 CLEARING AND GRUBBING

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.

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.

Methods, Tools and Equipment"s

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. 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.

Disposal of Materials

All materials arising from clearing and grubbing operations shall be the property of Government/Owner 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 within boundary.

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, sub-grade and road construction

Measurements for Payment

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. Clearing and grubbing for road embankment shall be measured on area basis in terms of hectares. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the 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 operation.

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

a) Above 300 mm to 600 mm
b) Above 600 mm to 900 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.

Rates

The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labor, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm girth excavation and back-filling to required density, where necessary, and handling, disposing of the cleared materials with all lifts and leads. Ground levels shall be taken prior to and after clearing and grubbing. Levels taken prior to clearing and grubbing shall be the base level and will be accordingly used for computation of quantity of material arising due to clearing and grubbing, including the computation of unsuitable material, if any, which may be required to be removed as per the approval of the Engineer. The levels taken subsequent to clearing and grubbing shall be the base level for computation of earthwork for embankment. Clearing and grubbing shall be restricted to 150 mm only for payment purpose. Where clearing and grubbing is done a level beyond 150 mm, the excess excavation shall be made good as per Clause 301.3.3 and 301.6 to the satisfaction of the Engineer prior to taking up earthwork. This shall not be paid and shall be treated as part of clearing and grubbing.

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 within the boundary area.

202 DISMANTLING CULVERTS AND OTHER STRUCTURES/PAVEMENTS

Scope

This work shall consist of removing, as hereinafter set forth, existing culverts, 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 up to 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.

Dismantling Culverts

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 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.

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).

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.

Disposal of Materials

All materials obtained by dismantling shall be the property of Government/Owner. 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 up to 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 within Boundary area.

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.

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 with all lifts and up to a lead of 1000 m.

Measurements for Payment

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

a) Dismantling brick/stone masonry/ concrete (plain and reinforced) - cu. m.
b) Dismantling flexible and cement concrete pavement - cu. m.
c) Dismantling steel structures – ton
d) Dismantling pipes, guard rails, kerbs, gutters and fencing linear - m.
e) Utility services - Nos.

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 labor, materials, tools, equipment, safeguards and incidents necessary to complete the work. These will also include excavation and backfilling where necessary to the required compaction and for handling, salvaging, piling and disposing of the dismantled materials within all lifts within Boundary area.

300 EARTHWORK, EROSION CONTROL AND DRAINAGE

301 EXCAVATION FOR ROADWAY AND DRAINS

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,

Classification of Excavated Material

Classification

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

a) Soil
This shall comprise topsoil, turf, land, silt, clay, mud, peat, Black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging 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 laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bar, 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.

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.

Construction Operations

Setting Out

After the site has been cleared as per Clause 201, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Engineer. 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.

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 reuse in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation isdesired.

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 slopes or below the established grades or loosen any material outside the limits of excavation. Subject to the permitted tolerances, any excess depth excavated below the specified levels on the road shall be made good at the cost of the Contractor with suitable material of similar characteristics 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..

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.

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.

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. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the Engineer, at the cost of the Contractor.

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.

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.

Dewatering

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

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 roadway embankment, existing pits in the right -of-way and for landscaping of the road as directed by the Engineer, including levelling and spreading with all lifts and any lead within Boundary area 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 within Boundary.

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

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.

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.

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 subsurface drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any change. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his expense. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of 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.

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 (that 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/base course.

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,

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.

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

i	Loosening and recompacting the loosened material at subgrade	Cum
ii	Loosening and removal of unsuitable material and replacing with a suitable material and compacting to required density	Cum
iv	Stripping including storing and reapplication of topsoil	Cum

Rates

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

i) setting out;
ii) transporting the excavated materials and depositing the same on sites of embankments, spoil banks or stacking as directed within all lifts and lead within Boundary;
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 pre splitting is prescribed to achieve a specified slope in rock excavation, the same shall be paid for vide Clause 303.5.

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

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.

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 up to 1000 m.

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 EXCAVATION FOR STRUCTURES

Scope

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

Classification of Excavation

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

Construction Operations

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.

Excavation

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

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

Dewatering and Protection

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

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

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

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

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

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

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 any other material as advised by Engineer as per use 2104.1 at the cost of the Contractor. Ordinary filling shall not be permitted to bring the foundation to the design level as shown in the drawing.

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

Slips and Slip-Outs

If there are any slips or slip-outs in the excavation, these shall be removed by the Contractor at his own cost.

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.

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 teen 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 one with the help of suitable equipment such as trench compactor, mechanical tamper, rammer plate vibrator etc., after necessary watering, so as to achieve the maximum dry

Disposal of Surplus Excavated Materials

Clause 301.3.11 shall apply.

Measurements for Payment

Excavation for structures shall be measured in cu.m for each class of material encountered, limited to the dimensions shown on the drawings or as directed by the Engineer. Excavation over increased width, cutting of slopes, production/support to the existing structures shoring, shuttering and planking shall be deemed as incidental to the main work and shall not be measured and paid separately.

Rates

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

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

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

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.

303 EMBANKMENT CONSTRUCTION

General

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.

Materials and General Requirements

Physical Requirements

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:

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

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.

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

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

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 meters height Not subject to extensive flooding	Not less than 16.0 kN/cu.m.
2	Embankments exceeding 3 meter's height or embankments of any height subject to long periods of inundation	Not less than 17 kN/cu.m.
3	Subgrade and earthen shoulders/verges/backfill	Not less than 18.0 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-2

General Requirements

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.

Borrow Materials

No borrow area shall be made available by the Employer. The arrangement for the source of supply of the material for embankment and sub-grade complying with the guidelines 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.

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.

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 there from.

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

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

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 & Subgrade

Sl. No .	Type of Work/ Material	Relative compaction as percentage of max. laboratory dry density as per IS : 2720 (Part VIII)	Minimum CBR %
1.	Sub-grade and earthen shoulders	Not less than 98%	10.00
2.	Embankment	Not less than 97%	5.00
3.	Expansive clays Sub-grade and 500mm. portion just below Remaining portion of embankment	Not allowed Not less than 90%	4.00

The subgrade shall be stablized with lime, by mechanical stablization so as per direction of Engineer in Charge.

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 fill 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.

Construction Operations

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.

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.

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 revegetation 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.

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 Rolling in accordance with clause no 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the 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 up to 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 303.2.1.1, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

Spreading Material in Layers and Bringing to Appropriate Moisture Content

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 placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table 300-2 and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

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 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, work on compaction shall be suspended.

Moisture content of each layer of soil shall be check 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 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 harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

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

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 overthem.

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 the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical 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.

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 be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of 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 efficiency 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.

Each layer of the material shall be thoroughly compacted to the densities specified in Table 300-2. Subsequent layers shall be placed only after the finished layer has been tested

according to Clause 903.2.2 and accepted by the Engineer. The Engineer may permit measurement, of field dry density by 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.

Drainage

The surface of the embankment/subgrade at all times 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.

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

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 mm to 150 mm.

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

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

Construction of Embankment and Subgrade under Special Conditions

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.

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.

Earthwork over Existing Road Surface

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

If the existing road surface is of granular 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.

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.

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.

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 up to 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 E n g i n e e r 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 all 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 b a c k f i l l , 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.

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 303.3.

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 nonplastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

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 of 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 it's 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.

Settlement Period

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

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.

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.

Subgrade Strength

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.

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.

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 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.

Rates

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 corners;
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.

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 transportation involved beyond the specified initial lead.

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

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

Clauses 301.9.1 and 303.8 shall apply as regards Contract rates for items of removal of unsuitable material and replacement with suitable material respectively.

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

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

The Contract unit rate for providing and laying filter material 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.

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

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

304 TURFING WITH SODS

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.

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.

Construction Operations

Preparation of the Earth Bed

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

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

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 flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over tin's followed by its thorough compaction.

Staking the Sods

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

Top Dressing

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

Watering and Maintenance

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

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

Measurements for Payment

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

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, equipment and incidentals to complete the work in accordance with these Specifications.

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

305 SEEDING AND MULCHING

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.

Materials

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.

   i) Fertilizer shall consist of standard commercial materials and conform to the grade specified.

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 percent 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.

   ii) 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.

306 SURFACE/SUB-SURFACE DRAINS

Scope

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

Surface Drains

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

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

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

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

Sub-Surface Drains

Scope

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

Materials

Pipe

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

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 specified any particular gradings for the backfill material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Engineer, the backfill material shall be provided on the following lines:

i) Where the soil met with in the trench is of fine grained type (e.g., silt, clay or a mixture thereof), the backfill material shall conform to Class I grading set out in-Table 300-4;
ii) Where the soil met with in the trench is of coarse silt to medium sand or sandy type, the backfill material shall correspond to Class II grading of Table 300-4; and
iii) Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class III grading of Table 300-4.

Thickness of backfill material around the pipe shall be as shown on the drawings subject to being at least 150 mm around in all cases.

Trench Excavation

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

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

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.

Table 300-3: Grading Requirements for Filter Material

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

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

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

Non-perforated pipes shall be laid with joints as close as possible with the open joints wrapped with suitable pervious material (like 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 the top by means of 150 mm thick layer of compacted clay so as to prevent percolation of surface water.

Use of Geosynthetic in Laying of Pipe and Backfilling

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

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

Drain Outlet

The outlet for a sub-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.

Aggregate Drains

Aggregate drains shall be placed within the verge/ shoulders after completion of the pavement. Depth, thickness and spacing of the aggregate drains shall be as shown on the 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 in 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. TypeA grading allows a much wider range.

Table 300-4: Grading Requirements for Aggregate Drains

Sieve Designation	Per cent passing 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	-

Measurements for Payment

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

Rates

The Contract unit rates for surface and sub-surface drains shall be payment in full for all items such as excavation, dressing the sides and bottom; providing lining, turfing, pitching, masonry, concrete and plastering; providing, laying and jointing pipes; 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 including for removal of unsuitable material. Provision of inlets, gratings, sumps, outlet pipes, bedding, disbursers etc. wherever required shall be incidental to construction of drain.

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

401 GRANULAR SUB-BASE

Scope

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

Materials

The material to be used for the work shall be natural sand, 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 grading's given in Table 400-1 and physical requirement given in table 400-2

Grading 3 and 4 shall preferably be used in lower sub base. The grading to be adopted for a project shall be specified in a Contract/Construction Drawing. Where the sub base is laid in 2 layers as upper sub base and lower sub base, the thickness of each layer shall not be less than 150 mm.

The material shall have a 10 percent fines value of 50kN or more (for sample in soaked condition) when tested in compliance with IS:2386 (Part IV) 1963. The water absorption value of the coarse aggregate shall be determined as per IS:2386 (Part 3). If the water absorption of the aggregate determined as per IS:2386 (part 3) is greater than 2%,the aggregate shall be tested for wet aggregate impact value (AIV) (IS:5640). Soft aggregate like kankar, brick ballast and laterite shall also be tested for wet (AIV) (IS: 5640).

TABLE 400-1: Grading for Granular Sub-Base Materials

Percent by Weight Passing the IS Sieves						
IS Sieve Designation	**Grading I**	**Grading II**	**Grading III**	**Grading IV**	**Grading V**	**Grading VI**
75.0 mm	100	-	-	-	100	-
53.0 mm	80-100	100	100	100	80-100	100
26.5 mm	55-90	70-100	55-75	50-80	55-90	75-100
9.5 mm	35-65	50-80	-	-	35-65	55-75
4.75 mm	25-55	40-65	10-30	15-35	25-50	30-55
2.36 mm	20-40	30-50	-	-	10-20	10-25
0.85 mm	-	-	-	-	2-10	-
0.0425 mm	10-15	10-15	-	-	0-5	0-8
0.075 mm	<5	<5	<5	<5		

TABLE 400-2: Physical requirement for material for granular sub base

Aggregate Impact Value (AIV)	IS:2386 (Part 4) or IS:5640	40 maximum
Liquid Limit	IS:2720 (P art 5)	Maximum 25
Plasticity Index	IS:2720 (P art 5)	Maximum 6
CBR at 98% dry density (at IS:2720-Part 8)	IS:2720 (P art 16)	Minimum 30 unless otherwise specified in the Contract

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 —qualityll of materials, as may be necessary.

Construction Operation

Preparation of Subgrade

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

Spreading and Compacting

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

Moisture content of the mix shall be checked in accordance with IS :2720 (part 2) and suitably adjusted so that ,at the time of compaction ,it is 1 to 2 % below the optimum moisture content Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80-100 KN weight may be used. For a compacted single layer up to 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80-100 kN static weight capable of achieving the required compaction. Rolling should commence at a lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or on super elevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and process towards the crown.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall shall be checked and any high spot or depression which become apparent, corrected by removing or adding fresh material. The speed of roller shall not exceed 5 km/hr.

Rolling should be continued till the density achieved is at least 98 % 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 ne well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material .all loose segregated and otherwise defective areas shall be made good to the full thickness of layer and re compacted.

Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirement of clause 902 control on the Quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

Arrangements for Traffic

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

Measurements for Payment

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

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

Rate

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

i) Making arrangements for traffic to Clause 112 except for initial treatment to verges, shoulders and construction of diversions;
ii) Supplying all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and lifts;
iii) All labour, tools, equipment and incidentals to complete the work to the Specifications;
iv) carrying out the work in pan widths of road where directed; and
v) Carrying out the required tests for quality control.

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

Scope

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

Materials

Soil

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

Lime

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

Quantity of Lime in Stabilized Mix

Quantity of lime to be added as percentage by weight of the dry soil shall be as specified in the Contract. The quantity of lime used shall be related to its calcium oxide content which shall be

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

Water

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

Constructions Operations

Weather Limitations

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

Degree of Pulverization

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

Table 400-2: Soil Pulverization Requirements for Lime Stabilization

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

Equipment for Construction

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

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

The thickness of any layer to be stabilized shall be not less than 100 mm when compacted. The

Maximum thickness can be 200 mm, provided the plant used is accepted by the Engineer.

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 stabilized layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled as directed by the Engineer.

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

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

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

Construction with Manual Means

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

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

Addition of Lime

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

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

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

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

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

Mixing or remixing operations, regardless of equipment used, shall continue until the material 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.

Moisture Content for Compaction

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

Rolling

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

Care shall be taken to see that the compaction of lime stabilized 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.

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.

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.

Strength

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

Arrangement for Traffic

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

Measurements of Payment

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

Rate

The Contract unit rate for lime stabilized soil sub-graded/ sub-base shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v).

406 WET MIX MACADAM SUB -BASE/BASE

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 are used, the compacted depth of single layer of the sub- base course may be up to 200mm with the approval of the engineer.

Material

Aggregates

Physical requirements: Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400 -10 below.

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).

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

	Test	Test Method	Requirements
1.	*Los Angles Abrasion value Or *Aggregate Impact value	IS: 2386 (Part-4) IS: 2386 (Part-4) Or IS: 5640	40 per cent (Max) 30 per cent (Max)
2.	Combined Flakiness and Elongation Indices (Total)	IS: 2386 (Part-1)	35 per cent (Max)**

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

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

406.2.1.2 Grading Requirements

The aggregate shall conform to the grading given in Table 400-11.

Table 400-13: Grading Requirements of Aggregates for Wet Mix Macadam

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

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 fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

Construction Operations

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

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

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

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 408.4.1

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 pug mill or pan type mixer of concrete batching plant. The plant shall have following features:

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

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

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 by a paver finisher. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used.

The paver finisher shall be self-propelled, of repute make, proven design and adequate capacity with following features:

i) Tractor unit shall have crawler tracks or pneumatic tyre.
ii) Racks provide greater traction and suitable to work on soft or loose subbases and laying large width up to 10 m or more. Wheeled paver is faster and normally preferred to work on hard surfaces with width up to 8 m.

iii) Material distribution system comprising of hopper, two conveyor belts each working independently, conveyor speed adjustable with limit switches and auger system easily capable of raising and lower; to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.

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

v) The drive shall be hydrostatic with infinite variable speed.

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

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

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

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 up to 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.

Setting and Drying

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

Opening to Traffic

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.

Surface Finish and Quality Control of Work

Surface Evenness

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

Quality Control

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

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 case shall depressions be filled up with unmixed and ungraded material or fines.

Arrangement for Traffic

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

Measurements for Payment

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

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 401.7.

408 SHOULDERS, ISLANDS AND MEDIAN

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 channelizing 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.

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 paved as per Clause 410.3.4 or 410.3.5.

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

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.

Construction Operations

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

Compaction requirement of earthen shoulder shall be as per Table 300-3. In the case of bituminous courses, 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.

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.

Brick/Stone Block Edging

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

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.

Measurement for Payment

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

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

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 401.7 (i) to (v) as applicable. The rate for brick/stone block edging shall include the cost of sand cushion.

409 CONCRETE KERB

Scope

This work shall consist of constructing cement concrete kerbs and kerbs with channel in the

central median and/or along the footpaths or separators in conformity with the lines, levels and dimensions as specified in the drawings or as directed by the Engineer.

Materials

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

Type of Construction

These shall be precast concrete blocks as per approved drawing.

Construction Operations

Kerb shall be laid on firm foundation of minimum 100 mm thickness of cement concrete of M 15 grade cast in-situ or on extended width of pavement. The foundation shall have a projection of 50 mm beyond the kerb stone. Before laying the foundation of lean concrete, the base shall be leveled and slightly watered to make it damp.

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

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.

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

Measurements for Payment

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

Rate

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

410 FOOTPATHS AND SEPARATORS

Scope

The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the Engineer.

The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed by the Engineer.

Materials

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

a) Cast-in-situ or precast cement concrete of Grade M 20 as per Section 1700 of the Specifications. The minimum size of the panels shall be as specified in the drawings.
b) Precast cement concrete blocks and interlocking blocks/tiles of grade not less than M 30 as per Section 1700 of the Specifications. The thickness and size of the cement concrete blocks or interlocking blocks/ tiles shall be as specified in the drawings.
c) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The thickness and size of the natural stone slab shall be as specified in the drawings.

Construction Operations

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

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

The base for cast-in-situ cement concrete panels/ tiles/ nature stone slab shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings.

Over the prepared base, precast concrete interlocking blocks/tiles/natural stone slabs and/or cast-in- situ slab shall be set/laid as described in Clauses 410.3.4 and 410.3.5.

Tiles/Natural Stone Slabs

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

Cast-in-Situ Cement Concrete

The panels of specified size shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per Section 1700 of the Specifications.

Precast Concrete Blocks and Interlocking Concrete Block Pavements

The precast concrete blocks and interlocking concrete block pavement shall be laid on a bedding of sand of thickness specified in the drawing. The grading of the sand layer shall be as in Table 400-16.

Table 400-16

IS Sieve Size	Percent Passing
9.52 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-95
600 micron	25-60
300 micron	10-30
150 micron	0-15
75 micron	0-10

The joints shall be filled with sand passing a 2.35 mm size with the grading as in Table 400-6.

Table 400-17

IS Sieve Size	Percent Passing
2.36 mm	100
1.18 mm	90-100
600 micron	60-90
300 micron	30-60
150 micron	15-30
75 micron	0-10

The bedding sand slightly moist, the moisture content being about 4 percent.

The bedding sand shall be compacted by vibratory plate compactor.

The blocks shall be laid to the levels indicated on the drawings and to the pattern directed by the Engineer. The surface tolerance shall be ±10 mm with respect to the design level. The blocks shall be embedded using a hammer.

Measurements for Payment

Footpaths and separators shall be measured in Sq.m between inside of kerbs. The edge restraint block and kerb shall be measured separately in linear meter. The items pertaining to linage shall be measured separately.

Rates

Contract unit rates shall be inclusive of full compensation for all labour, materials, tools, equipment for footpaths including the base. Cost of providing pipes and arrangement for their discharge into appropriate drainage channels shall be incidental to the construction of footpaths.

500 BASES AND SURFACE COURSES (BITUMINOUS)

501 GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

General

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

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

Materials

Binder

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

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

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

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

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

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

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

Lowest Daily Mean Air Temperature, °C	HIGHEST DAILY MEAN AIR TEMPERATURE, °C		
	Less than 20°C	20° to 30°C	More than 30°C
More than -10 °	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

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

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

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

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

Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder and wearing courses. However, natural sand up to 50 percent of the fine aggregates may be allowed in base courses. Fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37). The plasticity index of the fraction passing 0.425 mm shall not exceed 4 when tested in accordance with IS:2720 (Part 5). The fine aggregates shall satisfy the physical requirements set forth in the individual relevant-clause for the material in question.

Sources of Material

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

Mixing

Pre-mixed bituminous materials shall be prepared in a batch type hot mix plant of capacity 100 to 120 TPH and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures are given in Table 500-2 of these Specifications, the difference in temperature between the binder and aggregate shall at no time exceed 14°C. In order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in Annex A of IRC:27.

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

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	*Rolling Temperature
VG-40	160-170	160-170	160-170	150 Min	100 Min
VG-30	150-165	150-170	150-165	140 Min	90 Min
VG-20	145-165	145-170	145-165	135 Min	85 Min
VG-10	140-160	140-165	140-160	130 Min	80 Min

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

Transporting

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

Laying

Weather and Seasonal Limitations

Laying shall be suspended:

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

Cleaning of Surface

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

Spreading

Prior to spreading the mix, the base shall be prepared by carrying out the required operations as per Clause 501.8 depending upon the site conditions. Except in areas where paver cannot get access, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine equipped with an electronic sensing device. The essential features of the paver finisher shall conform to Annex A of IRC: 27. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space (such as confined space, foot ways, of irregular shape and varying thickness, approaches to expansion joints etc.) where paver cannot be used, the material shall be spread, raked and levelled with suitable hand tools by trained staff.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these Specifications. When laying binder course

or wearing course approaching an expansion joint of a structure, machine laying shall stop 300 mm short of the joint. The remainder of the pavement up to the joint, and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

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

Cleanliness and Overlaying

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

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

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

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

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

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

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

sufficient moisture to prevent adhesion between the wheels of rollers and the mix should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

Joints

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

a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face coated with a suitable viscosity grade hot bitumen, or cold applied emulsified bitumen. While spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix shall be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.

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

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

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

Preparation of Surface

Scope

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

Materials

For Scarifying and Re-laying the Granular Surface

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

For Patching Potholes and Sealing Cracks

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

For Profile Corrective Course

The type of material for use as profile corrective course shall be as shown on the drawing 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.

Construction Operations

Preparing Existing Granular Surface

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

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

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

Scarifying Existing Bituminous Surface

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

The compacted finished surface shall be primed in accordance with **Clause 502.** Reusable materials shall be stacked as directed by the Engineer with all leads and lifts.

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.

Profile Corrective Course

A. Application of Profile Corrective Course

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

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

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

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

B. Laying on Granular Base

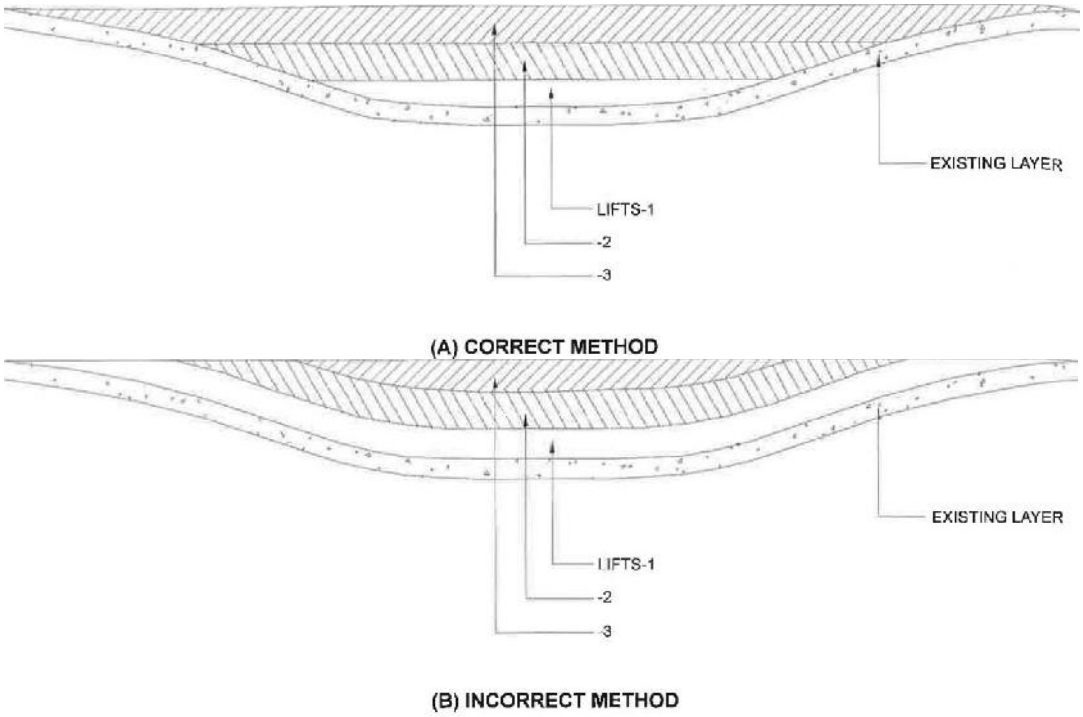
After preparing the granular surface in accordance with Clauses 501.8.3.1 and 501.8.3.2, the profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4 (a), or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.

C. Laying on Existing Bituminous Surface

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

D. Correction of Local Depressions, Camber and Super-Elevation

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



Note: Profile corrective course material to be in accordance with the lift thickness

Fig. 500-1: Methods for Providing Corrective Course for Short Sags and Depressions

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

Covering the Profile Corrective Courses

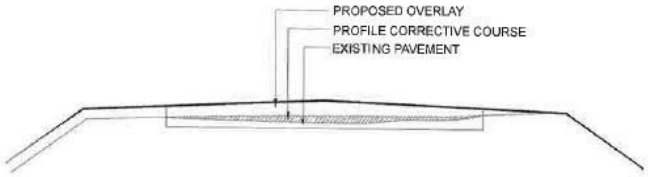
Profile corrective course shall be so planned that the layer shall be covered by the designed base/wearing course at the earliest opportunity, before opening to regular traffic.

Surface Finish and Quality Control of Work

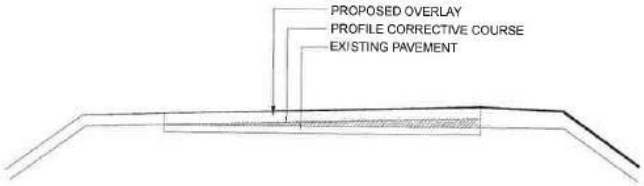
The relevant provisions of Section 900 shall apply.

Arrangements for Traffic

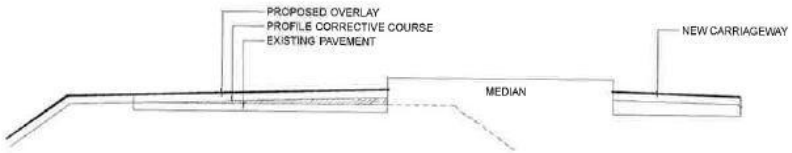
During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.



Case I : Deficiency in camber being rectified by profile corrective course



Case II : Deficiency in super-elevation being rectified by profile corrective course



Case III : Converting two-sided camber to one-sided cross-fall during provision of a dual carriageway

Fig. 500-2 : Correction of Camber or Super-Elevation

Environmental Protection

The provisions of clause 111 and the provision of Annex A to Clause 501 shall apply.

Measurement for Payment

Cleaning of the Surface

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

Scarifying

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

Environmental Protection

The provisions of Clause 111 and the provision of Annex A to Clause 501 shall apply.

Measurement for Payment

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

Scarifying

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

Prime Coat

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

Tack Coat

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

Potholes and Crack Sealing

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

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

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

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

Profile Corrective Course

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

Filling of Local Depressions

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

Rates

Rate for Scarifying

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

501 8.8.2 Rate for Premixed Bituminous Material

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

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

Rate for Potholes and Crack Sealing

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

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

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

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

Rate for Prime Coat

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

Rate for Tack Coat

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

Rate for Filling of Local Depressions

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

Rate for Profile Corrective Course

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

Annex „A" to Clause 501 Annex „A" PROTECTION OF THE ENVIRONMENT

a. General

This Appendix sets out limitations on the Contractor's activities specifically intended to protect the environment.

The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on or off site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in these specifications.

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. 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 areas to its original state to the satisfaction of the Engineer.

b. Water

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. Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be reused for dust suppression and rinsing. All water and other liquid waste products arising on the site shall be collected and disposed of at a location on or off the site and in a manner that shall not cause nuisance or pollution. 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. 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. 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.

c. Air Quality

The Contractor shall devise and arrange methods of working to minimize dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimize adverse impacts on air quality.The Contractor shall utilize effective water sprays during delivery, manufacture, processing and handling of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials shall be covered with clean tarpaulins, with application of sprayed water during dry and windy weather. Stockpiles of material or debris shall be dampened prior to their movement, except where this is contrary to the Specifications. Any vehicle with an open load-carrying area used for transporting potentially dust producing material shall have properly fitting side and tail boards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards, and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extended at least 300 mm over the edges of the side and tail boards.

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

d. Noise

i. The Contractor shall consider noise abutment measures in his planning and execution of the Works.

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

e. Control Of Wastes

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

f. Emergency Response

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.

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.

g. Measurement

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

502 PRIME COAT OVER GRANULAR BASE

Scope

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

Materials

The bituminous material to be used as primer shall be such that it can penetrate about 10 mm deep into base course. Bitumen emulsion SS1 grade conforming to IS:8887/ASTM D2397 or medium curing cutback bitumen conforming to IS:2177 can be used as primer

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

TABLE 500-3: Quantity of Bitumen Emulsion for Various Types of Granular Surfaces

Type of Surface	Rate of Spray (Kg/ Sqm)
WMM / WBM	0.7 – 1.0
Stabilized soil base/Crusher Run Macadam	0.9 – 1.2

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

Table 500-4: Type and quality of cutback bitumen for various types of granular surface

Type of Surface	Type of Cutback	Rate of Spray (Kg/ Sqm)
WMM / WBM	MC30	0.6-0.9
Stabilised soil base/Crusher Run Macadam	MC70	0.9-1.2

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

Weather and Seasonal Limitations

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Cutback bitumen as primer shall not applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

Construction

Equipment

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall

not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

Preparation of Road Surface

The surface to be primed shall be prepared in accordance with Clauses 501.8 and 902 as appropriate. Immediately prior to applying the primer, the surface shall be swept clean of dust and loose and other foreign particles using power broom or mechanical sweepers, care being taken not to disturb the interlocked aggregates. 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.

Application of Bituminous Primer

After preparation of base as per 502.4.2, the 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.

No heating or dilution of SS1 emulsion and preparation of cutback bitumen shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively.

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.

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.

Arrangements for Traffic

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

Measurement for Payment

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

Rate

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v) and as applicable to the work specified in these Specification. Payment shall be made on the basis of the provision of prime coat at an application rate of 0.6 kg per square metre or as specified, 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

Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous, cement concrete or primed granular surface preparatory to

the superimposition of a bituminous mix, when specified in the Contract or instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with Clause 501.8.

Materials

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

Weather and Seasonal Limitations

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

Construction

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 shall not be permitted except in small areas, inaccessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

Preparation of Base

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

Application of Tack Coat

The application of tack coat shall be at the rate specified in Table 500- 5 and it shall be applied uniformly. No dilution or heating at site of RS 1 bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Table 500-5: Rate of Application of Tack Coat

Type of Surface	Rate of Spray of binder in Kg per Sq. m
Bituminous Surfaces	0.20 – 0.30
Granular surfaces treated with Primer	0.25 – 0.30
Cement concrete pavement	0.30 – 0.35

503.4.4. Curing of Tack Coat

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

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.

Arrangements for Traffic

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

Measurement for Payment

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

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 these Specification. 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 the payment adjusted accordingly.

504 BITUMINOUS MACADAM

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 508 and 505. Since the bituminous macadam is an open-graded mixture, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer should have proper drainage quality to prevent moisture-induced damage to the BM.

Materials

Bitumen:

The bitumen shall be viscosity graded paving bitumen complying with Indian Standard Specifications for Paving Bitumen IS:73. Guidelines for selection of viscosity grade of paving grade of bitumen are given in Table 500- 1.

Table 500-6: Physical Properties of Coarse Aggregate

Property	Test	Requirement	Test method
Cleanliness	Grain Size Analysis	Max. 5% passing 0.075 micron	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max. 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max. 40% Max. 30%	IS:2386 Part IV IS:2386 Part IV
Durability	Soundness (Sodium or Magnesium)	5 Cycles	

Property	Test	Requirement	Test method
	Sodium Sulphate Magnesium Sulphate	 Max. 12% Max. 18%	 IS:2386 Part V IS:2386 Part V
Water absorption	Water absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate	Minimum retained coating 95%	IS:6241
water sensitivity	Retained Tensile strength*	Min. 80%	AASHTO 283

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

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, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. The aggregates shall satisfy the physical requirements set forth in Table 500-6. Where crushed material retained on 4.75mm sieve shall have at least two fractured faces resulting from crushing operation. Before approval of the source, the aggregates shall be tested for stripping. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, without additional payment.

Fine Aggregates

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

Aggregate Grading and Binder Content

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

Proportioning of Material

The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 500-7. The binder content shall be within a tolerance of ± 0.3 per cent by weight of total mix when individual specimens are taken for quality control tests in accordance with the provisions of Section 900.

Construction Operations

Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

Table 500-7: Aggregate Grading and Bitumen Content

Grading Nominal Maximum 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	100
37.5	90-100	
26.5	75-100	
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 mass of total mix	3.3**	3.4**

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

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

Preparation of the Base

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clauses 501.8 and 902.3 as appropriate, and a prime coat, shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer.

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.

Preparation and Transportation of the Mixture

The provisions of Clauses 501.3 and 501.4 shall apply.

Spreading

The provisions of Clauses 501.5.3 shall apply.

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.

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.

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 512 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

Arrangements for Traffic

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

Measurement for Payment

Bituminous macadam shall be measured as finished work 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.

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.

505 DENSE GRADED BITUMINOUS MACADAM

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. 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.

Materials

Bitumen

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

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

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, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates 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.

Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand up to 50 percent of the fine aggregate may be allowed in base courses. The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720(37). The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4, when tested in accordance with IS: 2720 (Part 5)

Filler

Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in Table 500-9. The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. 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.

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 500-8: Physical Requirements for coarse Aggregate for Dense Bitumen Macadam

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35% Max 27%	IS:2386 Part IV
Durability	Soundness either :Sodium Sulphate or Magnesium Sulphate	Max 12% Max18%	IS :2386 Part V
Water Absorption	Water absorption	Max 2%	IS :2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength**	Min. 80%	AASHTO 283

Notes: 1. IS: 2386Part I

2. IS: 2386 Part I*

3. IS: 2386 Part 4**

4. IS: 2386Part4**

5. IS: 2386Part5

6. IS: 2386 Part 3

7. IS: 6241

8. AASHTOT283***

(The elongation test to be done only on non-flaky aggregates in the sample)

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

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

Table 500-9: Grading Requirements for Mineral Filler

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

TABLE 500-10: Composition of dense Grade Bituminous Macadam

Grading	1	2
Nominal aggregate Size	**37.5**	**26.5**
Layer Thickness	**75-100 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	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0**	Min 4.5**

Notes: 1. IS: 2386Part I
2. IS: 2386 Part I*
3. IS: 2386 Part 4**
4. IS: 2386Part4**
5. IS: 2386Part5
6. IS: 2386 Part 3
7. IS: 6241
8. AASHTOT283***

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

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

Bitumen content indicated in Table 500-10 is the minimum quality. The quantity shall be determined as per 505.3.

Mix Design

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt institute Manual MS-2. The fines to bitumen (F/B) ratio by weight shall range 0.6-1.2.

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

Properties	Viscosity Grade Paving Bitumen	Modified bitumen		Test Method
		Hot climate	Cold climate	
Compaction level	75 blows on each face of the specimen			
Minimum stability (kN at 600C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245
Marshall Quotient (Stability/Flow)	2-5	2.5-5		MS-2 and ASTM D2041
% air voids	3-5			
% Voids Filled with Bitumen (VFB)	65-75			
Coating of aggregate particle	95% MINIMUM			IS:6241
Tensile Strength ratio	80% MINIMUM			AASHTO T283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 500-13			

*The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12

Notes: 1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 percent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

Binder Content

The binder content shall be optimized to achieve the requirements of the mix set out in Table 500-11. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in Table 500-12 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

Table 500-12: Minimum Percent Voids In Mineral Aggregate (VMA)

Nominal Maximum particle Size1 (mm)	Minimum VMA Percent Related to Design Percentage Air voids		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0

Nominal Maximum particle Size1 (mm)	Minimum VMA Percent Related to Design Percentage Air voids		
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 percent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

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;

   a) Proportions of all materials expressed as follows where each is applicable:
   b) Binder type, and percentage by weight of total mixture;
   c) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

ii) A single definite percentage passing each sieve for the mixed aggregate;
iii) The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.
iv) The results of tests enumerated in Table 500-11 as obtained by the Contractor;
v) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch,
vi) Test results of physical characteristics of aggregates to be used;
vii) 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.

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	Base/binder Course
Aggregate passing 19 mm sieve or larger	± 8 %
Aggregate passing 13.2 mm, 9.5 mm	± 7%

Description	Base/binder Course
Aggregate passing 4.75 mm	± 6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%
Aggregate passing 0.3 mm, 0.15 mm	± 4%
Aggregate passing 0.075 mm	± 2%
Binder content	± 0.3%
Mixing temperature	± 10°C

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. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density based on theoretical maximum specific gravity obtained on the day of compaction in accordance with ASTM D 2041.

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

Construction Operations

Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

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.

Stress Absorbing Layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements as per clause 517

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.

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.

Mixing and Transportation of the Mixture

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

Spreading

The provisions of Clauses 501.5.3 and 501.5.4 shall apply.

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.

Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hours or the layer has cooled to ambient temperature after laying and completion of compaction or until , without the express approval of the Engineer in writing.

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.

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.

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.

Rate

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

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

507 BITUMINOUS CONCRETE

Scope

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25mm/40 mm/50 mm thick.

Materials

Bitumen

The bitumen shall conform to Clause 505.2.1.

Coarse Aggregates

The coarse aggregates shall be generally as specified in Clause 505.2.2, except that the aggregates shall satisfy the physical requirements of

Table 500-18 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 500-18: Physical Requirements for Coarse Aggregate for Bituminous Concrete

Property	Test		Specification
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Flakiness Index Elongetion index	Max 15% Max 20%	IS:2386 Part I
Strength	Los Angeles Abrasion Value Aggregate Impact Value	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either : Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished stone value	Min 55	IS:2386 Part IV
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

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

Fine Aggregates

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

Filler

Filler shall be as specified in Clause 505.2.4.

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 500-19 for grading 1 or 2, as specified in the Contract.

Table 500-19 Composition of Bituminous Concrete Pavement Layers

Grading	1	2
Nominal aggregate size*	**19mm**	**13.2mm**
Layer thickness	**50 mm**	**25/40 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	5.2	5.4

Notes: * The nominal maximum particle size is the largest specified sieve size up on which any of the aggregate is retained.

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

Mix Design

Requirements for the Mix

Clause 505.3.1 shall apply.

Binder Content

Clause 505.3.2 shall apply.

Job Mix Formula

Clause 505.3.3 shall apply.

Plant Trials – Permissible Variation in Job Mix Formula

The requirements for plant trials shall be as specified in Clause 505.3.4, and permissible limits for variation as given in Table 500-20.

Table 500-20: Permissible Variations from the Job Mix Formula

Description	Bituminous concrete
Aggregate passing 19 mm sieve or larger	+ 7%
Aggregate passing 13.2 mm, 9.5 mm	+ 6%
Aggregate passing 4.75 mm	+ 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	+ 4%
Aggregate passing 0.3 mm, 0.15 mm	+ 3%
Aggregate passing 0.075 mm	+ 1.5%
Binder content	+ 0.3%
Mixing temperature	+ 10°C

Laying Trials

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

Construction Operations

Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

Preparation of Base

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

Geosynthetics

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

Stress Absorbing Layer

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

Tack Coat

The provisions as specified in Clause 505.4.5 shall apply.

Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3, 501.4 and 505.4.7 shall apply.

Spreading

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

Rolling

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

Opening to Traffic

Provisions in Clause 505.5 shall apply.

Surface Finish and Quality Control

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

Arrangements for Traffic

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

Measurement for Payment

The measurement shall be as specified in Clause 505.8.

Rate

The contract unit rate shall be all as specified in Clause 505.9, except that the rate shall include the provision of bitumen at 5.2 percent and 5.4 percent for grading 1 and grading 2, by weight of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

517 CRACK PREVENTION COURSES

Scope

This clause covers the provisions of Stress Absorbing Membrane (SAM) and Stress Absorbing Membrane Interlayer (SAMI) as measures to inhibit the propagation of cracks. 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 single coat or a double coat. 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. SAMI may be a material similar to that used for a SAM. It may alternatively consist of a bitumen impregnated geotextile.

Materials

Binder

Binder shall be a modified binder complying with the requirements of IS:15462, according to the requirements of the Contract, except that viscosity grade VG 10 complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

Aggregate

The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of SAMI. Where required by the contract, aggregate shall be pre-coated using either of the techniques permitted by Clause 510.2.5.

Rates of Spread of Binder and Aggregate

The rate of spread of binder and aggregate shall be according to one of the size alternatives in Table 500-42, as required by the Contract.

Geotextile

The use of geotextile as prescribed for Sl.No.7 in Table 500-42 shall conform to the requirements of Clause 703.3.

Construction Operations

Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

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.

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 geotextile shall be applied according to Clause 502.4. The surface on which the binder is to be applied shall be dry.

Table 500-14: Quantity of Materials Required for 10 sq.m of Road Surface for Stress Absorbing Membrane

Sl.No.	Type and Width of Crack	Specification of SAM to be Applied	Quantity of binder Kg/10m²	Quantity of Chipping
1	Hair cracks and map cracks up to 3mm width	Single coat SAM or 2nd coat of two coat SAM	8-10	0.10m³ Of 5.6 mm chips
2	Map carcks or alligator cracks 3mm to 6mm width	Single coat SAM	10-12	0.11m³ Of 5.6 mm chips
3	Map cracks or alligator cracks 6 mm to 9 mm width	Two coat SAM 1st coat 2nd coat	12 – 14 8 – 10	12 m³ of 5.6 mm and 11.2 mm chips in 1:1 ratio 10 0.10 m³ of 5.6 mm chips
4	Cracks above 9mm width and cracked area above 50%	Two coat SAM 1st coat 2nd coat	14 – 16 8 – 10	0.12 m³ of 11.2 mm chips 0.10 m³ of 5.6 mm chips

Sl.No.	Type and Width of Crack	Specification of SAM to be Applied	Quantity of binder Kg/10m²	Quantity of Chipping
5	All types of cracks with crack width below 6 mm	Single coat SAM	8 – 10	10 0.10 m³ of 5.6 mm chips
6	All types of cracks with crack width below 6 mm	Single coat SAM	10 – 12	0.10 m³ of 11.2 mm chips

Note: Binder quantities for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 litres/m². Binder quantities outside this range are permitted according to the geotextile manufacturer's instructions and subject to the agreement of the Engineer.

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.

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.

Two coat SAM or SAMI

Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first coat.

Geotextile Placement

For bitumen impregnated geotextile, the requirements of Clause 703.4.4 shall apply.

Opening to Traffic

Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20km/h, until the following day. Speed control measures are to be approved by the Engineer, prior to laying.

Surface Finish and Quality Control of Work

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

Arrangements for Traffic

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

Measurement for Payment

Each application of SAM, SAMI or bitumen impregnated geotextile shall be measured as finished work, for the area specified, in square metres.

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.

516 MASTIC ASPHLAT

Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogenous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and void less mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

Materials

Binder

Subject to the approval of the Engineer, the binder shall be a paving/ Industrial grade bitumen meeting the requirements given in Table 500-39.

Table 500-39: Requirements for Physical Properties of Binder

Property	Test Method	Requirements
Penetration at 25°C	IS:1203	15 ± 5*
Softening point, °C	IS:1205	65± 10
Loss on heating for 5h at 163°C, % by mass Max	IS:1212	2.0
Solubility in trichloroethylene, % by mass Min.	IS:1216	95
Ash (mineral matter), % by mass Max.	IS:1217	1.0

*In cold climatic regions (temperature less than 10°C), VG 40 grade bitumen may be used.

Coarse Aggregates

The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from Soft, organic or other deleterious substances. They shall satisfy the physical requirements given in Table 500-6.

The percentage and grading of the coarse aggregates to be incorporated in the mastic: asphalt depending upon the thickness of the finished course should be as specified in Table 500-40.

Table 500-40: Grade and Thickness of Mastic Asphalt Paving and Grading of Coarse Aggregates

Application	Thickness Range(mm)	Nominal Size of Coarse Aggregate (mm)	Coarse Aggregate Content, % by Mass of Total Mix
Roads and bridge	25-50	13	40±10
Heavily stressed areas i.e. Junctions and toll plazas	40-50	13	45±10
Nominal size of coarse aggregate		13 mm	
IS Sieve (mm)		Cumulative % passing by weight	

Application	Thickness Range(mm)	Nominal Size of Coarse Aggregate (mm)	Coarse Aggregate Content, % by Mass of Total Mix
19		100	
13.2		88-96	
2.36		0-5	

Fine Aggregates: The fine aggregates shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry, and free from soft or flaky pieces and organic or other deleterious substances.

Filler : The filler shall be limestone powder passing the 0.075 mm sieve and shall have a calcium carbonate content of not less than 80 percent by weight when determined in accordance with IS:1514.

The grading of the fine aggregate inclusive of filler shall be as given in Table 500-41.

Table 500-41: Grading of Fine Aggregate {Inclusive of Filler)

IS Sieve	Percentage by weight of aggregate
Passing 2.36 mm but retained on 0.600 mm	0-25
Passing 0.600 mm but retained on 0.212 mm	10-30
Passing 0.212 mm but retained on 0.075 mm	10-30
Passing 0.075 mm	30-55

Mix Design

Hardness Number

The mastic asphalt shall have a hardness number at the time of manufacture of 50 to 70 at 25^{o}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 15:1195-1978.

Binder Content

The binder content shall be so fixed as to achieve the requirements of the mix specified in Clause 516.3.1 and shall be in the range of 14 to 17 percent by weight of total mix as indicated in Table 500-42.

Table 500-42: Composition of Mastic Asphalt Blocks without Coarse Aggregate

IS Sieve	Percentage by Weight of Mastic Asphalt	
	Minimum	Maximum
Passing 2.36 mm but retained on 0.600 mm	0	22
Passing 0.600 mm but retained on 0.212 mm	4	30
Passing 0.21·2 mm but retained on 0.075 mm	8	18
Passing 0.075 mm	25	45

Bitumen Content % by mass	14	17

Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of the work the job mix formula proposed to be used by him for the work, indicating the source ad 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.

Construction Operations

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.

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.

Tack Coat

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

Preparation of Mastic Asphalt

Preparation of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170°C to 210°C. Required quantity of bitumen shall be heated to 170°C to 180°C and added to the heated aggregated. They shall be mixed and cooked in an approved type of mechanically agitated mastic cooker for some time till the materials are thoroughly mixed. Initially the filler alone is to be heated in the cooker for an hour and then half the quantity of binder is added. After heating and mixing for some time, the fine aggregates and the balance of binder are to be added and further cooked for about one hour. The second stage is incorporation of coarse aggregates and cooking the mixtures for a total period of 3 hours. During cooking and mixing care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210°C.

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 kg each. Before use, these blocks shall be reheated to a temperature of not less than 175°C and not more than 210°C, thoroughly incorporated with the requisite quantity of coarse aggregates and mixed continuously. Mixing shall be continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-42.

The mix shall be transported to the laying site in a towed mixer transporter having arrangements for stirring and keeping the mix hot during transportation.

Spreading

The Mastic asphalt shall be laid, normally in one coat, at a temperature between 175°C and 210°C spread uniformly by hand using wooden floats or by machine on the prepared surface. The thickness of the mastic asphalt and the percentage of added coarse aggregate shall be in accordance with Table 500-40 or as specified by the Engineer. Where necessary, battens of the requisite dimensions should be employed. Any blow holes that appear in the surface shall be punctured while the material is hot, and the surface made good by further floating.

Laying surface over existing bridge deck : Before laying bitumen over existing bridge deck, the existing cross fall/camber, expansion joint members and water drainage spouts shall be carefully examined for their proper functioning in the bridge deck structure and any deficiency found shall be removed. Loose elements in the expansion joint shall be firmly secured. The existing wearing coat shall be removed, as per Clause 2809. The cracks in the concrete surface, if any, shall be repaired and filled up properly or replaced by new concrete of specified grade before laying the bitumen mastic over bridge deck.

Laying over new bridge deck: New concrete bridge deck which is not in camber/cross fall shall first be provided with required camber and cross fall by suitable concrete or bituminous treatment.

Treatment where mastic asphalt is laid over a concrete surface: In case of laying over and concrete surface, following measures shall be taken:

1) For proper bond with new concrete deck, surface shall be roughened by means of stiff broom or wire brush and it shall be free from ridges and troughs.
2) A thin bituminous tack coat (with bitumen of grade VG 30) shall be applied on the concrete deck before pouring mastic. The deck shall be dry. The quantity of bitumen for tack coat shall be as per Table 500-6.
3) After applying tack coat, chicken-mesh reinforcement of 1.5 mm dia steel wire with hexagonal or rectangular openings of 20-25 mm shall be placed and held properly in position on the concrete surface before pouring mastic.

Joints

All Construction joints shall be properly and truly made. These joints shall be made by warming exiting mastic asphalt by the application of an excess quantity of the hot mastic asphalt mix which afterwards shall be trimmed to leave it flush with the surfaces on either side.

Surface Finish

The mastic asphalt surface can have poor skid resistance after floating in order to provide resistance to skidding, the mastic asphalt after spreading, while still hot and in a plastic condition, shall be covered with a layer of stone aggregate . This aggregate shall be 13.2 mm size (passing the 19.0 mm sieve and retained on the 6.7 mm sieve) or 9.5 mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the Engineer. Hard stone chips, complying with the quality requirements of Table 500.16 shall be precoated with bitumen at the rate of 2 ± 0.4 percent of VG 30 grade. The addition of 2 percent of filler complying with Table 500.9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cum 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.

Opening of Traffic

Traffic may be allowed after completion of the work when the mastic asphalt temperature of the completed layer has cooled to the daytime maximum ambient temperature.

Surface Finish and Quality Control of Work

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

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

The surface of the mastic asphalt, tested with a straight edge 3 m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7 mm. The same shall also apply to the transverse profile when tested with a camber template.

Arrangements for Traffic

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

Measurement for Payment

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.

Rate

The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under Clause 501.8.2.2.

800 TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES

803 ROAD MARKINGS

Scope

The work shall consist of providing road markings of specified width, layout and design using paint of the required specifications as given in the Contract and as per guidelines contained in from IRC: 35-1997.

Materials

Road markings shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorised paint as specified in the item and the material shall meet the requirements as specified in these Specifications.

Ordinary Road Marking Paint

Ordinary paint used for road marking shall conform to Grade I as per IS:164.

The road marking shall preferably be laid with appropriate road marking machinery.

Hot Applied Thermoplastic Road Marking

Thermoplastic Material

General

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads. The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

Requirements

i) Composition: The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 800-9.

Table 800-9: Proportions of Constituents of Marking Material (Percentage by Weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-30	30-30
Titanium Dioxide	10.0 min.	--
Calcium Carbonate and Inert Fillers	42.0 max.	See Note below
Yellow Pigments	--	See Note below

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

ii) **Properties:** The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part I), shall be as below:

a) Luminance:

White: Daylight luminance at 45°-65 percent min. as per AASHTO M 249
Yellow: Daylight luminance at 45°-45 percent min. as per AASHTO M 249

b) Drying time: When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.
c) Skid resistance: not less than 45 as per BS: 6044
d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
e) Softening point: 102.5°C ± 9.5°C as per ASTM D 36.
f) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

iii) Storage life: The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/ Contractor.

iv) Reflectorisation: Shall be achieved by incorporation of beads grading and other properties of the beads shall be as specified in Clause 803.4.2.

v) Marking: Each container of the thermoplastic material shall be Clearly and indelibly marked with the following information:

a) The name, trademark or other means of identification of manufacturer
b) Batch number
c) Date of manufacture
d) Colour (white or yellow)
e) Maximum application temperature and maximum safe heating temperature.

vi) **Sampling and Testing:** The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

Reflectorizing Glass Beads

General

This Specification covers two types of glass beads to be used for the production of reflectorized pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-9 and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6.4.

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

These shall conform to the requirements spelt out in Clause 803.4.2.3.

Specific Requirements

a) **Gradation:** The glass beads shall meet the gradation requirements tor the two types as given in Table 800-10.

Table 800-10: Gradation Requirements for Glass Beads

Sieve Size	Percent Retained	
	Type 1	Type 2
1.8 mm	0 to 3	
850 micron	5 to 20	0 to 5

Sieve Size	Percent Retained	
	Type 1	Type 2
600 micron	- -	5 to 20
4250 micron	65 to 95	- -
300 micron	- -	30 to 75
180 micron	0 to 10	10 to 30
Below 180 micron	- -	0 to 15

b) **Roundness:** The glass beads shall have a minimum of 70 percent true spheres.
c) **Refractive index:** The glass beads shall have a minimum refractive index of 1.50.
d) **Free flowing properties**: The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

Test Methods

The specific requirements shall be tested with the following methods:

i) Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter dessicator which is filled within 25 mm of the top of a dessicator plate with sulphuric acid water solution (specific gravity 1.10). Cover the dessicator and let it stand for 4 hours at 20°C to 29°C. Remove sample from dessicator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.
ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part I).
iii) The Contractor shall furnish to the Engineer a copy of certified test reports from the of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these specifications. However, if so required, these tests may be carried out as directed by the Engineer.

Application Properties of Thermoplastic Material

The thermoplastic material shall readily get screeded/extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

The material upon heating to application temperatures shall not exude fumes 8 which are toxic, obnoxious or injurious to persons or property.

Preparation

i) The material shall be melted in accordance with the manufacturer's instructions in a heater with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

ii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirements of Clause 803.4.2.

Application

Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and /or curing compound shall be removed before the markings are applied.

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

The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

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

The markings shall be done to accuracy within the tolerances given below:

i) Width of lines and other markings shall not deviate from the specified width by more than 5 percent.
ii) The position of lines, letters, figures, arrows and other markings shall not deviate from the position specified by more than 20 mm
iii) The alignment of any edge of a longitudinal line shall not deviate from the specified alignment by more than 10 mm in 15 m.
iv) The length of segment of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

In broken lines, the length of segment and the gap between segments shall be as indicated on the drawings; if these lengths are altered by the Engineer, the ratio of the lengths of the painted sections shall remain the same.

Properties of Finished Road Markings

The finished lines shall be free from ruggedness on sides and ends and be parallel to general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

a) The stripe shall not be slippery when wet.
b) The marking shall not lift from the pavement in freezing weather.
c) After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperature: up to 60°C.
d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic.
e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS: 164

Measurements for Payment

The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any).

In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

Rate

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

803.7

804 REFLECTIVE PAVEMENT MARKERS (ROAD STUDS) AND SOLAR POWERED ROAD MARKERS (SOLAR STUDS)

Scope

The work shall cover the providing and fixing of reflective pavement marker (RPM) or road stud a device which is bonded to or anchored within the road surface, for lane marking and delineation for night-time visibility, as specified in the Contract.

Material

Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrite) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 4280.

Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methecrylate conforming to ASTM D 788 or equivalent.

Design

The slope or retro-reflecting surface shall preferably be 35 ± 5° to base and the area of each retro-reflecting surface shall not be less than 13.0 sq.cm.

Optical Performance

Unidirectional and Bi-directional Studs

Each reflector or combination of reflectors on each face of the stud shall have a Coefficient of Luminous Intensity (C.1.L) not less than that given in Tables 800-13 or 800-14 as appropriate.

Omni-directional Studs

Each Omni-directional stud shall have a C.I.L. of not less than 2 mcd/lx.

Table 800-13: Minimum C.I.L. Values for Category 'A' Studs

Entrance Angle	Observation Angle	C. I. L. in mcd/lx		
		White	Amber	Red
0° U 5° L &R	0.3°	220	110	44
0° U 10° L&R	0.5°	120	60	24

Table 800-14: Minimum C.I.L. Values for Category 'B' Studs

Entrance Angle	Observation Angle	C. I. L. in mcd/lx		
		White	Amber	Red
0° U 5° L &R	0.3°	20	10	4
0° U 10° L&R	0.5°	15	7.5	3

Note:

1) The entrance angle of 0° U corresponds to the normal aspect of the reflectors when the reflecting road stud is installed in horizontal road surface.
2) The stud incorporating one or more corner cube reflectors shall be included in Category A. The stud incorporating one or more bi-convex reflectors shall be included in Category 'B'.

Tests

Co-efficient of luminance intensity can be measured by procedure described in ASTM E 809 "Practice for Measuring Photometric Characteristics" or as recommended in BS:873-Part 4: 1973.

Under test conditions, a stud shall not be considered to fail the photometric requirements if the measured C.I.L. at any one position of measurement is less than the values specified in Tables 800-13 or 800-14 provided that the value is not less than 80 percent of the specified minimum, and the average of the left and right measurements for the specific angle is greater than the specified minimum.

Solar Powered Road Markers (Solar Studs)

The solar studs shall be made of Aluminum alloy and poly carbonate material which shall be absolutely weather resistant and strong enough to support a load of 13,635 kg tested in accordance with ASTM 04280. Its colour may be white, red, yellow, green or blue or combination as directed by the Engineer. Its water resistance shall meet the requirements of IP 65 in accordance with 18:12063:1987 Category 2 for protection against water ingress. The dimensions of solar studs shall not be less than 100 mm x 100 mm x 10 mm. It shall have super bright LEDs so as to provide long visibility from a distance of more than 800 m. Its flashing rate shall not be less than 1 Hz. It should be able to give the prescribed performance in the temperature range of -40°C to +55°C. Its life shall be not less than 3 years.

Fixing of Reflective Markers

804.7.1 Requirements

The enveloping profile of the head of the stud shall be smooth and the studs shall not present any sharp edges to traffic. The reflecting portions of the studs shall be free from crevices or ledges where dirt might accumulate. Marker height shall not be less than 10 mm and shall not exceed 20 mm. and its width shall not exceed 130 mm. The base of the marker shall not be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from a flat surface. All road studs shall be legibly marked with the name, trade mark or other means of identification of the manufacturer.

804.1.2 Placement

The reflective marker shall be fixed to the road surface using the adhesives and the procedure recommended by the manufacturer. No nails shall be used to affix the marker so that they do not pose safety hazard on the roads. Regardless of the type of adhesive used, the markers shall not be fixed if the pavement is not surface dry and on new asphalt concrete surfacing until the surfacing has been opened to traffic for a period of not less than 14 hours. The portions of the highway surface, to which the marker is to be bonded by the adhesive, shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the of the marker in a quantity sufficient to result in complete coverage of the area of contract of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed.

804.7.3 Warranty and Durability

The contractor shall submit a two year warranty for satisfactory field performance including stipulated retro-reflectance of the reflecting panel, to the Engineer. In addition, a two year warranty for satisfactory infield performance of the finished road marker shall also be given by the contractor who carries out the work of fixing of reflective road markers. In case the markers are displaced, damaged, get worn out or lose their reflectivity compared to stipulated standards,

the contractor would be required to replace all such markers within 15 days of the intimation from the Engineer, at his own cost.

Measurement for Payment

The measurement of reflective road markers/solar powered road studs shall be in numbers of different types of markers supplied and fixed.

Rate

The contract unit rate for reflective road markers/solar powered road studs shall be payment in full compensation for furnishing all labour, material, tools, equipment including incidental costs necessary for carrying out the work at site conforming to the specification complete per approved drawings or as directed by the Engineer.

811 CRASH BARRIERS

Scope

The work shall consist of construction, provision and installation of crash barriers at locations as shown in the drawing or as directed by the Engineer. The type of the crash barrier shall be as specified in the Contract.

Concrete Crash Barrier

Materials

All materials shall conform to Section1000 Materials for Structures as applicable, and relevant Clauses in Section 1600 shall govern the steel reinforcement.

The minimum grade of concrete shall be M25.

Construction Operations

The concrete barriers shall be either (i) precast or (ii) constructed by the "cast-in-place with fixed forms" method or the "extrusion or slip form" method or a combination thereof at the Contractor's option with the approval of the Engineer. Where "extrusion or slip form" method is adopted full details of the method and literature shall be furnished.

The concrete barrier may be precast in lengths upto 6 m depending upon the feasibility of transport and lifting arrangements. Longitudinal roadside concrete barrier shall be placed on adequate bedding as detailed in the drawing. The top and exposed faces 0 the barriers shall conform to the specified tolerance, as defined in Clause 810.2.2.3, when tested with 3 m straight edge, laid on the surface.

An expansion joint with pre-moulded asphalt filler board shall be provided at the 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 Backfilling to the concrete barriers shall be compacted in layers to the compaction of the surrounding earthwork.

Tolerance

The overall horizontal alignment of rails shall not depart from the road alignment by more than ± 30mm, nor deviate in any two successive lengths from straight by more than 6 mm and the faces shall not vary more than 12 mm from the edge of a 3 m straight edge. Barriers shall be at

the specified height as shown in the plans above the edge of the nearest adjacent carriageway or shoulder, within tolerance of ±30mm.

811.2.2.3End Treatment

The road side concrete barrier shall be provided with an end treatment by tapering the height of terminating end within a length of 8 m to 9 m. Median crash barrier shall be terminated sufficiently away from the median opening. It shall be provided with an end treatment, which shall be obtained by tapering the height of terminating end of the median barrier within a length of 8 m to 9 m.

Measurement for Payment

All barriers shall be measured by linear metres of completed and accepted length in place, corresponding end to end along the face of concrete barriers including approach and departure ends.

Rate

!he Contract unit rate shall include full compensation for furnishing all labour, materials including steel for reinforcement tools, equipment and incidental costs necessary for doing all the work involved in constructing the concrete barrier complete in place in all respects as per these Specifications.

Metal Beam Crash Barrier

Materials

811 3.1.1 Metal beam rail shall be corrugated sheet steel beams of the class, type, section and thickness indicated on the drawings. Railing posts shall be made of steel of section, weight and length as shown on the drawings. All complete steel rail elements, terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanized. All elements of the railing shall be free from abrasions, rough or sharp edges and shall not be kinked, twisted or bent.

The "W" beam type safety barrier shall consist of a steel post and a 3 mm thick "W" beam rail element. The steel post and the blocking out spacer shall both be channel section of 75 mm x150 mm & size 5 mm thick. The rail shall be 70 cm above the ground level and posts shall be spaced 2 m center-to-center. Double "W" beam barrier shall be as indicated in IRC:5-1998.

The thrie beam safety barrier shall have posts and spacers similar to the ones mentioned above for "W" beam type. The rail shall be placed at 85 cm above the ground level.

The "W" beam, the thrie beam, the posts, spacers and fasteners for steel barriers shall be galvanized by hot dip process (zinc coated, 0.55 kg per square metre; minimum single spot) unless otherwise specified. The galvanizing on all other steel parts shall conform to the relevant IS Specifications. All fittings (bolts, nuts, washers) shall conform to the IS:1367 and IS:1364. All galvanizing shall be done after fabrication.

Concrete for bedding and anchor assembly shall conform to Section 1700 of these Specifications.

Construction Operations

The line and grade of railing shall be true to that shown on the plans. The railing shall be carefully adjusted prior to fixing in place, to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment.

Unless otherwise specified on the drawing, railing steel posts shall be given one shop coat of paint (primer) and three coats of paint on structural steel after erection, if the sections are not galvanized. Any part of assembly below ground shall be painted with three coats of red lead paint.

Splices and end connections shall be of the type and designs specified 0.r shown on the plans and shall be of such strength as to develop full d1asign strength of the rail elements.

Installation of Posts

Holes shall be dug or drilled to the depth indicated on the plans or post 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.
All post holes that are dug or drilled shall of such size as will permit proper setting of the posts and allow sufficient room for backfilling and tapping.

Holes shall be backfilled with selected earth or stable materials in layers not exceeding 100 mm thickness and each layer shall be thoroughly tamped and rammed. When backfilling and tamping are completed, the posts or anchors shall be held securely in place.

511.3.3.4 Post holes that are drilled in rock and holes for anchor posts shall be backfilled with concrete.

1 3.3.5 Posts for metal beam guardrail on bridges shall be bolted to the structure as detailed on the plans. The anchor bolts shall be set to proper location and elevation with templets and carefully checked.

Erection

All guard rail anchors shall be set and attachments made and placed as indicated on the plans or as directed by the Engineer.

All bolts or clips used for fastening the guardrail or fittings to the posts shall be drawn up tightly. Each bolt shall have sufficient length to extend at least 6 mm through and beyond the full nut, except where such extensions might interfere with or endanger traffic in which case the bolts shall be cut off flush with the nut.

All railings shall be erected, drawn and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

End Treatment for Steel Barrier

End treatments shall from an integral part of safety barriers which should not spear, vault or roll a vehicle for head-on or angled impacts. The two end treatments recommended for steel barriers are "Turned-down-guardrailll and "Anchored in back slope", as shown on the drawings or as directed by the Engineer.

Tolerance

The posts shall be vertical with a tolerance not exceeding 6 mm in a length of 3 m. The railing barrier shall be erected true to line and grade.

Measurements for Payment

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.

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 on included in the price for other items of construction.

No measurement for payment will be made for excavation or backfilling performed in connection with this construction.

Rate

The Contract unit rate shall include full compensation for furnishing of labour, materials, tool equipment and incidental costs necessary for doing all the work involved in constructing the metal beam railing barrier complete in place in all respects as per these Specifications.

900 QUALITY CONTROL OF ROAD WORKS

901 GENERAL

All materials to be used, all methods to be adopted and all works to be performed shall be strictly in accordance with the requirements of these specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out Quality Control for works and all the required tests as per specifications and /or as directed by the Engineer. The provision and maintenance of the laboratory shall be as per Clause 120 and /or as directed by the Engineer. The list of equipment and the facilities to be proved shall be got approved from the Engineer in advance.

The Contractor's laboratory shall be manned by a qualified Materials Engineer/ Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.

The Contractor's 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.

For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the engineer (by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth hereunder. Additional tests may also be conducted where, in the opinion of the engineer, need for such test exists.

The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This shall include provision of laboratory equipment, transport, consumables, and personnel including labour attendants, assistants in packing and dispatching and any other assistance considered necessary in connection with the tests.

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.

The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer. Works falling short of quality shall be rectified/redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.

The cost of laboratory building including essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no payment shall be made for the same.

For testing of soils/soil mixes, granular materials and mixes, bituminous materials and mixes, cement concrete and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied by the Contractor at his own cost.

For cement, bitumen, steel, emulsion, road marking paint, sign boards, geo-synthetics and similar other materials where essential tests are to be carried out in the presence of Engineer at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of tests certificates shall be borne by the Contractor.

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

The method of sampling and testing of materials shall be in accordance with the requirements of the relevant Indian Standards and these Specifications. Where they are contradicting, the provisions in these Specifications shall be followed. Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor. The cost of all tests shall be borne by the Contractor.

The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

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

Defective Materials

All materials which the Engineer 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 instruction of the Engineer, the Engineer shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

Imported Materials

The Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor's responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/finished products are not covered by the Specifications in the Contract, the details of laboratories/establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified in the lot of materials shall be furnished at the Contractor's cost.

902 CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

General

All works performed shall conform to the lines, grades, and cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after.

Horizontal Alignment

Horizontal alignment 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.

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
2)	Sub-base a) Flexible pavement b) Concrete pavement	 ±10mm ±6mm
3)	Base-course for flexible pavement a) Bituminous Base/Binder course b) Granular i) Machine laid ii) Manually laid	 ±6mm ±10mm ±15mm
4)	Wearing course for flexible pavement a) Machine laid b) Manually laid	 ±6mm ±10mm

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 the following limits:

a) 4 mm for bituminous wearing course of thickness 40 mm or more
b) mm for bituminous wearing course of thickness less than 40 mm

For checking compliance with the above requirement for subgrade, sub-base and base course, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses, measurements of the surface levels shall be taken on a grid 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.

Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straight edge as directed 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				Surface of Laybys, Service Areas and all Bituminous Base Courses			
Irregularity	4mm		7mm		4mm		7mm	
Length (m)	300	75	300	75	300	75	300	75
Number of Surface Irregularities on National Highways/Expressways*	15	9	2	1	40	18	4	2
Number of Surface Irregularities on roads of lower category	40	18	4	2	60	27	6	3

*Category of each section of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous)	3mm
for bituminous base courses	6mm
for granular sub-base/base courses	8mm
for sub-bases under concrete pavements	10mm
for subgrade	15mm

Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances in Clause 902.4, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

i) **Subgrade:** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305.

ii) **Granular Sub-base:** Same as at (i) above, except that the degree compaction and the type of material to be used shall conform to the requirements of Clause 401.

iii) **Lime/Cement Stabilized Soil Sub-base:** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.

iv) For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed materials as necessary and recomputed as per the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

v) **Wet Mix Macadam Sub-base/Base:** Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recomputed as per Clause 406 in the case of Wet Mix Macadam.

vi) **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 recomposing as per specifications. Where the surface is high, the extra thickness in the affected 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 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.

Riding Quality

The riding quality of bituminous concrete wearing surface, as measured by a standard towed fifth wheel bump integrator, shall not be more than 1200 mm per Km.

903 QUALITY CONTROL TESTS DURING CONSTRUCTION

General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the Clauses for the relevant items of work.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing Procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

Table 900-3: Control Tests and their Minimum Frequency for Sub-Bases and Bases (Excluding Bitumen Bound Bases)

S.no.	Type of Construction	Test	Frequency (min.)
1)	Granular	Gradation	One test per 400 cu.m
		Atterberg limits	One test per 400 cu.m
		Moisture content prior to compaction	One test per 400 cu.m
		Density of compacted layer	One test per 1000 sq.m
		Deleterious constituents	As required
		CBR	As required
2)	Lime/Cement Stabilized Soil Sub base	Quality of lime/ cement	One test for each consignment subject to a minimum of one test per 5 tonnes
		Lime/Cement content	Regularly, through procedural checks
		Degree of pulverization	Periodically as considered necessary
		CBR or Unconfined Compressive Strength test on a set of 3 specimens	As required
		Moisture content prior to compaction	One set of two tests per 500 sq.m
		Density of compacted layer	One set of two tests per 500 sq.m
		Deleterious constituents	As required

3)	Wet Mix Macadam	Aggregate Impact Value Grading of aggregate Combined Flakiness and Elongation Indices Atterberg limits of portion of aggregate passing 425 micron sieve Density of compacted layer	One test per 1000 cu.m of aggregate One test per 200 cu.m of aggregate One test per 500 cu.m of aggregate One test per 200 cu.m of aggregate One set of three tests per 1000 sq.m

Table 900-4: Control Tests for Bituminous Works and their Minimum Frequency

S.N.	Type of Construction	Test	Frequency(min.)
1)	Prime Coat/ Tack coat/Fog Spray	i. Quality of binder ii. Binder temperature for application iii. Rate of spread of Binder	Number of samples per lot and tests as per IS:73, IS:217 and IS:8887 as applicable At regular close intervals Three tests per day
2)	Seal Coat/Surface Dressing	i. Quality of Binder ii. Aggregate Impact Value or Los Angeles Abrasion Value iii. Combined Flakiness and Elongation Indices iv. Stripping value of aggregates (Immersion Tray Test) Water absorption of aggregate v. Water sensitivity of mix vi. Grading of aggregate vii. Soundness (Magnesium Sulphate/ Sodium Sulphate) viii. Polished stone value (not applicable for SAM/SAMI) ix. Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction x. Rate of spread of materials xi. Percentage of fractured faces (When aravel is used	Same as mentioned under Serial No. 1 One test per 200 cu.m of each source and whenever there is change in the quality of aggregate One test per 100 cu.m of aggregate for each source and whenever there is change in the quality of aggregate One test of each source and whenever there is change in the quality of aggregate -do- -do- Two tests per day One test for each source and whenever there is change in the quality of aggregate -do- At regular intervals Same as mentioned under Serial No. 1 One test per 100 cu.m of aggregate
3)	Dense Bituminous Macadam/Bituminous Concrete	i. Quality of binder ii. Aggregate Impact Value/ Los Angeles Abrasion Value iii. Flakiness and Elongation Indices iv. Soundness test	i. Number of samples per lot and tests IS:73 or IRC:SP:53, IS:15462 ii. One test per 350 cu.m of aggregate each source and whenever there in the quality of aggregate

S.N.	Type of Construction	Test	Frequency(min.)
		(Sodium or Magnesium Sulphate test)	iii. One test per 350 cu.m of aggregate each source and whenever there in the quality of aggregate
		v. Water absorption of aggregates	iv. One test for each source and whenever there is change in the quality of aggregate
		vi. Sand equivalent test	v. One test for each source and whenever there is change in the quality of aggregate
		vii. Plasticity Index	vi. One test for each source and whenever there is change in the quality of aggregate
		viii. Polished stone value	vii. One test for each source and whenever there is change in the quality of aggregate
		ix. Percentage of fractured face	viii. One test for each source and whenever there is change in the quality of aggregate
		x. Mix grading	ix. One test per 350 cu.m of aggregate when crushed gravel is used
		xi. Stability and voids analysis of mix including theoretical maximum specific of loose mix	x. One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant
		xii. Moisture Susceptibility of mix (AASHTO T283)	xi. Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to minimum of two tests per day per plant
		xiii. Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction	xii. One test for each mix type whenever there is change in the quality or source of coarse or fine aggregate
		xiv. Binder content	xiii. At regular intervals
		xv. Rate of spread of mix material	xiv. One set for each 400 tonnes of mix subject to minimum of two tests per day per plant
		xvi. Density of Compacted layer	xv. After every 5th truck load
			xvi. One test per 700 sq.m area
4)	Mastic asphalt	i. Quality of binder	i. Same as mentioned under Serial No. 3
		ii. Aggregate Impact Value and Los Angeles Abrasion Value	ii. Same as mentioned under Serial No. 3
		iii. Combined Flakiness and Elongation Indices	iii. Same as mentioned under Serial No. 3
		iv. Stripping value	iv. Same as mentioned under Serial No. 2
		v. Water Sensitivity of mix	v. Same as mentioned under Serial No. 3
		vi. Grading of aggregates	vi. Two tests per day per plant on the individual constituent and mixed aggregates from the dryer
		vii. Water absorption of aggregates	vii. Same as mentioned under Serial No. 3
		viii. Soundness (Magnesium Sulphate/ Sodium Sulphate)	viii. Same as mentioned under Serial No. 3
		ix. Percentage of fractured faces	ix. Same as mentioned under Serial No. 3
		x. Binder content and aggregate grading	x. Same as mentioned under

S.N.	Type of Construction	Test	Frequency(min.)
		xi. Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling xii. Rate of Spread of Mixed Material xiii. Hardness number	Serial No. 2 xi. At regular close intervals xii. Regular control through check of layer thickness xiii. Minimum two tests per day
10)	Recycle Material Grading of aggregate		Two tests per day
12)	Quality of Modified Binder		Number of samples per lot and tests as per IS: 15462.

Note: Daily, weekly, monthly reports on test results shall be prepared indicating the location of sampling and testing, deviation from the specified values for materials and works and remedial action taken in respect of removal of defective work shall certified be prepared by the Contractor. The test record shall be certified by the Engineer that these tests were done in his presence and testing carried as per prescribed methodology.

Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

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 for every 3000 cum for each source:

a) Sand Content [IS:2720 (Part-4)]: 2 tests per 3000 cu.m of soil.
b) Plasticity Test [IS:2720 (Part-5)]: Each type to be tested, 2 tests.
c) Density Test [IS:2720 (Part-8)]: Each soil type to be tested, 2 tests.
d) Deleterious Content Test [IS:2720 (Part-27)]: As and when required by the Engineer.
e) Moisture Content Test [IS:2720 (Part-2)]: Two tests.
f) CBR Test on materials to be incorporated in the subgrade on soaked/ unsoaked samples [IS:2720 (Part-16)] : One CBR test (average of three specimens) or closer as and when required by the Engineer.

Compaction Control

Control shall be exercised on each layer by taking at least one set of ten measurements of density for each 3000 sq.m of compacted area, or closer as required to yield the minimum number tests 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. If non-destructive tests are carried out, the number of tests shall be doubled. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

$$\left[1.65 - \frac{1.65}{(No.\ of\ samples)^{0.5}}\right] \text{ times the standard deviation}$$

However, for earthwork in shoulders (earthen) and in the subgrade, at least one set of ten density measurements shall be taken for every 2000 sq.m for the compacted area. In other respects, the control shall be similar to that described earlier.

Cut Formation

Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903.2.2.

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 given Trimble 900-3. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2.2.

Acceptance Criteria

The acceptance criteria for tests on the strength of cement/lime stabilized soil and distribution of stabilizer content shall be subject to the condition that the mean value is not less than the Specified value plus:

$$\left[1.65 - \frac{1.65}{(No.\ of\ samples)^{0.5}}\right] \text{ times the standard deviation}$$

Tests on Bituminous Construction

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.

Acceptance Criteria

The acceptance criteria for tests on density shall be subject to the condition that the mean value is not less than the specified value plus:

$$\left[1.65 - \frac{1.65}{(No.\ of\ samples)^{0.5}}\right] \text{ times the standard deviation}$$

Where the Contract specifies the surface roughness requirements, in terms of Bump Integrator value, the surface roughness shall be measured by a calibrated Bump Integrator as per the procedure described in IRC:SP:16. The measurements shall be taken at centre line of each lane for a minimum completed length of one Km.

Quality Control Tests for Concrete Road Construction

Dry Lean Concrete Sub-base

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 1000sq.m or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150 mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that cubes shall be compacted by means of a vibratory hammer with the moulds placed on level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with square or rectangular foot having an area of between 7500 to 14000 sq.mm. The compaction shall be uniformly applied for 60± 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. TL surface of each

compacted layer shall be scarified before the next layer is added to give k: for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete shall be cured in accordance with IS:516.

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 sq.m or part thereof laid each day and shall comply with the requirements as per Clause 601.6.5.1. 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.

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 8 mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.6.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

Frequency of Quality Control Tests

The frequency of quality control tests for levels, alignment and materials shall be as given in Table 900-6.

Pavement Concrete

Sampling and Testing of Beam and Cube Specimens

At least three beams and three cube specimens, one set of three each for 7 day and 28 day strength tests shall be cast for every 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 at the rate of 2 cores for every 150 cu.m of concrete. The average of the results of crushing strength tests on these cores shall not be less than 0.8 x 0.85 times the corresponding characteristic compressive strength of cubes, where the height to diameter ratio of the cores is two. Where height to diameter ratio is not two, necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$f = 0.11\ n+0.78$

where f = correction factor and

n = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for

assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm.

If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., at least over an area extending between two transverse joints where the defects could be isolated or over larger area, 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 1 in 20 of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 1.65 times the standard deviation calculated first orn 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 1.65 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 minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the 28 day flexural strengths to detect any deterioration in the quality of the concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence of non-compliance of the concrete from which they were taken.

Concrete shall be deemed not to 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 1.65 times the standard deviation of the batch.

Should the concrete fail to comply with 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 in-situ 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 percent 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

Days	0	2	4	6	8
20	94.0	96.0	97.5	98.5	100.0
30	101.0	102.0	103.5	104.5	105.5
40	106.5	107.0	108.0	109.5	110.0
50	110.5	111.0	112.0	112.5	113.0
60	114.0	114.5	115.0	115.5	116.0
70	116.5	117.0	117.5	118.0	118.5
80	119.0	119.5	119.5	120.0	120.5
90	121.0	121.5	122.0	122.0	122.5
100	123.5	123.5	123.5	124.0	124.5
110	125.0	125.0	125.5	125.5	126.0
120	126.0	126.0	127.0	127.0	127.5
130	127.5	128.0	128.5	128.5	129.0
140	129.0	129.5	129.5	130.0	130.0
150	130.5	130.5	131.0	131.0	131.5
160	131.5	131.5	132.0	132.0	132.5
170	132.5	132.5	133.0	133.0	133.5
180	133.5	134.0	134.0	134.5	134.5
190	135.0	135.0	135.0	135.5	135.5
200	135.5	135.5	136.0	136.0	136.5
210	136.5	136.5	137.0	137.0	137.0
220	137.0	137.5	137.5	137.5	138.0
230	138.0	138.5	138.5	138.5	138.5
240	139.0	139.0	139.0	139.5	139.5
250	139.5	140.0	140.0	140.0	140.0
260	140.5	140.5	140.5	140.5	141.0
270	141.0	141.0	141.5	141.5	141.5
280	142.0	142.0	142.0	142.0	142.0
290	142.5	142.5	142.5	142.5	142.5
300	143.0	143.0	143.0	143.0	143.5
310	143.5	143.5	144.0	144.0	144.0
320	144.0	144.5	144.5	144.5	144.5
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

In-situ Density

The density of the compacted concrete shall be such that the total air voids are not more than 3 percent. The air voids shall be derived from the difference between the theoretical maximum dry density of the concrete calculated from the specific gravity of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150 mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the vibratory effort imparted i.e. the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. In case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculation of 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.

Thickness

Thickness shall be controlled by taking levels as indicated in Clause 902.3. Thickness of the slab at any point checked as mentioned above shall be within a tolerance of -5 mm to + 10 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 602.16.3. In no case' however, thickness deficiency shall be more than 10 mm.

Summary of Control Tests

Table 900-6 gives a summary of frequency of testing of pavement concrete.

Table 900-6: Frequency of Quality Control Tests for Pavement Concrete

Levels, alignment and texture			
i) Level tolerance			Clause 902.3
ii) Width of pavement and position of paving edges			Clause 902.2
iv) Alignment of joints, widths, depth of dowel groves			To be checked @one joint per 400m length or a day's work
v) Surface regularity both transversely and longitudinally			Once a day or one day's work without disturbing the curing
viii) Texture Depth			Clause 602.12
Quality of materials and concrete shall be as under:			
1) Cement of materials and chemical Tests	IS:269 IS:455 IS:1489 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 test data on cement released by the manufacturer
22) 2) Coarse	i) Gradation	IS:2386	One test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; (may be relaxed

Levels, alignment and texture			
and Fine Aggregate			later at the discretion of the Engineer)
	ii)Deleterious constituents	IS:2386 (Pt.2)	-do-
	iii)Water absorption	IS:2386 (Pt.3)	Regularly as required subject to a minimum of one test a day for coarse aggregate and two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix on a daily basis.
3 3) Coarse Aggregate	i) Los Angeles Abrasion value or Aggregate Impact test	IS:2386 (Pt.4)	Once for each source of supply and subsequently on monthly basis.
	ii) Soundness	IS:2386 (Pt.5)	Before approving the aggregates and every month subsequently.
	iii) Alkali aggregate reactivity	IS:2386 (Pt.7) IS:456	-do-
4444) Water	Chemical Tests	IS:2386 IS:2386	Once for approval of source of supply, subsequently only in case of doubt.
5) Concrete	i) Strength of concrete	IS:516 IS:516	2 cubes and 2 beams per 150 cu.m or part thereof (one for 7 day and other for 28 day strength) or minimum 6 cubes and 6 beams per day's work whichever is more
	ii) Core strength on hardened concrete	IS:516 IS:516	As per the requirement of the Engineer, only in case of doubt.
	iii) Workability of fresh concrete-Slump Test	IS:1199 IS:1199	One test per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumper.
	iv)Thickness determination		From the level data of concrete pavement surface and sub-base at grid points of 516.25 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 6.25m. The level tolerance allowed shall be +_2mm. these shall be got approved 1-2hours before the commencement of the concreting activity.

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: l077, except that the minimum compressive strength when tested flat shall not be less than 8.4 MPa for individual bricks and

MPa for average of 5 specimens. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of ±5 per cent.

1004 STONES

Stones shall be of the type specified. It shall be hard, sound, and 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: 1 124.

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 lS: 81 12.
d) Ordinary Portland Cement, 53 Grade, conforming to IS: 12269.
e) Sulphate Resistant Portland Cement, conforming to lS: 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 540kg/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 C3S/C2S, where C3S is Tricalcium Silicate and C2S 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 (0.03 per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, and 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 tn-calciumaluminate 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 pre-stressed 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 IS:2386, Parts I to VIII.

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

Maximum nominal size of coarse aggregate for various structural components in FCC, 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 for grading:

TABLE 1000-1: Requirements of Coarse Aggregate

IS Sieve Size	Per cent by Weight Passing the Sleve		
	40mm	20mm	12.5mm
63mm	100	-	-
40mm	95-100	100	-
20mm	30-70	95-100	100
12.5mm	-	-	90-100
10mm	10-35	25-55	40-85
4.75mm	0-5	0-10	0-10

1008 SAND/ FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS: 21 16.

For plain and reinforced cement concrete (FCC and RCC) or pre-stressed 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. Motorized 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, (Pans I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of lS: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 Sleve		
	Zone I	Zone II	Zone III
10mm	100	100	100
4.75mm	90-100	90-100	90-100
2.36mm	60-95	75-100	85-100
1.18mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

1009 STEEL

1009.1 Cast Steel

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

1009.2 Steel for Pre-stressing

The pre-stressing steel shall conform to either of the following:

a) Plain hard drawn steel wire conforming to IS: 1785 (Part I) and 1S~1785(Part II).
b) Cold drawn indented wire conforming to 1S:6003
c) High tensile steel bar conforming to lS:2090
d) Uncoated stress relieved strands conforming to 1S:600t

1009.3 Reinforcement I Untensioned Steel

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

TABLE 1000-3

Grade Designation	Bar Type conforming to governing IS Specification	Characteristic Strength fy MPa	Elastic Modulus GPa
S 240	IS:432 Part 1 Mild Steel Bar	240	200
S *415*	IS:1786 High Yield Strength Deformed Bars (HYSD)	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 180 shall only be used in conjunction with fusion bonded epoxy bars.
c) Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.
d) The cut ends and damaged portions shall be touched up with repair patch up material.
e) The bars shall be cut by saw-cutting rather than flame cutting.
f) While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.
g) The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethylene sheets or such other approved materials
h) While concreting, the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars.

When specified in the contract, protective coating prescribed by CECRI shalt be provided in conformance to specifications given in Appendix 1000/I. The CECRI coating process shall be allowed to be implemented at the site of works provided a representative of the Institute is present throughout the duration of the coating process who shall certify that the materials and workmanship are in accordance with prescribed specifications developed by the Institute.

1009.4 Grey Iron Castings

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

i) Minimum ultimate tensile strength 370 MPa
ii) Modulus of Elasticity 147000 Ml's
iii) Brinell Hardness 230 Ml's
iv) Shear Strength 370 Ml's
v) Compressive Strength 1370 Ml's

The testing shall be as specified in IS: 210.

1009.5 Steel Forgings

Forged steel pins shall comply with clause 3, 3A or IS: 1731. Dimension for Steel flats for structural and general engineering purposes IS: 1732. Dimension for round of IS: *1875* and steel forgings shall comply with clause 3, 3A or 4 of IS: 2004. Raw materials of the forging will be taken as per IS: 1875 with minimum reduction ratio of 1.8:1. Alternatively, if forging is made from ingot, a minimum reduction ratio between the ingot and forging will be 4:1. Forging shall be normalized.

1009.6 Structural Steel

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

IS:226 Structural Steel (Standard Quality)

1S:961 Structural Steel (High Tensile)

IS:2062 Weldable Structural Steel

IS:8500 Weldable Structural Steel (medium & high strength qualities)

IS 1148 Hot rolled rivet bars (0110 40mm dia) for structural purposes

IS:1149 High tensile rivet bars for structural purposes

IS: 1161 Steel tubes for structural purposes

IS:4923 Hollow Steel sections for structural use

lS:1 1587 Structural weather resistant steel

IS:808 Specifications, for Rolled Steel Beam, Channel and Angle Sections

IS:1239 Mild Steel Tubes

IS:1730 Dimension for Steel Plate, sheet and strip for structural and general engineering purposes and square steel bars for structural and general engineering purposes

IS:1852 Rolling and cutting tolerances for hot rolled steel products

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

1010 WATER

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values:

a) To neutralize 200 ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal NaOH.

b) To neutralize 200 ml sample of water, using methyl orange as art indicator, it should not require more than 10 ml of 0.1 normal H~.

c) The permissible limits for solids shall be as follows when tested in accordance with lS:3025:

Permissible Limits (max)	
Organic	200 mg/lit
Inorganic	3000 mg/lit
Sulphatcs (SO4)	500 mg/lit
Chlorides (Cl)	500 mg/lit *
Suspended matter	2000 mg/lit

In case of structures of lengths 30m and below, the permissible limit of chlorides may be increased upto 1000 mg/lit.

All samples of water (including potable water) shall be tested and suitable measures

taken where necessary to ensure conformity of the water so the requirements stated herein.

d) The pH value shall not be less than 6

1011 TIMBER

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

1012 CONCRETE ADMIXTURES

1012.1 General

Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened state.

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

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

a) Normal dosage and detrimental effects, if any, of under dosage and over dosage.
b) The chemical names of the main ingredients in the admixtures.
c) The chloride content, if any, expressed as a percentage by the weight of the admixture.
d) Values of dry material content, ash content and relative density of the admixture which can be used for Uniformity Tests.
e) Whether or not the admixture leads to the entertainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
f) Where two or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.
g) There would be no increase in risk of corrosion of the reinforcement or other embedments as a result of using the admixture.

1012.2 Physical and Chemical Requirements

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

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

    i. Dry Material Content to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer
    ii. Ash content to be within 1 per cent of the value stated by the manufacturer.

    Relative Density (for liquid admixtures) to be within 2 per cent of the value stated by the manufacturer.

f) All tests relating to the concretes admixtures shall be conducted periodically at an

independent laboratory and compared with the data given by the manufacturer

1013 REINFORCED CONCRETE PIPES

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

1014 STORAGE OF MATERIALS

1014.1 General

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

1014.2 Brick

Bricks shall not be dumped at site. They shall be stacked in regular Section 1000 Materials for structures tiers as they are unloaded, to minimize breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be stacked separately.

1014.3 Aggregates

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained. If necessary, the ground shall be covered with *50* mm plank.

Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is *25* mm or less and 3 sizes when the nominal size is 32 mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

In the case of fine aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Engineer.

1014.4 Cement

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.

Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.

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

The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

1014.5 Reinforcement /Untensioned Steel

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

1014.6 Prestressing Materials

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

Tendon: Wire, strand and bar from which tendons are to be fabricated shall be stored about 300mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances, tendon material shall be subjected to any welding operation or on site heat treatment or metallic coating such as galvanizing. Storage facilities and the procedures for transporting material into or out of store, shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, foe wires above 5mm dia, coils of about 2sn dia without breaks or joints shall be obtained from manufacturer and stored. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.

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

Prestressing steel shall be stored in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable grease. The prestressing steel should be absolutely clean and without any signs of rust.

All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

1014.7 Water

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

1015 TESTS AND STANDARD OF ACCEPTANCE

All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use independent testing of cement for every consignment shall be done by the Contractor at Site in the laboratory approved by the Engineer before use. Any cement with lower quality than those shown in manufacturer’s certificate shall be debarred from

use. In case of imported cement, the same series of tests shall be carried out before acceptance.

1015.1 Testing and Approval of Material

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

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

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

1015.2 Sampling of Materials

Samples provided to the Engineer or his representative for their retention are to be in labelled boxes suitable for storage.

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

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

1015.3 Rejection of Materials not conforming to the Specifications

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

1015.4 Testing and Approval of Plant and Equipment

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

1100 PILE FOUNDATION

1101 DESCRIPTION

The work shall cover furnishing and providing bored cast-in-situ reinforced concrete pile foundation, in accordance with the drawings and these specifications or as directed by the Engineer.

The construction of pile foundations requires a careful choice of the piling system depending upon sub-soil conditions and loading characteristics and type of structure. The permissible limits of total and differential settlements, unsupported length of pile under scour, impact/entanglement of floating bodies and any other special requirements of project are also equally important criteria for selection of the piling system. The method of installing the piles, including details of the equipment shall be submitted by the Contractor and got approved from the Engineer.

The work shall be done as per IS: 291l except as modified herein.

1102 SUB-SURFACE INVESTIGATION

The complete sub-surface investigation of strata in which pile foundation are proposed shall be carried out in advance and by in-situ pile tests. For details of geotechnical sub surface explorations reference may be made to section 2400 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress. At least one bore-hole for every foundation of the bridge shall be executed. Boring should be carried up to sufficient depth so as to ascertain the nature of strata around the pile shaft and below the pile tip. However, depth of boring shall not be less than:

i) 1.5 times estimated length of pile in soil but not less than 15 m beyond the probable length of pile.
ii) 15 times diameter of pile in weak/jointed rock but minimum 15 m in such rock.
iii) 4 times diameter of pile in sound, hard rock but minimum 3 m in such rock.

The sub-surface investigation shall define adequately stratification of sub-strata including the nature and type of strata, its variation and extent and specific properties of the same. The investigation shall be adequate for the purpose of selection of appropriate piling system and for estimating design capacities for different diameters and length of piles.

Pressure meter tests may be used in the case of rock, gravel or soil for direct evaluation of strength and compressibility characteristics. Though these tests are of specialized nature they are most appropriate for difficult/uncertain sub-strata especially for important projects,

For piles socketed into rocks, it is necessary to determine the uniaxial compressive strength of the rock and its quality.

The investigation shall also include location of ground water table and other parameters including results of chemical tests showing sulphate and chloride content and any other deleterious chemical content in soil and/or ground water, likely to affect durability.

1103 TYPE OF PILES

The piles may be of reinforced concrete, pre-stressed concrete, steel or timber. The piles may be of solid or hollow sections or steel cased piles filled with concrete. Concrete piles may be driven cast-in-situ or precast or bored cast-in-situ or precast piles driven into preformed bores. The shape of piles may be circular, square, hexagonal, octagonal, –Hll or -Ill Section.

1104 MATERIALS

The basic materials shall conform to the specifications for materials given in Section 1000. The specifications for steel reinforcement, structural concrete, prestressed concrete and structural steel to be used in pile foundations shall be as given in the relevant sections.

1104.1 Concrete in Piles

Grade of concrete to be used in cast-in-situ piles shall not be less than M 20 and the cement content shall not be less than 400 kg per cubic meter of concrete. Grades of concrete for precast reinforced and prestressed concrete piles shall not be less than M 25 and M 35 respectively. Maximum water cement ratio shall be 0.5 for cast-in-situ piles and 0.45 for precast piles.

The minimum slump of concrete for driven cast-in-situ piles shall be 100 mm to 150 mm and that of bored cast-in-situ piles 150 mm to 200 mm. The slump should not exceed 200 mm in any case.

Concrete mix should have homogeneous mixture with required workability for the system of piling adopted. Suitable and approved admixtures may be used in concrete mix where necessary.

Where piles are exposed to action of harmful chemicals or severe conditions of exposure due to presence of sulphate, chloride etc. It may be preferable to opt for higher grades of concrete restricting water cement ratio to 0.45. Special types of cement, such as sulphate resistant cement mayll be used where considered appropriate.

1105 TEST PILES

Test piles which are shown on the drawings or specified in the contract or installed by the Contractor on his own to determine the lengths of piles to be furnished shall conform to the requirements for piling as indicated in these specifications, if they are to be incorporated in the completed structure.

Test piles that are to become a part of the completed structure shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure.

Test piles which are not to be incorporated in the completed structure shall be removed to at least 600 mm below the proposed soffit level of pile cap and the remaining hole shall be backfilled with earth or other suitable material.

The piles shall be load tested in accordance with provisions laid down in this section.

1107 CAST-IN-SITU CONCRETE PILES

Cast-in-situ concrete piles may be either installed by making a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as ‑bored pilesǁ and ‑driven pilesǁ respectively. Cast-in-situ concrete piles may be cast in metal shells which may remain permanently in place. However, other types of cast-in-situ concrete piles, plain or reinforced, cased or uncased, may be used if in the opinion of the Engineer the soil conditions permit their use and if their design and the methods of placing are satisfactory.

The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any, has been withdrawn.

Cast-in-situ concrete driven piles shall be installed using a properly designed detachable shoe at the bottom of the casing. Certain specific requirements of cast-in-situ driven piles shall be as per Clauses 1110 and 1111.

Any liner or bore-hole which is improperly located or shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

Wherever practicable, concrete should be placed in a clean dry hole. Where concrete is placed in dry and there is casing present, the top 3 m of the pile shall be compacted using internal vibrators.

The concrete should invariably be poured through a tremie with a funnel so that the flow is directed and concrete can be deposited in the hole without segregation. Where the casing is withdrawn from cohesive soils for the formation of cast-in-situ pile, the concreting should be done with necessary precautions to minimise the softening of the soil by excess water. Where mud flow conditions exist, the casing of cast-in-situ piles shall not be allowed to be withdrawn. Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.

If the concrete is placed inside precast concrete tubes or consists of precast sections, these shall be free from cracks or other damage before being installed.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

The placing of concrete shall be a continuous process from the toe level to the top of the pile. To prevent segregation, a tube or tremie pipe as appropriate shall be used to place concrete in all piles.

To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6 m (length of pile) per hour.

Bored cast-in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2.0 m length of top of bore shall invariably be provided with casing to ensure against loose soil falling into the bore. In cases in which the side soil can fall into the hole, it is necessary to stabilize the side of the bore hole with drilling mud, or a suitable steel casing. The casing may be left in position permanently specially in cases where~ the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

For bored cast-in-situ piles, casing/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means.

Where bored cast-in-situ piles are used in soils liable to flow, the bottom of the casing shall be kept enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimize inflow of water or leakage of slurry during concreting.

Boring shall be carried out using rotary or percussion type equipment. Unless otherwise approved by the Engineer, the diameter of the bore-holes shall be not more than the inside diameter of the liner. Prior to the lowering of the reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials. Cover to reinforcing steel shall be maintained by suitable spacers.

The diameter of the finished pile shall not be less than that specified and a continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the pile length cast.

Before concreting under water, the bottom of the hole shall be cleaned of drilling mud and all soft or loose material very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry is more than 1.2. The drilling mud should be maintained at 1.5m above the ground water level.

Concreting under water for cast-in-situ concrete piles may be done either with the use of tremie method or by the use of an approved method specially designed to permit under water placement of concrete.

General requirements and precautions for concreting under water are as follows;

i) The concreting of a pile must be completed in one continuous operation. Also, for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for full height must be accomplished in one continuous operation without any stoppage.
ii) The concrete should be coherent, rich in cement with high slump and restricted water cement ratio.
iii) The tremie pipe wilt have to be large enough with due regard to the size of aggregate. For 20 mm aggregate the tremie pipe should be of diameter not less than 150 mm and for larger aggregate, larger diameter tremie pipes may be necessary.
iv) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.
v) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.
vi) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile to prevent the laitance from being entrapped within the pile.
vii) All tremie tubes should be thoroughly cleaned after use.

The minimum embedment of cast-in-situ concrete piles into pile cap shall be 150 mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from the top of the pile shall be not less than 25 mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully to avoid damaging the rest of the pile, in cases where the pile cap is to be laid on ground, a levelling course of M 15 nominal mix concrete 100 mm thick shall be provided. Defective piles shall be removed or left in place as judged convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

1110 DRIVING EQUIPMENT

Piles or their casings may be driven with any type of drop hammer, diesel hammer or single-acting steam or compressed air hammer, provided they penetrate to the prescribed depth or attain the designed resistance without being damaged. The weight or power of the hammer should be sufficient to ensure a penetration of at least 5 mm per blow, unless rock has been reached. It is always preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. The minimum weight of the hammer shall be 2.5 tons. In the case of precast concrete piles the mass of the hammer shall be not less than 30 times the mass of 300 mm length of pile. Steam or air hammers shall be furnished along with boiler or air compressor of capacity at least equal to that specified by the manufacturer of the hammers. The boiler or air compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed, will be obtained. Inefficient steam, air or diesel hammers shall be removed from the work.

1111 DRIVING

1111.1 General Procedure

Details of the equipment and the method proposed for driving the piles shall be submitted with the tender for scrutiny and approval of the Engineer. Piles shall be installed from firm ground or from temporary supports or from fixed platform. The arrangement shall provide sufficient rigidity to ensure accuracy of pile driving under all conditions of tide, stream flow or hammer drop.

During driving the top of pile shall be protected by a suitable helmet of substantial steel construction. The helmet shall provide uniform bearing across the top of the pile and shall hold the pile centrally under the hammer. No pile shall be driven unless inspected and approved by the Engineer.

Piles shall be driven from a fixed frame of sufficient rigidity to ensure accuracy of driving within specified tolerances. Forces producing undue bending or torsional stresses in piles shall not be applied during driving. The force of the hammer shall be directed centrally and axially during driving.

The stroke of a single acting or drop hammer shall be limited to 1.2 m unless otherwise permitted by the Engineer. A shorter stroke may be necessary when there is danger of damaging the pile.

Piles shall not be bent or sprung into position but shall be effectively guided and held on-line during the initial stages of driving. Attempts to correct any tendency for the pile to run off-line by the application of significant horizontal restraint will not be permitted. Shortly after the commencement of driving and at regular intervals throughout the driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile due to restraint within the helmet.

If the indications are that a pile will finish outside the specified tolerances, driving operations on that pile will cease. The pile shall be withdrawn, the hole filled and the pile re-driven at no extra cost.

To avoid the possibility of premature ‗set-up‖ pile driving shall be continuous in the later stages, without any deliberate stops. (Delays of an hour or less may lead to significant ‗set-up‖ in piles resistance to further driving increases after driving is stopped).

If any pile is damaged in any way during driving, it shall be repaired or replaced as directed by the Engineer, at no extra cost. If during driving, the head of a pile is damaged to the extent that further driving is not possible, the head shall be cut off and driving continued. The cost of cutting off shall be borne by the Contractor and where, as a result of such cutting off the head, the pile is too short, the Contractor, shall, at his own cost, supply and splice on sufficient length of pile to restore the pile to its correct length.

Piles should be driven to the minimum acceptable penetration shown on the drawings. This may require preboring and/or jetting as indicated in these specifications with the full approval of the Engineer.

Piles shall be driven to nominal refusal or the required ultimate dynamic capacity nominated on the drawings or until the top of the pile is at the level required and specified on the drawing whichever gives the lowest toe elevation. The Engineer's decision in these matters shall be final. Nominal refusal shall be taken as equivalent to 25 mm total penetration for the final 20 blows using a hammer of driving energy as specified and shall be used as the criterion for acceptance for piles founded on rock. Severe driving which results in an average set per blow less than 0.5 mm will not be permitted.

Where hard drilling is encountered because of dense strata or obstructions located above the predetermined pile tip level, nominal refusal shall not be considered to have been achieved unless the Engineer is satisfied that the total number of blows, as the average driving resistance specified for nominal refusal, indicates that further driving will not advance the pile through dense strata or obstructions, The pile shall be driven as accurately as possible to the vertical or to specified batter. Straining the pile into position can damage it and the driving equipment should be adjusted as much as possible to follow the position of the pile. Any deviation from the proper alignment shall be noted and promptly reported to the Engineer. If the deviation is to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties, such a pile shall, at the discretion of the Engineer, be replaced or supplemented by an additional pile. Unless otherwise specified, the permissible positional deviation for piles shall be limited to those indicated in Clause 1116 (Tolerance).

Care shall be taken not to damage the pile by over-driving. Any sudden change in the rate of penetration which cannot be ascribed to the nature of the ground shall be noted and its cause ascertained, if possible, before driving is continued.

When employing a tube which is subsequently withdrawn for the formation of cast-in-situ pile, consideration shall be given to the possibility of doing harm to a pile recently formed by driving the tube nearby before the concrete has sufficiently set. The danger of doing harm is greater in compact soils than loose soils. No pile shall be bored or driven within 3 in of a newly cast pile until at least 24 hours after completion of its installation.

Driving piles in loose sand tends to compact the sand which in turn increases the skin friction. Therefore, driving a number of friction piles in a group shall proceed outward from the centre as otherwise it will be difficult to drive the inner piles to the same depth as the others.

In the case of stiff clay also, the driving for a group of piles shall proceed outward from the centre. However, in case of very soft soil, the driving may proceed from outside to inside, so that the soil is restrained from flowing out during driving operations.

If there is a major variation between the depths at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressive material below the level of the shorter pile, it will be necessary to enforce penetration of all the piles to a level below the bottom of the zone which shows such pockets.

1111.2 Preboring and Jetting

Driving of the piles may be assisted by preboring holes or by the use of jets or both subject to the approval of the Engineer. These may be used essentially to achieve the minimum penetration shown on the drawings where such penetration is not reached under normal conditions of driving indicated in Clause 1111.1 (Driving).

The diameter of the hole shall not be greater than the diagonal dimension of the pile less 100 mm. The maximum depth of the preboring shall be such that the specified set (or less) is obtained when the toe of the pile is at founding level. Preboring shall be as approved by the Engineer and shall not extend below one metre above the founding level and the pile shall be driven to at least one metre below the prebored hole. To ensure that the pile is properly supported laterally in the hole, any space remaining around the pile at the ground level after driving is finished shall be backfilled with approved granular material.

When water jetting is used, at least two jets shall be attached to the pile symmetrically when this type of technique is used. The volume and pressure of water at the outlet nozzles shall be sufficient to freely erode material adjacent to the toe of the pile. The maximum depth of jetting shall be such that the specified set (or less) is obtained when the toe of the pile is at founding level. Jetting shall cease as directed by the Engineer and shall not proceed below one metre above the founding level and the pile shall be driven at least one metre below the pre-bored hole.

To avoid very hard driving and vibration in materials such as sand, jetting of piles by means of water may be carried out only by express permission of the Engineer and in such a manner as hot to impair the bearing capacity of piles already in place, the stability of the soil or the safety of any adjoining buildings. Details of the arrangement for jetting shall be got approved from the Engineer in advance.

If, for jetting, large quantities of water are used, it may be necessary to make provision for collection of water when it comes to the ground surface, so that the stability of the piling plant is not endangered by the softening of the ground.

Jetting shall be stopped before completing the driving which shall always be finished by ordinary methods. Jetting shall be stopped if there is any tendency for the pile tips to be drawn towards the pile already driven owing to the disturbance to the ground.

1113 PILE TESTS

1113.1 General

The bearing capacity of a single pile may be determined from test loading a pile. The load test on a concrete pile may not be carried out earlier than 28 days from the time of casting of the pile.

There shall be two categories of tests on piles, namely, initial tests and routine tests. Initial tests should be carried out on test piles which are not to be incorporated in the work, Routine tests shall be carried out as a check on working piles. The number of initial and routine tests on piles shall be as determined by the Engineer depending upon the number of foundations, span length, type of superstructure and uncertainties of founding strata. In any case, the initial load

tests shall not be less than 2 in number, while the routine load tests shall not be less than 2 per cent of the total number of piles in the structure nor less than 2 in number.

The above stipulations hold good for both vertical as well as lateral load tests on pile foundations. However, both initial and routine tests may be suitably increased for important structures or cases with large variation in the subsurface strata. The methodology of carrying out load tests and of arriving at sale load on piles shall conform to IS: 2911 (Part IV).

In case of any doubt of workmanship or load carrying capacity of working piles not subjected to routine tests, or when ordered by the Engineer, or when provided in the contract, load tests on working piles may be supplemented by non-destructive testing. Such tests may include ‑integrity Testing‖ of concrete in the installed pile and utitisation of ‑Pile Driving Analyser‖ which gives an indication of pile capacity in end bearing and side friction.

1114 PILE CAP

Pile Caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a leveling course of minimum 100 mm thickness of M 15 nominal mix concrete shall be provided.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted after three days of pile casting, while pneumatic tools for chipping shall not be used before seven days after pile casting. The top of pile alter stripping shall project at least 150 mm into the pile cap. A layer of surface reinforcement may be provided with a cover of 25 mm to retain the integrity of concrete below the main cap reinforcement which is to be laid 25 mm above the pile top.

Concreting of the pile cap shall be carried out in dry conditions. The bottom of the pile cap shall be laid preferably as low as possible taking account of the water level prevalent at the time of casting. The top of concrete in a pile shall be brought above cut-off level to permit removal of all laitance and weak concrete before pile cap is laid. This will ensure good concrete at the cut-off level.

1115 IMPORTANT CONSIDERATIONS, INSPECTION/PRECAUTIONS FOR BORED CAST-IN-SITU PILES

While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete is to be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimize the softening of the soil by excess water. Uncased cast-in-situ piles shall not be allowed where mudflow conditions exist.

The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level to ensure the stability of the strata which is being penetrated throughout the boring process until the pile has been concreted.

Where bentonite suspension is used to maintain the stability of the bore-hole, it is essential that the properties of the material be carefully controlled at stages of mixing, supply to the bore-hole and immediately before concrete is placed. It is usual to limit

i) The density of bentonite suspension to 1.05 g/cc.
ii) The marsh cone viscosity between 30 and 40
iii) The p11 value between 9.5 and 12
iv) he silt content less than I per cent
v) The liquid limit of bentonite not less than 400 per cent

These aspects shall act as controlling factors for preventing contamination of bentonite slurry for clay and silt.

The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz, after completion of boring and prior to concreting alter placing of reinforcement cage. Flushing of bentonite shall be done continuously with fresh bentonite slurry till the consistency of inflowing and out-flowing slurry is similar.

Tremie of 150 mm to 200 mm diameter shall be used for concreting. The tremie should have uniform and smooth cross-section inside, and shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal. Other recommendations for tremie concreting are

i) The sides of the bore-hole have to be stable throughout.
ii) The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection
iii) The tremie pipe shall be large enough in relation to the size of aggregates. For 20 mm aggregate the tremie pipe shall be of diameter not less than 150 mm and for larger size aggregate tremie pipe of larger diameter is required.
iv) The tremie pipe shall be lowered to the bottom of the bore-hole, allowing water or dotting mud to rise inside it before pouring concrete.
v) The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the bore-hole with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

For very long or large diameter piles, use of retarding plasticiser in concrete is desirable.

For large diameter piles, it may be essential to conduct non-destructive pile integrity tests to evaluate integrity of the pile.

Where possible, it may be desirable to grout the base of pile with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose, conduit pipes with easily removable plugs at the bottom end should be placed in the bore along with reinforcement cage before concreting.

1116 TOLERANCES

Permissible Tolerances for Pile

i) Bored Piles

a) Variation in cross-sectional dimensions + 50 mm, -10 mm
b) Variation from vertical or specified rake 1 in 50
c) Variation in the final position of the head in plan: 50 mm
d) Variation of level of top of piles ±25 mm

Permissible Tolerances for Pile Caps

a) Variation in dimensions: ±50mm - 10 mm
b) Misplacement from specified position in plan: 15 mm
c) Surface irregularities measured with 3 m straight edge 5 mm
d) Variation of levels at the top: ±25 mm

1117 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1118 MEASUREMENTS FOR PAYMENT

For supply of precast concrete, timber or steel piles of specified cross-section, the measurement shall be in metres of the length of piles ordered in writing by the Engineer measured from the head to the butt of the shoe or the tapered point. Reinforcement in precast concrete piles shall not be measured for payment.

For cast-in-situ driven and bored concrete piles of specified cross section, the measurement shall be the length in metres of the accepted pile that remains in the finished structure complete in place. Reinforcement in cast-in-situ driven and bored concrete piles shall be measured for payment as per Section 1600.

Routine and Initial Pile Load Tests shall not be measured for payment.

For installation of the pile, i.e. by driving in the case of precast concrete, timber, steel and cast-in-situ driven piles, and by boring in the case of cast-in-situ bored piles the measurement shall be the length in metres that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

No distinction shall be made for penetration through hard strata or rock and socketing into rock.

For steel Liner/casing shown on the drawings to be permanently left in place, the measurement shall be by weight in tones that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

For the pile cap, the quantity of concrete shall be measured in cubic metres as per Section 1700. While reinforcement in pile cap shall be measured in tones as per Section 1600.

1119 RATE

The contract unit rate for cast-in-situ driven and bored piles shall include the cost of concrete and all other items as per Section 1700.

The contract unit rate shall also include costs of all labour, materials, equipments and all other incidentals involved in conducting routine and initial pile load tests including installation of piles for initial load tests.

The contract unit rate for reinforcement in cast-in-situ driven and bored piles shall be as per Section 1600.

The contract unit rate for installation of piles shall include full compensation for furnishing all labour, materials, tools and equipment, and incidentals for doing all the works involved making bores for cast-in-situ driven and bored concrete piles, cutting off pile heads, all complete in place to the specified penetration of piles. Providing temporary liner/casing and its withdrawal and placing reinforcement in position shall also be deemed to be included in the rate for installation of piles and no additional payment shall be made for the same.

The contract unit rate for permanent steel liners shall include cost of all labour, fabrication and placing the steel liner to the required depth as shown on the drawings and as ordered by the Engineer.

The contract unit rate for concrete in pile cap shall cover all costs of labour, materials, tools, plant and equipment, formwork and staging including placing in position, sampling and testing and supervision, all as per Section 1700. Reinforcement in the pile cap shall be paid for separately as per Section 1600.

The contract unit rates for excavation in foundation, lean concrete and concrete in foundation and reinforcement steel shall include all works as given in respective sections of these specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section.

1500 FORMWORK

1501 DESCRIPTION

Formwork shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support. The design, erection and removal of formwork shall conform to IRC: 87 -Guidelines for Design and Erection of False work for Road Bridges‖ and these specifications.

1502 MATERIALS

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

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

1503 DESIGN OF FORMWORK

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

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

The design of the formwork shall conform to provisions of IRC: 87. It shall ensure that the forms can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of formwork for inspection.

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

1504 WORKMANSHIP

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

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

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

As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used and these shall be left projecting so that they can be withdrawn easily. Use of double headed nails shall be preferred.
Use Qf ties shall be restricted, as far as practicable. Wherever ties are used they shall be used with HDPE sheathing so that the ties can easily be removed. No parts prone to corrosion shall

be left projecting or near the surface. The sheathing shall be grouted with cement mortar of the same strength as that of the structure.

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

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

The formwork shall be constructed with pre-camber to the soffit to allow for deflection of the formwork. Pre-camber to allow for deflection of formwork shall be in addition to that indicated for the permanent structure in the drawings.

Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, riveted or bolted should be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion.

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

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

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

The formwork shall take due account of the calculated amount of positive or negative camber so as to ensure the correct final shape of the structures, having regard to the deformation of false work, scaffolding or propping and the instantaneous or deferred deformation due to various causes affecting prestressed structures.

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

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

1505 FORMED SURFACE AND FINISH

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

1506 PRECAUTIONS

i) Special measures in the design of formwork shall be taken to ensure that it does not hinder the shrinkage of concrete. The soft fit of the formwork shall be so designed as to ensure that the formwork does not restrain the shortening and/or hogging of beams during pre-stressing. The forms may be removed at the earliest opportunity subject to the minimum time for removal of forms with props retained in position.

ii) Where necessary, formwork shall be so arranged that the soffit form, properly supported on props only can be retained in position for such period as may be required by maturing conditions.
iii) Any cut-outs or openings provided in any structural member to facilitate erection of formwork shall be closed with the same grade of concrete as the adjoining structure immediately after removal of formwork ensuring watertight joints.
iv) Provision shall be made for safe access on to and about the formwork at the levels as required.
v) Close watch shall be maintained to check for settlement of formwork during concreting. Any settlement of formwork during concreting shall ho promptly rectified.
vi) Water used for curing should not be allowed to stagnate near the base plates supporting the staging and should be properly drained.

1507 PREPARATION OF FORMWORK BEFORE CONCRETING

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

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

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

All forms shall he thoroughly cleaned immediately before concreting.

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

1508 REMOVAL OF FORMWORK

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

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

Where not specifically approved, the time of removal of formwork (when ordinary Portland cement is used without any admixtures at an ambient temperatures exceeding 10 degrees Celsius) shall be as under:

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

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

1509 RE-USE OF FORMWORK

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

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

1510 SPECIALIZED FORMWORK

Specialized formwork may be required in the case of slip form work, underwater concreting, segmental construction etc. Such specialized formwork shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialized formwork. In case proprietary equipment is used, the supplier shall supply drawings, details, installation instructions, etc. in the form of manuals along with the formwork. Where specialized formwork is used, close co-ordination with the design of permanent structure is necessary.

For slip form the rate of slipping the formwork shall be designed for each individual case taking into account various parameters including the grade of concrete, concrete strength, concrete temperature, ambient temperature, concrete admixtures, etc. In case of segmental construction, early strength so that the formwork is released as early as possible.

In order to verify the time and sequence of striking/removal of specialized formwork, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

For specialized formwork, the form lining material may be either plywood or steel sheet of appropriate thickness. Plywood is preferred where superior quality of surface is desired, whereas steel sheeting is normally used where large number of repetitions are involved.

1511 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1512 MEASUREMENTS FOR PAYMENT

Unless stated otherwise the rate for concrete in Plain Concrete or Reinforced Concrete or Prestressed Concrete shall be deemed to include all formwork required in accordance with this section and shall not be measured separately.

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

1513 RATE

The unit rate of the Plain Concrete or Reinforced Concrete or Prestressed Concrete as defined in respective sections shall be deemed •to cover the costs of all formwork, including cost of all materials, labor, tools and plant required for design, construction and removal of formwork and supervision as described in this section including properly supporting the members until the concrete is cured, set and hardened as required.

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

1600 STEEL REINFORCEMENT (UNTENSIONED)

1601 DESCRIPTION

This work shall consist of furnishing and placing coated or uncoated mild steel or high strength deformed reinforcement bars (untensioned) of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer.

1602 GENERAL

Steel for reinforcement shall meet with the requirements of Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

Reinforcements may be either mild steel/medium tensile steel or high strength deformed bars. They may be uncoated or coated with epoxy or with approved protective coatings.

1603 PROTECTION OF REINFORCEMENT

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or thoroughly cleaning all reinforcement to remove rust using any suitable method such as sand blasting, mechanical wire brushing, etc., as directed by the Engineer. Reinforcements shall be stored on blocks, racks or platforms and above the ground in a clean and dry condition and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete, shall be protected within one week after initial placing of concrete with a brush coat of neat cement mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

1604 BENDING OF REINFORCEMENT

Bar bending schedule shall be furnished by the Contractor and got approved by the Engineer before start of work.

Reinforcing steel shall conform to the dimensions and shapes given in the approved Bar Bending Schedules.

Bars shall be bent cold to the specified shape and dimensions or as directed by the Engineer using a proper bar bender, operated by hand or power to obtain the correct radii of bends and shape.

Bars shall not be bent or straightened in a manner that will damage rile parent material or the coating.

Bars bent during transport or handling shall be straightened before being used on work and shall not be heated to facilitate straightening.

1605 PLACING OF REINFORCEMENT

The reinforcement cage should generally be fabricated in the yard at ground level and then shifted and placed in position. The reinforcement shall be placed strictly in accordance with the drawings and shall be assembled in position only when the structure is otherwise ready for

placing of concrete. Prolonged time gap between assembling of reinforcements and casting of concrete, which may result in rust formation on the surface, shall not be permitted.

Reinforcement bars shall be placed accurately in position as shown on the drawings- The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS: 280 to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1 mm.

Ban shall be kept in position usually by the following methods:

a) In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover shall be placed between the bars and formwork subject to satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided "they have the same strength and specification as those of the member.

   i) In case of dowels for columns and walls, the vertical reinforcement shall be kept in position by means of timber templates with slots cut in them accurately, or with cover blocks tied to the reinforcement. Timber templates shall be removed after the concreting has progressed up to a level just below their location.
   ii) Layers of reinforcements shall be separated by spacer bars at approximately one metre intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be allowed to sag between supports.
   iii) Necessary stays, blocks, metal chairs, spacers, metal hangers, supporting wires etc. or other subsidiary reinforcement shall be provided to fix the reinforcements firmly in its correct position.
   iv) Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc., as devices for positioning reinforcement shall not be permitted.

b) Bars coated with epoxy or any other approved protective coating shall be placed on supports that do not damage the coating. Supports shall be installed in a manner such that planes of weakness are not created in hardened concrete. The coated reinforcing steel shall be held in place by use of plastic or plastic coated binding wires especially manufactured for the purpose. Reference shall be made to Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress for other requirements.

c) Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concrete is deposited.

1606 BAR SPLICES

1606.1 Lapping

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing, will be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other, and shall be kept apart by 25 mm or 1 ¼ times the maximum size of coarse aggregate, whichever is greater. If this is not feasible, overlapping bars shall be bound with annealed steel binding wire, not less than 1 mm diameter and twisted right in such a manner as to maintain minimum clear cover to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points, along the span where stresses are low.

1606.2 Welding

i) Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or

greater than that of the bars connected.

ii) While welding may be permitted for mild steel reinforcing bars conforming to IS: 432, welding of deformed bars conforming to IS: 1786 shall in general be prohibited. Welding may be permitted in case of bars of other than S 240 grade including special welding grade of S 415 grade bars conforming to IS: 1786, for which necessary chemical analysis has been secured and the carbon equivalent (CE) calculated from the chemical composition using the formula :

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mg+V}{5} + \frac{Ni+Cu}{15}$$ is 0.4 or less.

iii) The method of welding shall conform to IS: 2751 and IS: 9417 and to any supplemental specifications to the satisfaction of the Engineer.
Welding may be carried out by metal arc welding process. Oxy-acetylene welding shall not be permissible. Any other process may be used subject to the approval of the Engineer and necessary additional requirements to ensure satisfactory joint performance. Precautions on overheating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.
All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm), which may be lap, welded. Single-V or Double-V butt joints may generally be used. For vertical bars single bevel or double bevel joints may be used.
Welded joints shall be located well away from bends and not less than twice the bar diameter away from a bend.
Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, - process, consumables, operators, welding procedure are adequate to produce and maintain uniform quality at par with that attainable in shop welding to the satisfaction of the Engineer.
Joint welding procedures, which are to be employed, shall invariably be established by a procedure specification. All welders and welding operators to be employed shall have to be qualified by tests prescribed in IS: 2751 Inspection of welds shall confer s to IS: 822 and destructive or non-destructive testing may be undertaken when deemed necessary. Joints with weld defects detected by visual inspection or dimensional check inspection shall not be accepted.
Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in 2 or 3 stages, previous surface shall be cleaned properly. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Only competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars.
M.S. electrodes used for welding shall conform to IS: 814.

iv) Welded joints shall preferably be located at points where steel will not be subject to more than 75 per cent of the maximum permissible stresses and welds so staggered that at any one section, not more man 20 per cent of the bars are welded.

v) Welded pieces of reinforcement shall be tested. Specimens shall be taken from the site and the number and frequency of tests shall be as directed by the Engineer.

1606.3 Mechanical Coupling of Bars

Bars may be joined with approved patented mechanical devices as indicated on the drawing or as approved by the Engineer e.g. by special grade steel sleeves swaged on to" bars in end-to-end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 per cent of the characteristic strength of the reinforcement bar.

1607 TESTING AND ACCEPTANCE

The material shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, will be got carried out by the Contractor at his own cost.

The fabrication, furnishing and placing of reinforcement shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

1608 MEASUREMENTS FOR PAYMENT

Reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in tones on the basis of IS: 1732. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement

1609 RATE

The contract unit rate for coated/uncoated reinforcement shall cover the cost of material, fabricating, transporting, storing, bending, placing, binding and fixing in position as shown on the drawings as per these specifications and as directed by the Engineer, including all labour, equipment, supplies, incidentals, sampling, testing and supervision.

The unit rate for coated reinforcement shall be deemed to also include cost of all material, labour, tools and plant, royalty, transportation and expertise required to carry out the work. The rate shall also cover sampling, testing and supervision required for the work.

1700 STRUCTURAL CONCRETE

1701 DESCRIPTION

The work shall consist of furnishing and placing structural concrete and incidental construction in accordance with these specifications and in conformity with the lines, grades and dimensions, as shown on the drawings or as directed by the Engineer.

1702 MATERIALS

All materials shall conform to Section 1,000 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

1703 GRADES OF CONCRETE

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

Table 1700-1: Grades of concrete

Grade Designation	Specified characteristic Compressive strength of 150 mm cubes at 28 days, in Mpa
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40
M 45	45
M 50	50
M 55	55

The lowest grades of concrete in bridges and corresponding minimum cement contents and water-cement ratios shall be maintained as indicated in the table and TABLE 1700-2**.**

Minimum Cement Content and Maximum Water Cement Ratio

Table 1700-2: For bridges with pre-stressed concrete or those with individual span lengths more than 30 m or those that are built with innovative design/construction

Structural Member	Min. cement content for all exposure conditions (kg/cu.m.)	Max. water cement ratio Exposure conditions	
		Normal	Severe
a) PCC members	360	0.45	0.45
b) RCC members	400	0.45	0.40
c) PSC members	400	0.40	0.40

A. Minimum Strength of Concrete

Member	Conditions of Exposure	
	Moderate	Severe
a) PCC members	M 25	M 30
b) RCC members	M 35	M 40
c) PSC members	M 35	M 40

Table 1700-3: For bridges other than those mentioned in Table 1700-2 and for culverts and other incidental construction

Minimum cement content and maximum water cement ratio

Structural Member	Min. cement content (kg/cu.m.)		Max. water cement ratio	
	Exposure conditions		Exposure conditions	
	Normal	Severe	Normal	Severe
a) PCC members	250	310	0.50	0.45
b) RCC members	310	400	0.45	0.40

A. Minimum Strength of Concrete

Member	Conditions of Exposure	
	Moderate	Severe
a) PCC members	M 15	M 20
b) RCC members	M 20	M 25

Notes Applicable to table and Table 1700-3.

i) The minimum cement content is based on 20 mm aggregate (nominal max. size). For 40 mm and larger size aggregates, it may be reduced suitably but the reduction shall not be more than 10 per cent.
ii) For underwater concreting, the cement content shall be increased by 10 per cent.
iii) Severe conditions of exposure shall mean alternate wetting and drying due to sea spray, alternate wetting and drying combined with freezing and buried in soil having corrosive effect.
iv) Moderate conditions of exposure shall mean other that those mentioned in (iii) above.

The cement content shall be as low as possible but not less than the quantities specified above. In no case shall it exceed 540 kg/cu.m. of concrete.

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

If the Contractor so elects, the Engineer may permit the use of higher grade concrete than that specified on the drawing, in which event the higher grade concrete shall meet the specifications applicable thereto without additional compensation.

1704 PROPORTIONING OF CONCRETE

Prior to the start of construction, the Contractor shall design the mix in case of "Design Mix Concrete" or propose nominal mix in case of "Nominal Mix Concrete", and submit to the Engineer for approval, the proportions of materials, including admixtures to be used. Water-reducing admixtures (including plasticizers or super-plasticizers) may be used at the Contractor's option, subject to the approval of the Engineer. Other types of admixtures shall be prohibited, unless specifically permitted by the Engineer.

1704.1 Requirements of Consistency

The mix shall have the consistency, which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain uniform consistency.

The optimum consistency for various types of structures shall be as indicated in the table below or as directed by the Engineer. The slump of concrete shall be checked as per IS: 516.

Table 1700-4: Consistency requirements

S. No.	Type	Slump (mm)
1	Structures with exposed inclined surface requiring low slump concrete to allow proper compaction plain cement concrete	25 25
2	RCC structures with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40 – 50
3	RCC structures with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts well curb, well cap, walls with thickness greater than 300 mm	50 – 75
4	RCC and PSC structures with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm	75 – 125
5	Underwater concreting through tremie e.g. bottom plug, cast-in-situ piling	100 – 200

1704.2 Requirements for Designed Mixes

1704.2.1 Target Mean Strength

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

The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.

Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Error! Reference source not found.

Table 1700-5: Initial design mix current margin

Concrete Grade	Current Margin (MPa)	Target Mean Strength (MPa)
M 15	10	25
M 20	10	30
M 25	11	36
M 30	12	42

Concrete Grade	Current Margin (MPa)	Target Mean Strength (MPa)
M 35	12	47
M 40	12	52
M 45	13	58
M 50	13	63
M 55	14	69

The initial current margin given in the Error! Reference source not found. shall be used till sufficient data is available to determine the current margin as per sub-clause (i) above.

1704.2.2 Trial Mixes

The Contractor shall give notice to enable the Engineer to be present at the making of trial mixes and preliminary testing of the cubes. The Contractor shall prepare trial mixes, using samples of approved materials typical of those he proposes to use in the works, for all grades to the Engineer's satisfaction prior to commencement of concreting. The initial trial mixes shall generally be carried out in an established laboratory approved by the Engineer. In exceptional cases, the Engineer may permit the initial trial mixes to be prepared at the site laboratory of the Contractor, if a full-fledged concrete laboratory has been established well before the start of construction, to his entire satisfaction. In all cases complete testing of materials forming the constituents of proposed Design Mix shall have been carried out prior to making trial mixes.

Sampling and testing procedures shall be in accordance with these specifications.

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

Test cubes shall be taken from trial mixes as follows. For each mix, set of six cubes shall be made from each of three consecutive batches. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these specifications. The average strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

1704.2.3 Control of Strength of Design Mixes

a) Adjustment to Mix Proportions

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

b) Change of Current Margin

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with Clause 4.1.4.2.1. The recalculated value shall be adopted as directed by the Engineer and it shall become the current margin for concrete produced subsequently.

c) Additional Trial Mixes

During production, the Contractor shall carry out trial mixes and tests, if required by the Engineer, before substantial changes are made in the material or in the proportions of the materials to be used, except when adjustments to the mix proportions are carried out in accordance with sub-clause (a) above.

1704.2.4 Requirements of Nominal Mix Concrete

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

Table 1700-6: Proportions for nominal mix concrete

Concrete Grade	Total Quantity of dry aggregate by mass per 50 kg of cement to be taken as the sum of individual masses of floe and coarse aggregates (kg)	Proportion of fine to Coarse aggregate (by mass)	Maximum Quality of Water for 50 kg of Cement (Liters)	
			PCC	RCC
M 15	350	Generally 1:2 subject to upper limit 1:1.5 and lower limit of 1:2.5	25	
M 20	250		25	22

1704.2.5 Additional Requirements

Concrete shall meet with any other requirements as specified on the drawing or as directed by the Engineer. Additional requirements shall also consist of the following overall limits of deleterious substances in concrete:

a) The total chloride content of all constituents of concrete as a percentage of mass of cement in mix shall be limited to values given below:

Pre-stressed Concrete : 0.1 per cent
Reinforced concrete exposed to chlorides in service : 0.2 per cent
(e.g. structures located near sea coast)
Other reinforced concrete construction : 0.3 per cent

b) The total sulphuric anhydride (SO.) content of all the constituents of concrete as a percentage of mass of cement in the mix shall be limited to 4 per cent.

1704.2.6 Suitability of Proposed Mix Proportions

The Contractor shall submit the following information for the Engineer's approval:

i) Nature and source of each material
ii) Quantities of each material per cubic metre of fully compacted concrete
iii) Either of the following :

a) Appropriate existing data as evidence, of satisfactory previous performance for the target mean strength, current margin, consistency and water/cement ratio and .any other additional requirements) as specified.

b) Full details of tests on trial mixes.

iv) Statement giving the proposed mixes proportions for nominal mix concrete.
v) Any change in the source of material or in the mix proportions shall be subject to the Engineer's prior approval.

1705 ADMIXTURES

Use of admixtures such as super plasticizers for concrete may be made with the approval of the Engineer.

As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of his products only after obtaining complete knowledge of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the project.

1706 SIZE OF COARSE AGGREGATE

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be as detailed in Table 1700-7**.**

.

Table 1700-7: Coarse aggregate size

S. No.	Components	Maximum Nominal Size of Coarse Aggregate (mm)
1	RCC well Curb	20
2	RCC/PCC well steining	40
3	Well cap or Pile Cap Solid type piers and abutments	40
4	RCC works in girders. Slabs, wearing coat, kern, approach slab, hollow piers and abutments, pier/abutment caps, piles	20
5	PSC work	20
6	Any other item	as specified by Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values:

- 10 mm less than the minimum lateral clear distance between main reinforcements
- 10 mm less than the minimum clear cover to the reinforcements

The proportions of the various individual sizes of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

1707 EQUIPMENT

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under:

i) For Production of Concrete :

a) concrete batching and mixing plant fully automatic with minimum capacity of 15-cu.m.per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

Measurement of Cement	± 3 per cent of the quantity of cement in each batch
Measurement of Water	± 3 per cent of the quantity of water in each batch
Measurement of Aggregate	± 3 per cent of the quantity of aggregate in each batch
Measurement of Admixture:	± 5 per cent of the quantity of admixture in each batch

ii) For Concrete Transportation: depending upon actual requirement

Concrete dumpers	minimum 2 tonnes capacity
Powered hoists	minimum of 0.5 tonnes capacity
Chutes	
Buckets handled by cranes	
Transit truck mixer	
Concrete pump	

Concrete distributor booms

Belt conveyor

Cranes with skips

Tremies

iii) For Compaction of Concrete:

Internal vibrators	:	size 25 mm to 70 mm
Form vibrators	:	minimum 500 watts
Screed vibrators	:	full width of carriageway (upto two lanes)

1708 MIXING CONCRETE

Concrete shall be mixed in a batching and mixing plant, as per these specifications. Hand mixing shall not be permitted. The plant shall be at an approved location considering the properties of the mixes and the transportation arrangements available with the Contractor. The plant shall be approved by the Engineer.

Mixing shall be continued till materials are uniformly distributed and a uniform color of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement. In no case shall mixing be done for less than 2 minutes.

.. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

1709 TRANSPORTING, PLACING AND COMPACTION OF CONCRETE

The method of transporting and placing concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position, so that no contamination, segregation or loss of its constituent materials takes place. Concrete shall not be freely dropped into place from a height exceeding 1.5 metres.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without any segregation of its ingredients. The delivery -end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

All formwork and reinforcement contained in it shall be cleaned and' made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained.

If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete, which has been in position for more than 30 minutes unless a proper construction joint is formed.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not exceeding 300 mm in all other cases.

Concrete when deposited shall have a temperature of not less than 5 degrees Celsius, and not more than 40 degrees Celsius. It shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously, when this rime shall be within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. It may be necessary to add retarding admixtures to concrete if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over vibration shall be avoided to minimize the risk of forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrations shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and a half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

Mechanical vibrators used shall comply with IS: 2502, IS: 2506, IS: 2514 and IS: 4656.

1710 CONSTRUCTION JOINTS

Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings, except with express approval of the Engineer. The joints shall be provided in a direction perpendicular to the member axis.

Location, preparation of surface and concreting of construction joints shall conform to the additional specifications given in Appendix 1700/I of Specifications for Road & Bridges Works‖ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

1711 CONCRETING UNDER WATER

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used shall be got approved from the Engineer before any work is started.

Concrete shall contain 10 per cent more cement than that required for the same mix placed in the dry.

Concrete shall not be placed in water having a temperature below 5 degrees Celsius. The temperature of the concrete, when deposited, shall not be less than 16 degrees Celsius, nor more than 40 degrees Celsius.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 metres per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter. To minimize the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only, using tremie of appropriate diameter. The number and spacing of the tremies should be worked out to ensure proper concreting. The tremie concreting when started should continue without interruption for the full height of the member being concreted. The concrete production and placement equipment should be sufficient to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary stand-by equipment should be available for emergency situation.

The top section of the tremie shall have a hopper large enough to hold one full batch of the mix or the entire contents of the transporting bucket as the case may be. The tremie pipe shall not be less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength for the job shall be used. A separate lifting device shall be provided for each tremie pipe with its

hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the "pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper; so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise slowly the tremie in order to allow a uniform flow of concrete, but it shall not be emptied so that water is not allowed to enter above the concrete in the pipe. At all times after placing of concrete is started and until all the required quantity has been placed, the lower end of the tremie pipe shall be kept below the surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface and unless sealed 'by a check valve, it shall be replugged at the top end, as at the beginning, before refilling for depositing further concrete.

1712 ADVERSE WEATHER CONDITIONS

1712.1 Cold Weather Concreting

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5 degrees Celsius and that the temperature of the concrete shall be maintained above 4 degrees Celsius until it has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock-piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65 degrees Celsius. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and the water consent of the mix shall not exceed 30 litres per 50 kg of cement.

1712.2 Hot Weather Conditions

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40 degrees Celsius while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist, using cold water, reducing the time between mixing and placing to the minimum, cooling formwork by sprinkling water, starting curing before concrete dries out and restricting concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered a part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted.

The Contractor will be required to state his methodology for the Engineer's approval when temperatures of concrete are likely to exceed 40 degrees Celsius during the work.

1713 PROTECTION AND CURING

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor.

Curing and protection of concrete shall start immediately after compaction of the concrete to protect it from:

- Premature drying out particularly by solar radiation and wind
- High internal thermal gradients
- Leaching out by rain and flowing water
- Rapid cooling during the first few days after placing
- Low temperature or frost
- Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement

Where members are of considerable size and length, with high cement - content, accelerated curing methods may be applied, as approved by the Engineer.

1713.1 Water Curing

Water for curing shall be as specified in Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

Sea water shall not be used for curing. Sea water shall not come into contact with concrete members unless it has attained adequate strength.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacks, canvas, Hessian or similar materials and shall be kept constantly wet for a period of not less than 14 days from the date of placing of concrete.

1713.3 Curing Compounds

Curing compounds shall only be permitted in special circumstances and will require specific approval of the Engineer. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist, cured and no curing compound will be permitted in locations where concrete surfaces are required to be bonded together.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears, the second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

1714 FINISHING

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as is possible to use. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces, which have been pointed, shall be kept moist for a period of twenty tour hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of, forms, the concrete work shall be examined by the Engineer before any defects are made good.

The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance shall be rejected.

Surface defect of a minor nature may be accepted. On acceptance of such work by the Engineer, the same shall be rectified as directed by the Engineer.

1715 TOLERANCES

Tolerances for dimensions/shape of various components shall be as indicated in these specifications or shown on the drawings or as directed by the Engineer.

1716 TESTS AND STANDARDS OF ACCEPTANCE

Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

Random sampling and lot-by-lot of acceptance inspection shall be made for the 28 days cube strength of concrete.

Concrete under acceptance shall be notionally divided into lots for me purpose of sampling, before commencement of work. The delimitation of lots shall be determined by the following:

- No individual lot shall be more than 30 cu.m. in volume.
- At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day.
- Different grades of mixes of concrete shall be divided into separate lots.
- Concrete of a lot shall be used in the same identifiable component of the bridge.

1716.1 Sampling and Testing

Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS: 1199.

A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes shall be adopted.

150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS: 516. The 28-day test strength result for each cube shall form an item of the sample.

1716.2 Test Specimen and Sample Strength

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than ± 15 per cent of the average.

1716.3 Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 1700-8

Table 1700-8: Frequency of sampling

Quantity of Concrete in work, m^3	No. of samples
1 – 5	1
6 – 15	2
16 – 30	3
31 – 50	4
51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof

At least one sample shall be taken from each shift of work.

1716.4 Acceptance Criteria

a. Compressive Strength

When both the following conditions are met, the concrete complies with the specified compressive strength

The mean strength determined from any group of four consecutive samples should exceed the specified characteristic compressive strength.

Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

b. Chloride and Sulphate Content

The total chloride and sulphuric anhydride (SO3) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this section of the specifications.

1716.5 Density of Fresh Concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

1716.6 Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

1716.7 Permeability Test

The concrete should pass the following test if it is properly compacted and is not considered permeable.

i) Prepare a cylindrical test specimen 150 nun dia and 160 mm high.
ii) After 28 days of curing, the test specimen is fined in a machine such that the specimen can be placed in water under pressure up to 7 bars. A typical machine is shown in Appendix 1700/II of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.
iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
iv) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.
v) The water penetration in the broken core is to be measured with a scale and the depth of penetration assessed in mm (max. permissible limit 25 mm).

If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable after investigation, the Contractor shall remove the rejected concrete forthwith.

1717 MEASUREMENTS FOR PAYMENT

Structural concrete shall be measured in cubic metres. In reinforced or prestressed concrete, the volume occupied by reinforcement or prestressing cables and sheathing shall not be deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

1718 RATE

The contract unit rate for structural concrete shall cover costs of all materials, labour, tools, plant and equipment required for mixing, transporting and placing in position, vibrating and

compacting, finishing and curing as per this Section or as directed by the Engineer, including all incidental expenses, sampling and testing, quality assurance and supervision. Unless mentioned separately as an item in the Contract, the contract unit rate for concrete shall also include the cost of providing, fixing and removing formwork required for concrete work as per Section 2.16.

Where concrete is found to be acceptable as sub-standard work, the Contractor shall pay a discount over the contract unit rate, as decided by the Engineer. For deficiency in compressive strength of concrete when accepted by the Engineer, the reduction in rate may be applied as under

$$\text{Per cent reduction} = \frac{\text{Design Strength - Observed Strength}}{\text{Design Strength}} \times 100$$

1800 PRE-STRESSING

1801 DESCRIPTION

Structural concrete containing pre-stressed steel reinforcement to introduce pre-compression is termed as pre-stressed concrete.

1801.1 General

The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

Concrete and untensioned steel for the construction of pre-stressed concrete members shall conform to the requirements of sections 4.1 and section 5.1 for Structural Concrete and Steel Reinforcement respectively in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

1802 MATERIALS

All materials shall conform to Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

1802.1 Sheathing

The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS: 513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

The material shall normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used.

The thickness of sheathing shall be as shown on the drawing, but shall not be less than 0.3 mm,
0.4 mm and 0.5 mm for sheathing ducts having internal diameter of 50 mm, 75 mm and 90 mm respectively. For bigger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

The sheathing shall conform to the requirement as per tests specified in Appendix 1800/I of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

The length of the coupler should not be less than 150 mm but should be increased upto 200 mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath-making machine with the next higher size of die set.

The internal area of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons comprising 12/13 mm dia strands, the inner diameter of the sheathing shall not be less than 50 mm, 75 mm and 90 mm respectively or those shown in the drawing, whichever is greater.

Where prestressing tendons are required to be threaded after concreting the diameter of sheathing shall be about 5 mm larger than that required as above.

In severe environment, cables shall be threaded after concreting. In such cases a temporary tendon shall be inserted in the sheathing or the sheathing shall be stiffened by other suitable method during concreting.

1802.2 Anchorages

1803.3.1 Anchorages shall be procured from authorised manufacturers only. Anchorages shall conform to BS: 4447. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coaling.

1803.3.2 Swages of prestressing strand and button-heads of prestressing wire, where provided shall develop strength of at least 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging/button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

1803.3.3 Untensioned Steel reinforcements, around anchorages shall conform to the details of prestressing system and as shown on the drawing.

1803 TESTING OF PRE-STRESSING STEEL AND ANCHORAGES

All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

All wire, strand or bars to be shipped to the site' shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least
5.0 m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

1804 WORKMANSHIP

1804.1 Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

1804.2 Straightening

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing wire/strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires/strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

1804.3 Positioning

1804.3.1 Post-Tensioning

Pre-stressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The locationing of pre-stressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High capacity tendon shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distances between any two cables shall in no case be less than 100mm anywhere along the length of the superstructure. Where precast segments are used, the clear distance shall be at least 150 mm.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to the approval of the Engineer. The temporary tendon shall be pulled out before threading the permanent tendon into place by a special threading machine or other contrivance.

Where possible tendons shall not be placed until immediately prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendons damaged or contaminated shall be cleaned or replaced.

1804.3.2 Pre-Tensioning

Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete, which adheres to bearing or wedging surfaces, shall be removed immediately.

1804.4 Cutting

Suitable mechanical or flame cutters shall do cutting and trimming of wires or strands. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The location of flame cutting of wire or strand shall be kept beyond 75 mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

1804.5 Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer.

In the case of external prestressing, steel shall be encased in suitable polyethelene pipes before grouting.

1804.6 Sheathing

The joints of all sheathings shall be watertight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with heat shrink tape, to make it waterproof.

The heat-shrink tape is supplied in the form of bandage rolls, which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after healing the bandage material shrinks on the sheathing duct and ensures formation of a leak-proof joint. The heating is affected by means of a soft gas flame.

A sheath-making machine should be positioned at the site of work for large projects so that sheathing can be prepared as and when it is required for construction.

The sheathing and all joints shall be watertight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

1804.7 Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacings of consecutive vents do not exceed 20 m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without the loss of water, air pressure or grout.

1804.8 Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning.

Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre, line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface by a minimum cover of 100 mm.

After the prestressing operations are completed and prestressing wires/strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry Film thickness of
80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

1804.9 Structural Concrete

Structural concrete shall conform to Section 4.1. The formwork shall conform to Section 10.19.

1805 SUPERVISION

All pre-stressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the pre-stressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

1806 TENSIONING EQUIPMENT

All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

The means of attachments of the pre-stressing steel to the jack or any other tensioning apparatus shall be safe and secure.

Where two or more wires/strands constitute a tendon, a single multiple stressing jack shall be used which is capable of tensioning simultaneously all the wires/ strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.

The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of pre-stressing steel to the nearest mm and of any slip of the gripping devices at transfer.

All dynamometers and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 per cent and 80 per cent of its full capacity suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

1807 POST-TENSIONING

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load applied to the concrete before it attains the strength specified on the drawing or as stipulated by the pre-stressing system supplier, whichever is more.

After pre-stressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the pre-stressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during pre-stressing operations shall be regulated as follows:

If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed

times the calculated elongation. If 1.05 limes the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq. c.m. until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

If the elongation at 1.05 times the specified gauge pressure is less than 0.95 limes the calculated elongation, the following measures must be taken, in succession, to determine the cause of this lack of discrepancy:

Check the correct functioning of the jack, pump and leads.

Detension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retension the cable if free.

Re -establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

If the required elongation is still not obtained, farther finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress. The number of stages of prestressing and grouting shall be reduced to a minimum, preferably 2 in the case of simply supported girders.

1808 GROUTING OF PRESTRESSED TENDONS

Grouting shall conform to Appendix 1800/III of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress. A record of grouting operations shall be maintained in the format given in Appendix 1800/IV of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

1809 PRE-TENSIONING

1809.1 General

The planning and construction aspects of the tensioning bed, tensioning bench, abutments at location of anchorage, steam curing system, form work of the concrete elements and arrangements for de-molding, lifting, stacking and transportation of the pre-tensioned concrete elements are all specialised items and shall be entrusted to engineers specifically experienced in this type of work.

1810.7 Stressing Bed for Pre-tensioning

The abutments and bed for pre-tensioning of tendons shall be designed to withstand the total tensioning force.

A notice shall be displayed adjacent to the stressing bed showing the maximum tensioning force permitted.

Where concrete elements are cast and prestressed individually, the stressing bench or moulds shall be rigid enough to sustain the reaction of the pre-stressing force without distortion.

In the long line method of pre-stressing, sufficient locator plates should be distributed throughout the length of the bed to ensure that the wires are maintained in their proper position during concreting. The moulds shall be free to slide in the direction of their length and thus permit the transfer of the pre-stressing force to all the concrete elements along the whole line.

Sufficient space shall be left in between the ends of concrete elements to permit access for cutting the strands/wires after transfer. Hold-downs or deflectors shall be used for holding or deflecting the tendons in required position firmly. Deflectors, which are in contact with the tendon, shall have a diameter not less than the tendon or 15 mm, whichever is greater.

The tensioning force required to be applied as stated on the drawings shall be the force remaining in the strands/wires after all strands/wires have been anchored to the abutments of the stressing bed and after the anchorage slip has already taken place. The tensioning force shall be determined by direct reading of the pressure gauges or dynamometers and by the measured elongation after slip.

The Contractor shall submit method of tensioning the tendons including the arrangement and layout of pre-stressing beds and all tendon deflection points to the Engineer for approval before manufacture commences.

The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold-downs and the slip during anchoring.

Where sheathing of pre-tensioned tendons is required to prevent bond over a specified length, it shall consist of plastic tubing or other material approved by the Engineer and shall be of a quality, diameter and thickness such that bond shall be effectively prevented. The tubing shall be fastened to the tendon in such a manner that cement mortar cannot enter. The Engineer may order that the pull-in of the tendon be measured during the transfer of pre-stress.

The Contractor shall also submit calculations showing that the hold-downs have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

1809.2 Tensioning Procedure

The tensioning of the wires and strands shall be done not too much in advance of concreting.

The tensioning force shall be applied gradually and uniformly.

In order to remove slack and to lift tendons off the bed floor, an initial force approved by the Engineer shall be applied to the tendons. Allowance shall be made for this force in calculating the required elongation.

Tendons shall be marked for measurement of elongation after the initial force has been applied. When required by the Engineer, tendons shall be marked at both the jacking end and dead end of the stressing bed and at couplers if used so that slip and draw-in may be measured.

Where deflected strands have been specified, the Engineer may direct the elongation or strain gauge measurements be taken at various positions along the tendon to determine the force in the tendon at those positions.

1809.3 Transfer of Prestress

While the process of tensioning can be accomplished by means of hydraulic jacks, some positive mechanical means shall be provided to maintain the tension during the entire period between the tensioning of the wires/strands and transfer of the prestressing force to the concrete element.

Transfer of prestress shall not proceed until the Engineer has approved the proposed method. Tendons and deflection devices shall be released in such a pre-determined order that unacceptable tensile stresses are not induced in the concrete.

Prior to transfer of the force to the units, all tendons shall be tested for tightness and any loose tendon shall be reported to the Engineer who will decide whether the units affected shall be rejected.

The Engineer may require that tendons be marked at each end of any unit to allow measurement of the pull-in of the concrete.

Tendons shall be released gradually and preferably simultaneously.

Under no circumstances shall tendons be cut while under tension.

On completion of the transfer of prestress, the projecting lengths of tendon shall be- cut off flush with the end surface of the unit, unless otherwise shown, by a method approved by the Engineer.

In no case shall the transfer of prestressing force to the concrete elements take place before concrete attains the strength specified in the drawings. To determine the specified strength, additional cube testing shall be undertaken at the Contractor’s cost. In case steam curing is employed, the cubes shall be placed in the same environment as the concrete elements to obtain an accurate, assessment of concrete strength at the time of transfer.

The sequence of transfer of prestressing force shall be done strictly as indicated in the drawings and ensuring that eccentricities of the prestressing force in the vertical and horizontal directions of the concrete element is a minimum during the entire sequence.

The maximum slip of any tendon during transfer shall not exceed 3 mm at any end of the concrete element. In case this slip is exceeded, the concrete element in question shall be rejected.

1809.4 Protection of Ends

The exposed ends of the tendons and the concrete surfaces of the ends of the units shall be wire brushed clean of all rust, loose mortar, grease and dirt.

The exposed ends of the tendons and concrete surface within 50 mm of tendons shall be then abraded to provide a clean sound surface. An epoxy tar paint suitably formulated to give a dry film thickness of 80 microns per coat shall then be immediately applied over the ends of the tendons unless otherwise directed.

A second coat of paint shall be applied prior to the drying out of the first coat.

1810 SAFETY PRECAUTIONS DURING TENSIONING

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

During actual tensioning operation, warning sign shall be displayed at both ends of the tendon.

After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon, which has been affected by welding, weld spatter or heat, shall be rejected.

1811 TRANSPORTATION AND STORAGE OF UNITS

Precast girders shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side-supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being damaged. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

1812 TOLERANCES

Permissible tolerances for positional deviation of Pre-stressing tendons shall be limited to the following:

Variation from the specified horizontal profile	:	5 mm
Variation from the specified vertical profile	:	5 mm
Variation from the specified position in member	:	5 mm

1813 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1814 MEASUREMENTS FOR PAYMENT

Prestressed Concrete shall be measured in cubic metres. The volume occupied by mild steel reinforcement / HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

High tensile (pre-stressing) steel shall be paid for separately and its length shall be measured as actually incorporated in the finished work. From the length so measured its weight shall be calculated in tones on theoretical basis and paid for.

Anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same, protection by painting with epoxy and furnishing samples for testing shall all be deemed to be included in the item of high tensile steel and shall not be measured separately.

1815 RATE

The contract unit rate for cast-in-place prestressed concrete shall cover the cost of all materials, labor, tools and plant required for mixing, placing in position, vibrating and compacting, finishing as per directions of the Engineer, curing and other incidental expenses for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to specifications. The contract unit rate shall also -include the cost of making, fixing and removing of all centering and forms required for the work unless otherwise specified in the Contract.

For precast prestressed concrete members, the rate in addition to above shall also include the cost of all materials, labor, tools and plant required to transport and place these members in their final position as shown on the drawings and as directed by the Engineer.

The contract unit rate for high tensile steel shall cover the cost of material, labor, tools and plant required for manufacturing, placing, tensioning, anchoring and grouting the high tensile steel in the prestressed concrete as shown on the drawings and as per specifications herein above or as directed by the Engineer.

The cost of anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same, protection by painting with epoxy and furnishing samples for testing shall all be included in the unit rate. Rate shall also include payments if any to be made to the supplier of the pre-stressing system who has to

1900 STRUCTURAL STEEL

1901 DESCRIPTION

This work shall include furnishing, fabricating, transporting, erecting and painting structural steel, rivet steel, cast steel, steel forgings, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the drawings and these specifications or as desired by the Engineer.

1902 GENERAL

General requirements relating to the supply of material shall conform to the specifications of IS: 1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.

The acceptance of any material on inspection at the mill i.e. rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective.

Unless specified otherwise, high tensile steel rivets conforming to. IS: 1149 shall be used for members of high tensile steel conforming to IS: 961 and shall not be used for mild steel members.

Unless specified otherwise, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS: 4000.

Cast iron shall not be used in any portion of the bridge structure, except where it is subject to direct compression.

1903 MATERIALS

All materials shall conform to Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress. Special requirements are given below:

Mild steel for bolts and nuts shall conform to IS: 226 but have a minimum tensile strength of 44 kg/sq. mm. and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS:961 but with a minimum tensile strength of 58 kg/sq. mm. High strength friction grip bolts shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these specifications) specified by the Engineer or included in the special provisions.

For cast steel, the yield stress shall be determined and shall not be less than 50 per cent of the minimum tensile strength.

Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

Parallel barrel drifts shall have a tensile strength not less than 55 kg/sq. mm. with elongation of not less than 20 per cent measured on a gauge length of $4\sqrt{So}$ (So = cross sectional area).

1903.1 Materials for castings and forgings, fasteners and welding consumables shall be as under:

a) **Castings and forgings:** Steel castings and forgings shall comply with the requirements

of the following Indian Standards, as appropriate:

IS: 1030	Carbon Steel Castings for General Engineering purposes
IS: 1875	Carbon Steel Billets, blooms, slabs, bars for forgings
IS: 2004	Carbon Steel Forgings for General Engineering purposes
IS: 2644	High Tensile Steel Casings
IS: 4367	Alloy & tool steel forgings for general industrial use

b) **Fasteners:** Bolts, nuts, washers and rivets shall comply with the following or relevant IS Standards as appropriate:

IS: 1929	Hot forged steel rivets for hot closing (12-36mm dia) IS:
2155	Cold forged steel rivets for hot closing (6-16mm dia)
IS: 1363	Hexagon head bolts, screw and nuts product grade C
IS: 1364	Hexagon head bolts, screw & nuts product grade A & B
IS: 1367	Technical supply conditions for threaded steel fastener (Parts 1 to 18)
IS: 3640	Hexagon fit bolts
IS: 3757	High tensile friction grip bolts
IS: 6623	High strength structural nuts
IS: 6639	Hexagon bolts for steel structure
IS: 5624	Foundation bolts
IS: 7002	Prevailing torque type steel hexagon lock nuts
IS: 5369	Plain washers and lock washers - general requirements
IS: 5370	Plain washers with outside dia = 3 X inside dia
IS: 5372	Taper washers for channels (ISMC)
IS: 5374	Taper Washers for I beams (ISMB)
IS: 6610	Heavy washers for steel structures
IS: 6649	Hardened and tempered washers for high strength structural bolts and nuts

c) Welding consumables

Welding consumables shall comply with the following Indian Standards as appropriate:

IS: 814	Covered Electrodes for Metal Arc Welding of structural (Part 1) steel for welding other than sheets
IS: 814	for welding sheets (Part 2)
IS: 1278	Filler rods and wires for gas welding
IS: 1395	Low and medium alloy Steel covered electrodes for manual Metal Arc Welding
IS: 3613	Acceptance Tests for wire flux combinations for submerged arc welding of structural steel
IS: 7280	bare wire electrodes for gas shielded arc welding of structural steel
IS: 6419	Welding rods and bare electrodes for gas shielded arc welding of structural steel
IS: 6560	Molybdenum and chromium-molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding.

In aggressive environment, corrosion resistant steel can be used. These are low-alloyed steels containing a total of 1 per cent - 2 per cent alloys, in particular, copper, chromium, nickel and phosphorous.

d) Paints

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer.

The type of paints which can be used shall be as follows:

a) Ordinary i.e. paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy
b) Chemical Resistant - one pack type (ready for use) and two pack type (mixed before use).
c) Vinyl
d) Chlorinated rubber
e) Bituminous

f) Epoxy
g) Polyurethane
h) Zinc rich
i) Unless otherwise specified, paints shall conform to the relevant IS specifications. The paints which have been tested for the following qualities as per specifications given in the relevant IS codes only shall be used:
j) Weight test (weight for 10 litre of paint, thoroughly mixed)
k) Drying time
l) Consistency
m) Dry thickness and rate of consumption.

1904 FABRICATION

1904.1 General

All work shall be in accordance with the drawings and as per these specifications with care being taken that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number.

Unless specifically required under the contract, corresponding parts need not be interchangeable, but the parts shall be match marked as required under Clause 5.2.4.7.

Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Engineer before they are used in the finished structure.

All structural steel members and parts shall have straight edges and blunt surfaces. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. They shall also be free from twist. Pressure applied for straightening or flattening shall be such as would not injure the materials. Hammering shall not be permitted. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

The Contractor shall submit his programme of work to the Engineer for his approval at least 15 days before the commencement of fabrication. This programme shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures.

The Contractor shall prepare shop drawings for fabricating any member and obtain approval of the Engineer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop drawings. These drawings shall distinguish between shop and field welds.

1904.2 Preparation of Edges and Ends

All structural steel-parts, where required, shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape.

End/edge planning and cutting shall be done by any one of the following prescribed methods or left as rolled:

a) Shearing, cropping, sawing, machining, machine flame cutting.
b) Hand flame cutting with subsequent grinding to a smooth edge.
c) Sheared edges of plate not more than 16 mm thick with subsequent grinding to smooth profile, which are for secondary use such as stiffeners and gussets.
d) If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 per cent of the contact area does not exceed 0.25 mm.
e) Where flame cutting or shearing is used, at least one of the following requirements shall be satisfied.
f) The cut edge is not subjected to applied stress.
g) The edge is incorporated in weld.
h) The hardness of cut edge does not exceed 350 HV30.
i) The material is removed from edge to the extent of 2 mm or minimum necessary, so

that the hardness is less than 350 HV 30.

j) Edge is suitably heat treated by approved method to the satisfaction of the Engineer and shown that cracks had not developed by dye penetrant or magnetic particle test.

k) Thickness of plate is less than 40 mm for machine flame cutting for materials conforming to IS: 226 and IS: 2062. The requirement of hardness below 350 HV 30 of flame cut edges should be specified by the Engineer.

l) Wherever specified by the Engineer, the flame cut edges shall be ground or machined over and above the requirement (a) to (f).

m) Where machining for edge preparation in butt joint is specified, the ends shall be machined after the members have been fabricated.

n) Outside edges of plate and section, which are prone to corrosion, shall be smoothed by grinding or filing.

o) In the case of high tensile steel at least 6 mm of the material from the flame cut edge shall be removed by machining,

p) Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:

q) Rolled edges of single universal plates or flats may not be machined.

r) Covers to single flange plates may be left unmachined.

s) Machine flame cutting instead of machining is acceptable for edges of single plates in compression and for edges of single plates, 25 mm or less thick, in tension.

t) Edges of single shaped plates over 25 mm thick not capable of being machined by ordinary method may be machine flame cut and the end surface ground.

u) Edges of universal plates or flats of the same nominal width used in tiers may be left unmachined, if so authorised by the Engineer.

v) All edges of splice and gusset plates 12 mm thick and over shall be machined and those less than 12 mm thick may be sheared and ground.

w) The ends of plates and sections forming the main components of plate girders or of built-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

x) Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground, or hand flame cut and ground.

y) The ends of lacing bar shall be rounded unless otherwise required.

z) Other edges and ends of mild steel parts may be sheared and any burrs at edges shall be removed.

1904.3 Preparation of Holes

Drilling and punching: Holes for rivets, black bolts, high strength bolts and countersunk bolts/rivets (excluding close tolerance and turn fitted bolts) shall be either punched or drilled. The diameter of holes shall be 1.5 mm larger for bolts/rivets less than 25 mm dia and 2.0 mm for more than or equal to 25 mm.

All holes shall be drilled except for secondary members such as, floor plate, handrails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for material conforming to IS: 226.

Holes through more than one thickness of material or when any of the main material thickness exceeds 20 mm for steel conforming to IS: 2062 or 16 mm for steel conforming to IS: 961, IS: 8500, shall either be sub-drilled or sub-punched to a diameter of 3 mm less than the required size and then reamed to the required size. The reaming of material more than one thickness shall be done after assembly.

Where several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tacking bolts, and the holes be drilled through the group in one operation. Alternatively, and in the case of repetition work, the plates and sections may be drilled separately from jigs and templates. Jigs and templates shall be checked at least once after every 25 operations. All burrs shall be removed.

In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted to ensure strict interchangeability. In such cases, one span in ten or any number less than ten of each type shall be erected from pieces selected at random by the Engineer and should there be any failure of the pieces to fit, all similar spans shall be erected complete. In the event of spans

being proved completely interchangeable, all corresponding parts shall carry the same mark so that sorting of the materials at site is facilitated.

i) Block drilling: Where the number of plates to be riveted exceeds three or the total thickness is 90 mm or more, the rivet holes, unless they have been drilled through steel bushed jigs, shall be drilled out in place 3 mm all round after assembling. In such cases, the work shall be thoroughly bolted together.

ii) Size of holes: The sizes of holes in millimetres are given in Table 1900-1 below:

Table 1900-1: Diameter of holes for rivets

Nominal dia of Rivets (mm)	Dia of Holes (mm)
12	13.5
14	15.5
16	17.5
18	19.5
20	21.5
22	23.5
24	25.5
27	29.0
30	32.0
33	35.0

iii) Close tolerance bolts and barrel bolts: Holes for close tolerance and turn fitted bolts. The diameter of the holes shall be equal to the nominal diameter of the bolt shank minus 0.15 mm to 0.0 mm.

iv) The members to be connected with close tolerance or turn fitted bolts shall be firmly held together by service bolts or clamped and drilled through all thicknesses in one operation and subsequently reamed to required size within specified limit of accuracy as specified in IS: 919 tolerance grade H8.

v) The holes not drilled through all thicknesses at one operation shall be drilled to smaller size and reamed after assembly.

vi) Holes for high strength friction grip bolts: All holes shall be drilled after removal of burrs. Where the number of plies in the grip does not exceed three, the* diameters of holes shall be 1.6 mm larger than those of bolts and for more than three plies in grip, the diameters of hole in outer plies shall be as above and dia of holes in inner plies shall not be less than 1.6 mm and not more than 3.2 mm larger than those in bolts, unless otherwise specified by the Engineer.

vii) Removal of burrs: The work shall be taken apart after drilling and all burrs left by drilling and the sharp edges of all rivet holes completely removed.

1904.4 Rivet and Riveting

The diameter of rivets shown on the drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimensions as given in IS handbook on Steel Sections, Part I. It shall be free from burrs on the underside of the head.

When countersunk heads are required, the heads shall fill the countersunk. The included angle of the head shall be as follows:

a) For plates over 14 mm thickness : 90 degrees
b) For plates up to and including 14 nun thickness : 120 degrees

The tolerance on the diameter of rivets shall be in accordance with IS: 1148 and IS: 1149 for mild steel rivets and high tensile steel rivets respectively and unless otherwise specified, the tolerance shall be minus tolerance.

Rivets shall be driven when hot so as to fill the hole as completely as possible and shall be of sufficient length to form a head of standard dimension. When counter-sunk head is required, the head shall fill the counter-sunk hole. Projection after counter-sinking shall be ground off wherever necessary.

Rivets shall be heated uniformly to a "light cherry red" colour between 650 degrees Celsius to 700 degrees Celsius for hydraulic riveting and "orange colour" for pneumatic riveting of mild steel rivets and shall be red hot from head to the point when inserted and shall be upset in its entire length so as to fill the hole as completely as possible when hot. Rivets, after being heated and before being inserted in the hole shall be made free from scale by striking the hot rivet on a hard surface.

Wherever possible, the rivets shall be machine driven, preferably by direct acting riveters. The driving pressure shall be maintained on the rivets for a short time after the upsetting is completed. High tensile steel rivets shall be heated upto 1100 degrees Celsius. Any rivet whose point is heated more than prescribed, shall not be driven.

Where flush surface is required, any projecting metal shall be chipped or ground off.

Before riveting is commenced, all work shall be properly bolted up so that the various sections and plates are in close contact throughout Drifts shall only be used for drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a larger size than the nominal diameter of the hole shall not be used. The riveting shall be done by hydraulic or pneumatic machine unless otherwise specified by the Engineer.

Driven rivets, when struck sharply on the head by a quarter pound rivet testing hammer, shall be free from movement and vibrations. Assembled riveted joint surfaces, including those adjacent to the rivet heads, shall be free from scale, dirt, loose scale, bum, other foreign materials and defects that would prevent solid seating of parts.

All loose or burnt rivets and rivets with cracked or badly formed defective heads or with heads which are unduly eccentric with the shanks, shall be removed and replaced. In removing rivets, the head shall be sheared off and the rivet punched out so as not to injure the adjacent metal and, if necessary, they shall be drilled out. Recupping or recaulking shall not be permitted. The parts not completely riveted in the shop shall be secured by bolts to prevent damage during transport and handling.

1904.5 Bolts, Nuts and Washers

i) **Black bolts (black all over):** Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions as shown on the drawings.

ii) **Close tolerance bolts:** Close tolerance bolts shall be faced under the head and turned on the shank.

iii) **Turned barrel bolts:** The diameter of the screwed portion of turned barrel bolts shall be
1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Engineer. The diameter of the bolts as given on the drawing shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

iv) **High strength friction bolts and bolted connections:** The general requirement shall be as per relevant IS specifications mentioned in clause 5.3 of (Fasteners) of IRC: 24. Unless otherwise specified by the Engineer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS: 4000.

v) **Washers:** In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a steel washer under the nut of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up, from bearing on the bolt.

vi) For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole diameter not

less than 1.5 mm larger than the barrel and a thickness of not less than 6 mm so that the nut when screwed up, will not bear on the shoulder of the bolt.

vii) Taper washers with correct angle of taper shall be provided under all heads and nuts bearing on beveled surfaces.

viii) Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.

ix) Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of bolts or round washers having a diameter of 3½ times the diameter of bolts and with a thickness not less than one quarter of diameter shall be provided.

x) **Studs:** Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread "of the stud. Counter-sunk studs may be used for making connections where the surfaces are required to be clear of all obstruction, such as protruding heads of bolts or rivets, studs may also be welded on the steel work in the positions required.

xi) **Service bolts:** Service bolts shall have the same clearance as black bolts and where it is required that there should be no movement prior to final riveting, sufficient drifts or close tolerance bolts shall be used to locate the work.

xii) **Tightening bolts:** Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of codal requirements.

vi) The Engineer shall observe the installation and lightening of bolts to ensure that correct tightening procedure is used and shall determine that all bolts are tightened. Regardless of tightening method used, tightening of bolts in a joint should commence at the most rigidly fixed or stiffest point and progress towards the free edges, both in initial snugging and in final tightening.

vii) The tightness of bolts in connection shall be checked by inspection wrench, which can be torque wrench, power wrench or calibrated wrench.

viii) Tightness of 10 per cent bolts, but not less than two bolts, selected at random in each connection shall be checked by applying inspection torque. If no nut or bolt head is turned by this application, connection can be accepted as properly tightened, but if any nut or head has turned all bolts shall be checked and, if necessary, re-tightened.

xiii) **Drifts:** The barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass. The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of +0 mm and -0.125 mm. Both ends of the drift for a length equal to IV, times the diameter of the parallel portion of the bar shall be turned down with a taper to a diameter at the end equal to one-half that of parallel portion.

1904.6 Pins and Pin Holes

i) **Pins:** The pins shall be parallel throughout and shall have a smooth surface free from flaws. They shall be of sufficient length to ensure that all parts connected thereby shall have a full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place.

Pins more than 175 mm in length or diameter shall be forged and annealed.

ii) **Pin holes:** Pin holes shall be bored true to gauge, smooth, straight at right angles to the axis of the member and parallel with each other, unless otherwise required. The tolerance in the length of tension members from outside to outside of pin holes and of compression members from inside to inside of pin holes shall be one millimeter. In built-up members, the boring shall be done after the members have been riveted or welded.

The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1.0 mm.

1904.7 Shop Erection and Match Marking

Before being dispatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Engineer either wholly or in such portion as the Engineer may require so that he may be satisfied both in respect of the alignment and fit of all connections. For this purpose, sufficient number of parallel drifts and service bolts tightly screwed up shall be employed. All parts shall fit accurately and be in accordance with drawings and specifications.

The steel work shall be temporarily assembled at place of fabrication. Assembly shall be of full truss or girder, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly is specified by the Engineer.

The field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame assembled, aligned, accuracy of holes and camber shall be checked by Engineer and then only reaming of sub-size holes to specified size shall be taken up.

After the Engineer has passed the work and before it is dismantled, each part shall be carefully marked for re-erection with distinguishing marks and stamped with durable markings. Drawings showing these markings correctly shall be supplied to the Engineer.

Unloading, handling and storage of steel work as per these specifications shall be the responsibility of the Contractor. The cost of repairs or of rejected material, its removal and the cost of transporting replacement material to the site shall be borne by the Contractor.

Where close tolerance or turned barrel bolts are used for those cases where interchangeability is not insisted upon, each span shall be erected and members of each span marked distinctly.

1904.8 Welding

All welding shall be done with the prior approval of the Engineer and the workmanship shall conform to the specifications of IS: 823 or other relevant Indian Standards as appropriate.

When material thickness is 20 mm or more, special precautions like preheating shall be taken as laid down in IS: 823. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.

The general welding procedures including particulars of the preparation of fusion faces for metal arc welding shall be carried out in accordance with IS: 9595.

The welding procedures for shop and site welds including edge preparation of fusion faces shall be submitted in writing in accordance with Clause 22 of IS: 9595 for the approval of the Engineer before commencing fabrication and shall also be as per details shown on the drawings. Any deviation from above has to be approved by Engineer. Preparation of edges shall, wherever practicable, be done by machine methods.

Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planning and shall be left free of slag. Manual flame cutting shall be permitted by the Engineer only where machine cutting is not practicable.

Electrodes to be used for metal arc welding shall comply with relevant IS specifications mentioned in IRC: 24. Procedure test shall be carried out as per IS: 8613 to find out suitable wire-flux combination for welded joint.

Assembly of parts for welding shall be in accordance with provisions of IS: 9595.

The welded temporary attachment should be avoided as far as possible; otherwise the Engineer shall approve the method of making any temporary attachment. Any scars from temporary attachment shall be removed by cutting; chipping and surface shall be finished smooth by grinding to the satisfaction of the Engineer.

Welding shall not be done when the air temperature is less than 10 degrees Celsius. Welding shall not be done when the surfaces are moist, during periods of strong winds or in snowy weather unless the work and the welding operators are adequately protected.

For welding of any particular type of joint, welders shall qualify to the satisfaction of the Engineer in accordance with appropriate welders qualification test as prescribed in any of the Indian Standards IS: 817, IS: 1966, IS: 1393, IS-.7307 (part I), IS: 7310 (Part I) and IS: 7318 (part I) as relevant.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimize shrinkage stress.

All requirements regarding pre-heating of parent material, and interpass temperature shall be in accordance with provision of IS: 9595.

Peening of weld shall be carried out wherever specified by the Engineer:

If specified, peening may be employed to be effective on each weld layer except first.

The peening should be carried out after weld has cooled by light blows from a power hammer using a round nose tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.

Where the Engineer has specified the butt welds are to be ground flush, the loss of parent metal shall not be greater than that allowed for minor surface defects. The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by use of extension pieces, cross runs or other means approved by the Engineer. Extension pieces shall be removed after the joint has cooled and the ends of the weld shall be finished smooth and flush with the faces of the abutting parts.

The joints and welds listed below are prohibited type, which do not perform well under cyclic loading.

i) Butt joints not folly welded throughout their cross-section
ii) Groove welds made from one -side only without any backing grip
iii) Intermittent groove welds
iv) Intermittent fillet welds
v) Bevel-grooves and J-grooves in butt joints for other than horizontal position.
vi) Hug and slot welds

The run-on and run-off plate extension shall be used providing full throat thickness at the end of butt welded joints. These plates shall comply with the following requirements.

One pair of "run-on" and one pair of "run-off plates prepared from same thickness and profile as the parent metal shall be attached to start and finish of all butt welds preferably by clamps.

When "run-on" and "run-off plates shall be removed by flame cutting, it should be cut at more than 3 mm from parent metal and remaining metal shall be removed by grinding or by an" other method approved by the Engineer.

1904.9 Welding of Stud Shear Connectors

The stud shear connectors shall be welded in accordance with the manufacturer's instructions including preheating.

The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanized or cadmium plated prior to welding.

Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder is adequately protected.

The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs.

The procedural trial for welding the stud shall be carried out when specified by the Engineer.

1904.10 Tolerances

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 1900**.**

A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5 m.

Table 1900-2: Fabrication tolerances

A	Individual Components	
1.	Length Member with both ends finished for contact bearing Individual components of members with end plate connection Other members Upto and including 12 M Over 12 M	 ± 1 mm + 0 mm -2 mm ± 2 mm ± 3.5 mm
2.	Width Width of built – up girders Deviation in the width of members required to be inserted in other members	 ± 3 mm + 0 mm - 3 mm
3.	Depth Deviation in the depths of solid web and open web girders	 + 3 mm - 2 mm
4.	Straightness a) Deviation from straightness of columns In elevation In plan	 L/3000 subject to a maximum of 15 mm where L is length of member + 5 mm - 0 mm L/1000 subject to a maximum of 10 mm
5.	Deviation of center line of web from center line of flanges in built-up members at contract surfaces	3 mm
6.	Deviation from the flatness of plate of webs of built-up members in a length equal to the depth of the member	0.005 d to a maximum of 2 mm where d is depth of the member
7.	Tilt of flange of plate girders At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings at other places	 0.005 b to a minimum of 2 mm where b is width of the member 0.015 b to a maximum of 4 mm where b is width of the member
8.	Deviation from square ness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagonal
9.	Deviation from square ness of fixed base plate (not machined) to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contract with the base plate	D/500, where D is the distance from the column axis to the point under consideration on the base plate.
10.	Deviation from square ness of machined ends to axes of columns	D/1000, where D is as defined in 9 above.
11.	Deviation from square ness of machined ends to axes of beams or girder	D/1000, where D is as defined in 9 above
12.	Ends of members abutting at joints through cleats or end palates, permissible deviation from square ness of ends	1/600 of depth of member subject to a maximum of 1.5 mm.

1905 ERECTION

1905.1 General

The provisions of this item shall apply to erection of steel bridge superstructures or main members of bridge superstructures, composed of steel, which span between supports.

If the sub-structure and the superstructure are built under separate contracts, the department will provide the substructure, constructed to correct lines, dimensions and elevations properly finished and will establish the lines and the elevation required for setting steel.

The Contractor shall erect the structural steel, remove the temporary construction, and do all the work required to complete the construction included in the contract in accordance with the drawings and the specifications and to the entire satisfaction of the Engineer.

1905.2 Organisation and Equipment

The Contractor shall submit erection plans prepared by the fabricator, showing a method and procedure of erection, compatible with the details of fabrication.

A detailed scheme must be prepared showing stage-wise activities, with complete drawings and working phase-wise instructions. This should be based on detailed stage-wise calculation and take into account specifications and capacity of erection equipment machinery, tools, tackles to be used and temporary working loads as per Codal provisions.

The scheme should be based on site conditions e.g. hydrology, rainfall, flood timings and intensity, soil and sub-soil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space, etc.

The scheme should indicate precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection. The working drawings should give clearly the temporary jigs, fixtures, clamps, spacer supports, etc.

Unless otherwise provided in the contract, the contractor shall supply and erect all necessary false work and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects.

The Contractor shall supply all rivets, bolts, nuts, washers, etc. required to complete erection at site with an allowance for wastage, etc., of 12 ½ per cent of the net number of field rivets, bolts, washers required, or a minimum of five number of each item.

Service bolts and nuts, ordinary platters, washers and drifts for use in the erection of work shall be supplied at 60 per cent (45 per cent bolts and 15 per cent drifts) of the number of field rivets per span in each size (this includes wastage). A reduction in the quantities of, service bolts, etc., may however, be specified by the Engineer if more than one span of each type is ordered.

Prior to actual commencement of erection all equipment, machinery, tools, tackles, ropes, etc. heed to be tested to ensure their efficient working. Frequent visual inspection is essential in vulnerable areas to detect displacements, distress, drainages, etc.

Deflection and vibratory tests shall be conducted in respect of supporting structures, launching truss as also the structure under erection and unusual observations reviewed; looseness of fittings are to be noted.

For welded structures, welders' qualifications and skill are to be checked as per standard norms. Non-destructive tests of joints as per designer's directives are to be carried out.

Precision non-destructive testing instruments available in the market should be used for noting various important parameters of the structures frequently and systematic record is to be kept.

Safety requirements should conform to IS: 7205, IS: 7273 and IS: 7269 as applicable and should be a consideration of safety, economy and rapidity.

Erection work should start with complete resources mobilized as per latest approved drawings and after a thorough survey of foundations and other related structural work. In case of work of magnitude, maximum mechanization is to be adopted.

The structure should be divided into erectable modules as per the scheme. This should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

The structure shall be set out to the required lines and levels. The stocks and masses are to be carefully preserved. The steelwork should be erected, adjusted and completed in the required, position to the specified line and levels with sufficient drifts and bolts. Packing materials are to be available to maintain this condition. Organised "Quality Surveillance" checks need to be exercised frequently.

Before starting work, the Contractor shall obtain necessary approval of the Engineer as to the method adopted for erection, the number and character of tools and plants. The approval of the Engineer shall not relieve the Contractor of his responsibility for the safety of his method or equipment or from carrying out the work fully in accordance with the drawings and specifications.

During the progress of work, the Contractor shall have a competent Engineer or foreman in charge of the work, who shall be adequately experienced in steel erection and acceptable to the Engineer.

1905.3 Handling and Storing of Materials

Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during the working period and the storage area should be on levelled and firm ground.

The store should be provided with adequate handling equipment e.g. road mobile crane, gantries, derricks, chain pulley blocks, winch of capacity as required. Stacking area should be planned and have racks, stands sleeper, access tracks, etc., and properly lighted.

Storage should be planned to suit erection work sequence and avoid damage or distortion. Excessively rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not shall be subject to the approval of the Engineer.

Fabricated materials are to be stored with erection marks visible, such as not to come into contact with earth surface or water and should be accessible to handling equipment.

Small fitting hand tools are to be kept in containers in covered stores.

All materials, consumables, including raw steel or fabricated material shall be stored specification-wise and size-wise above the ground upon platforms, skids or other supports. It shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion. The electrodes shall be stored specification-wise and shall be kept in dry warm condition in properly designed racks. The bolts, nuts, washers and other fasteners shall be stored on racks above the ground with protective oil coating in gunny bags. The paint shall be stored under cover in air-tight containers.

IS: 7293 and IS: 7969 dealing with handling of materials and equipments for safe working should be followed. Safety nuts and bolts as directed are to be used while working. The Contractor shall be held responsible for loss or damage to any material paid for by the Department while in his care or for any damage to such material resulting from his work.

1905.4 Formwork

The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor of his responsibility.

1906.4.1 Straightening Bent Material

The straightening of plates, angles and other shapes shall be done by methods not likely to produce fracture or any injury. The metal shall not be heated unless permitted by the Engineer for special cases, when the heating shall not be to a temperature higher than that producing a dark "cherry red" color, followed by as slow cooling as possible. Following the straightening of a bend or buckle the surface shall be carefully investigated for evidence of fracture. Sharp kinks and bends may be the cause for rejection of material.

1905.4.2 Assembling Steel

The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tendon chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

All joint surface for bolted connections including bolts, nuts washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, plane normal to bolt axis, otherwise suitable tapered washer shall be used.

All fasteners shall have a washer under nut or bolt head whichever is turned in tightening.

Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

The field riveting, welding, bolted and pin connection shall conform to the requirements of Clause 5.2.4 as appropriate.

The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in the presence of the Engineer.

1905.5 Field Inspection

1905.5.1 General

All materials, equipment and work of erection shall be subject to the inspection of the Engineer who shall be provided with all facilities including labor and tools required at all reasonable times. Any work found defective is liable to be rejected.

No protective treatment shall be applied to the work until the appropriate inspection and testing has been carried out. The stage inspection shall be carried out for all operations so as to ensure the correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

1905.5.2 Testing of Material

Structural steel shall be tested for mechanical and chemical properties as per various IS codes as may be applicable and shall conform to requirements specified in IS: 226, IS: 2062, IS: 11587, IS: 1977, IS: 8500 and IS: 961, etc.

Rivets, bolts, nuts, washers, welding consumables, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in the appropriate IS Code.

Rolling and cutting tolerance shall be as per IS: 1852. The thickness tolerance check measurements for the plate and rolled sections shall be taken at not less than 15 mm from edge.

Laminations in plates shall be carried out by ultra-sonic testing or any other specified methods.

Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for his decision.

Chipping, grinding, machining or ultrasonic testing shall be used to determine depth of imperfection.

1905.5.2.1 Bolted Connections

Bolts and bolted connection joints with high strength friction grip bolts shall be inspected and tested according to IS: 4000.

Rivets and riveted connection shall be inspected and tested for compliance of codal requirements.

The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted.

Driven rivets shall be checked with rivet testing hammer. When struck sharply on head with rivet testing hammer, rivet shall be free from movement and vibration.

All loose rivets and rivets with cracks, badly formed or deficient heads or with heads which are eccentric with shanks, shall be cut out and replaced.

The alignment of plates at all bolted splice joints and welded butt joints shall be checked for compliance with codal requirements.

Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

1905.5.2.2 Welding and Welding Consumables

Welding procedure, welded connection and testing shall be in compliance with codal requirements.

All facilities necessary for stage inspection during welding and on completion shall be provided to the Engineer or their inspecting Authority by manufacturer.

Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom it was carried out.

All metal arc welding shall be in compliance with IS: 9595 provisions.

The method of inspection shall be in accordance with IS: 822 and extent of inspection and testing shall be in accordance with the relevant standards or in the absence of such a standard, as agreed with the Engineer.

1905.5.2.3 Procedure Tests

The Destructive and Non-Destructive test of weld shall be carried out according to IS: 7307 (Part I).

Non-Destructive Testing of Welds

One or more of the following methods may be applied for inspection or testing of weld:

Visual Inspection: All welds shall be visually inspected, which should cover all defects of weld such as size, porosity, crack in the weld or in the HAZ (Heat Affected Zone) etc. Suitable magnifying glass may be used for visual inspection. A weld shall be acceptable by visual inspection if it shows that:

The weld has no cracks.

Through fusion exists between weld and base metal and between adjacent layers of weld metal.

Weld profiles are in accordance with requisite clauses of IS: 9595 or as agreed with the Engineer.

The weld shall be of full cross section, except for the ends of intermittent fillet welds outside their effective length.

When weld is transverse to the primary stress, undercut shall not be more than 0.25 mm deep in the pan that is undercut and shall not be more than 0.8 mm deep when (he weld is parallel to the primary stress in the pan that is undercut.

The fillet weld in any single continuous weld shall be permitted to under run the nominal fillet weld size specified by 1.6 mm without correction provided that undersize portion of the weld does not exceed 10 per cent of the length of the weld. On the web-to-flange welds on girders, no under-run is permitted at the ends for a length equal to twice the width of the flange.

The piping porosity in fillet welds shall not exceed one in each 100 mm of weld length and the maximum diameter shall not exceed 2.4 mm, except for fillet welds connecting stiffeners to web where the sum of diameters of piping porosity shall not exceed 9.5 mm in any 25 mm length of weld and shall not exceed 19 mm in any 300 nun length of weld.

The full penetration groove weld in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the piping porosity shair not exceed one in 100 mm of length and the maximum diameter shall not exceed 2.4 mm.

Magnetic Panicle and Radiographic Inspection: Welds that are subject to radio-graphic or magnetic panicle testing in addition to visual inspection shall have no crack.

Magnetic panicle test shall be carried out for detection of crack and other discontinuity in the weld according to IS: 5334.

Radiographic lest shall be carried out for detection of internal flaws in the weld such as crack, piping porosity inclusion, lack of fusion, incomplete penetration, etc. This test mat be carried out as per IS: 1182 and IS: 4853.

Acceptance Criteria: The weld shall be unacceptable if radiographic or magnetic panicle testing shows any of the type of discontinuities indicated in the code.

Ultrasonic Inspection: The Ultrasonic testing in addition to visual inspection shall be carried out for detection of internal flaws in the weld such as cracks, piping porosity inclusion, lack of fusion, incomplete penetration, etc. Acceptance criteria shall be as per IS: 4260 or any other relevant IS Specification and as agreed to by the Engineer.

Liquid Penetration Inspection: The liquid penetrant lest shall be carried out for detection of surface defect in the weld, as per IS: 3658, in addition to visual inspection.

The non-destructive testing of following welds be carried out using one of the method or methods described at (ii), (iii) and (iv) above, as may be agreed to by the Engineer.

All transverse butt welds in tension flange.

10 per cent of the length of longitudinal and transverse butt welds in tension flanges.

5 per cent of the length of longitudinal and transverse butt welds in compression flanges.

All transverse butt welds in webs adjacent to tension flanges as .specified by the Engineer.

The particular length of welds in webs to be tested shall be agreed with the Engineer, in case of (b) or (c).

Where specified by the Engineer, bearing stiffeners or bearing diaphragms adjacent to welds, flange plates adjacent to web/flange welds, plates at cruciform welds, plates in box girder construction adjacent to comer welds or other details shall be ultrasonically tested after fabrication.

Any lamination, lamellar tearing or other defect found shall be recorded and reported to Engineer for his decision.

Testing of Welding for Cast Steel: The testing of weld for cast steel shall be carried out as may be agreed to by the Engineer.

Stud Shear Connectors: Stud shear connectors shall be subjected to the following tests:

The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Engineer.

The selected stud head stroked with 6 kg hammer shall be capable of lateral displacement of approximately 0.25 the height of the stud from its original position. The stud weld shall not show any sign of crack or lack of fusion.

The studs whose welds have failed the tests given in (a) and (b) shall be replaced.

1905.5.2.4 Inspection Requirement

The fabricated member/component made out of rolled and built-up section shall be checked for compliance of the tolerances given in Table 1900-2. Inspection of member/components for compliance with tolerances, and the check for deviations shall be made over the full length.

During checking, the inspection requirement shall be placed in such a manner that local surface irregularities do not influence the results.

For plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of plate.

The relative cross-girder or cross frame deviation shall be checked over the middle third of length of the cross girder or frame between each pair of webs and for cantilever at the end of member.

The web of rolled beam or channel section shall be checked for out-of-plane deviation in longitudinal direction equal to the depth of the section.

During inspection, the component/member shall not have any load or external restraint.

Inspection Stages: The inspection to be carried out for compliance' of tolerances snail include but not be limited to the following stages:

For completed parts, component/members on completion of fabrication and before any subsequent operation such as surface preparation, painting, transportation, erection.

For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints, on completion of site joint.

For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased on completion of site assembly.

Where, on checking member/component for the deviations in respect of out-of-plane or out-of-straightness at right angles to the plate surface, and any other instances, exceed tolerance, the maximum deviation shall be measured and recorded. The recorded measurements shall be submitted to the Engineer who will determine whether the component/member may be accepted without rectification, with rectification or rejected.

1906 PAINTING

1906.1 General

Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include preparation of metal surfaces, application of protective covering and drying of the paint coatings and supply of all tools, scaffolding, labour and materials necessary.

Coatings shall be applied only to dry surfaces and the coated surfaces shall not be exposed to rain or frost before they are dry. The coatings shall be applied to all surfaces excluding shear connectors and inner surfaces of fully sealed hollow sections. Care shall be taken during coating of adjacent surfaces to build up primer on the shear connectors.

1906.2 Types of Paints

a) Ordinary Paints

These include paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy, etc.

Alkyd resin paints for the protection of steel structures are based partly on natural oils and partly on synthetic resins. These paints shall be used for steel structures in atmospheres, which are not too aggressive.

Oil based paints can be used for steel structures in cases where the surface preparation cannot be ideal. Ordinary painting can generally be sub-divided into two groups:

i) Primary Coats

   a) This shall be applied immediately after the surface preparation and should have. The properties of adhesion, corrosion inhibition and imperviousness to water and air.

ii) Finishing Coats

   a) These are applied over the primary coat and should have the properties of durability, abrasion resistance, aesthetic appearance and smooth finish.

b) Chemical Resistant Paints

The more highly corrosion resistant paints can be divided into two main groups:

One pack paints (ready for use)

Two pack paints (mixed before use)

The two pack paints shall be mixed together immediately before use since they are workable thereafter only for a restricted period of time and dry -up as a result of a reaction between their components and yield hard tough films with resistance to abrasion.

c) Vinyl Paints

These are based on polyvinyl resins such as polyvinyl-chloride (PVC) and polyvinyl-acetate, etc.

Certain types of vinyl resin paints yield thick, relatively soft and rubber like coatings with good chemical resistance. They can be repainted without difficulty.

d) Chlorinated Rubber Paints

These paints also have good chemical resistance. The main fields of applications shall be in aggressive environments. In general, chlorinated rubber paints do not have a high gloss.

e) Bituminous Paints

As a paint vehicle, bituminous is inferior, but because of the low price, this should be applied in greater thickness (upto several millimetres) and may be suitable for some situations. A significant advantage of bitumen paints is their impermeability to ingress of water. However, bituminous paints do not withstand effectively detrimental effects of oil.

f) Epoxy Paints

These resin paints have good adherence to a well-prepared substrata. They are mechanically strong and resistant to chemicals. A disadvantage of epoxy resin paints is that it can rapidly become dull when exposed to strong sunlight. These disadvantages do not, however, greatly influence their protective power.

g) Polyurethane Paints

The chemical and mechanical behaviour of polyurethane paint resembles those of epoxy paint very much. However, polyurethane paint retains its gloss for a longer period. Because of the high price of polyurethane paint, a combination of the two viz., polyurethane and epoxy paints may sometimes be used.

h) Zinc Rich Paints

Instead of introducing an inhibitive pigment into paint, metallic zinc can be used and such paints can provide cathodic protection to steel.

5.2.6.1.2 Surfaces, which are inaccessible for cleaning and painting after fabrication shall bepainted as specified before being assembled for riveting.

All rivets, bolts, nuts, washers etc., are to be thoroughly cleaned and dipped into boiling linseed oil conforming to IS: 77.

All machined surfaces are to be well coated with a mixture of white lead conforming to IS: 34 and Mutton Tallow conforming to IS: 887.

For site paintings, the whole of the steel work shall be given the second cover coat after final passing and after touching up the primer and cover coats, if damaged in transit.

1906.3 Choice of Painting System

The choice of suitable painting system is dependent on factors such as:

i) Available application methods viz. brash, roller or spray
ii) Durability in a specific environment
iii) Availability of skilled manpower
iv) Cost / benefit etc.

It is therefore necessary to consult various manufacturers of paint and ascertain the above aspects while deciding on the appropriate choice of painting system.

1906.4 Quality of Paint

The paints which have been tested for the following qualities as per the specifications given in the relevant IS codes should only be used:

i) Weight Test (weight per 10 litre of paint thoroughly mixed)
ii) Drying time
iii) Flexibility and Adhesion
iv) Consistency
v) Dry thickness and rate of consumption

Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS: 1477 (Part 1).

1906.5 Surface Preparation

Steel surface to be 'painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer :

- Dry or wet grit / Sand blasting
- Pickling which should be restricted to single plates, bars and sections
- Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, primary coat shall be applied while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

1906.6 Coatings

Prime coat to be used shall conform to the specification of primers approved by the Engineer. Metal coatings shall be regarded as priming coatings. Primer shall be applied to the blast-cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The undercoat and finishing coat shall preferably be from the same manufacturer. Successive coats of paints shall be of different shades or colors and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, comers, welds and rivets. Typical

guidelines for epoxy based paints and the conventional painting system for bridge girders as given below may be complied with:

i) Epoxy Based Painting

Surface preparation: Remove oil/grease by use of petroleum hydrocarbon solution (IS: 1745) and Grit blasting to near white metal surface.

Paint system: 2 coats of epoxy zinc phosphate primer = 60 micron; Total 5 coats = 200 micron

Conventional Painting System for areas where corrosion is not severe

ii) Priming Coat

One heavy coat or ready mixed paint, red lead primer conforming to IS: 102.

OR

One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS: 2074.

OR

Two coats of zinc chromates red oxide primer conforming to IS: 2074

iii) Finishing Coats

Two cover coats of red oxide paint conforming to IS: 123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

Conventional Painting System for areas where corrosion is severe

iv) Priming Coat

Two coats of ready mixed red lead primer conforming to IS: 102

OR

One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of zinc chromate conforming oxide primer to IS: 2074.

v) Finishing Coats

Two coats of aluminum paint conforming to IS: 2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

1906.7 Painting in the Shop

All fabricated steel shall be painted in the shops after inspection and acceptance with at least one priming coat, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanized surfaces.

Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. No paint shall be applied within 50mm of designed location of field welds. Paint shall be completely dried before loading and transporting to site.

Surface not in contact but inaccessible after shop assembly shall receive the fully specified protective treatment before assembly.

Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is expected to impair the quality of site welds.

Exposed machined surfaces shall be adequately protected.

1906.8 Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

Specified protective treatment shall be completed after erection.

1906.9 Methods of Application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and shall be as approved by the Engineer. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas hard to gain access to for painting and areas shaded for spray application shall be coated first by brushing.

Oil based red lead primers must be applied by brush only, taking care to work into all comers and crevices.

The primer, intermediate and finishing coats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes shall not be accepted. Where the Engineer so directs, the coating shall be removed by abrasive blast cleaning and replaced at the Contractor's expense.

1906.10 Guideline of Specifications for Protective Coating System in Different Environments

Since the seriousness of the problem of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

However, as a guide, broad recommendations are given in **Table 1900-3** for various types of coatings in various environmental conditions which should be complied with. Approximate life to first maintenance is also indicated and can be used as a guide.

Table 1900-3: Recommendations for types of protective coatings

System		Environment
i)	Wire brush to remove all loose rust and scale; 2 coats during oil type primer, 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness = µm	Suitable for mild conditions where appearance is of some importance and where regular maintenance is intended. This system may deteriorate to a marked extent if it is exposed to moderate aggressive atmospheric conditions for lengthily period.
ii)	Wire brush to remove all loose rust and scale 2; coats drying oil type prime; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 µm	Similar to (i) but where appearance is not very important provides longer life in mild condition. Will provide upto 5 years life to first maintenance in polluted inland environment.
iii)	Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat film thickness : 130 – 150 µm	Compared to (i) this would provide a longer life in mild conditions and could be used in less mild situation e.g. inland polluted, where maintenance could easily be carried out at regular intervals.
iv)	Blast clean the surface; 2 coats of drying type oil primer; 1 undercoat micaceous iron oxide	Suitable for general structural steel work exposed to ordinary polluted inland

System		Environment
	pigmented drying oil type paint. Total dry film thickness : 165 – 190 µm	environments where appearance is not of primary importance.
v)	Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber; 1 finishing coat of chlorinated rubber. Total dry film thickness : 200 µm	Suitable for structures in reasonably aggressive conditions e.g. near the coast. Will provide long-term protection than (iv) in non-coastal situations. Also suitable for aggressive interior situations such as industrial areas.
vi)	Blast clean the surface; 350 – 450 µm thickness coal tar epoxy	Suitable for seawater splash zones or for conditions of occurrence of frequent salt sprays.
vii)	Pickle; hot dip galvanized (Zinc). Total thickness = 85 µm	Suitable or steel work in reasonably mild conditions Life of 15 – 20 years before first maintenance could be expected in many situations
viii)	Grit blast, hot dip galvanised. (Zinc). Total thickness = 140 µm	Provides a longer life than (vii) because of thicker zinc coating
ix)	Grit blast; 1 coat of sprayed zinc/ aluminum followed by suitable sealer Total thickness = 150 µm	Expected to provide long term protection approx. 15 – 20 years in aggressive atmosphere

1907 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost

The fabrication, furnishing, erecting, painting of structural steel work shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

1908 MEASUREMENTS FOR PAYMENT

The measurements of this item shall be in tonnes based on the net weight of metal in the fabricated structure computed on the basis of nominal weight of materials.

The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis:

- Rolled or cast steel: 7.84 X 10-3 kg/cu. cm
- Cast Iron: 7.21 x 10-3 kg/cu. cm
- Weight of structural sections shall be nominal weight
- Weight of castings shall be computed from the dimensions shown on the drawings with an addition of 5 per cent for fillets and over-runs
- Weight of weld fillets and the weight of protective coatings shall not be included
- Weight of rivet heads shall be computed by taking the weight of 100 snap heads as given in Table 1900-4

When specially agreed upon, allowance for snap heads may be taken as a flat percentage of the total weight. This percentage may be taken as 3 per cent or modified by mutual agreement.

Table 1900-4: Weight of rivet heads

Dia of Rivet as manufactured mm	Weight of 100 snap heads Kg
12	1.3
14	2.1
16	3.4
18	4.45

Dia of Rivet as manufactured mm	Weight of 100 snap heads Kg
20	6.1
22	8.1
24	10.5
27	15.0
30	20.5
33	27.2

The Contractor shall supply detailed calculation sheets for the weight of the metal in the fabricated structure.

No additions shall be made for the weight of protective coating or weld fillets.

Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure, deductions being made for all cuts, except for rivet holes. Additions shall be made for the rivet heads as mentioned above.

When specially agreed upon, the basis for payment may be the bridge weight complete, according to specifications included in special provisions of the Contract.

1909 RATE

The contract unit rate for the completed structural steel work shall include the cost of all materials, labour, tools, plant and equipment required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the drawings and as specified in these Specifications

2100 OPEN FOUNDATION

2101 DESCRIPTION

The work shall cover furnishing and providing plain or reinforced concrete foundation placed in open excavation, in accordance with the drawings and these specifications or as directed by the Engineer.

2102 MATERIALS

Materials shall conform to Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

2103 GENERAL

A method statement for construction indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of open foundation:

i) Sources of Materials
ii) Design, erection and removal of formwork
iii) Production, transportation, laying and curing of concrete
iv) Personnel employed for execution and supervision
v) Tests and sampling procedures
vi) Equipment details
vii) Any other point

Necessary arrangements for execution under water wherever necessary, shall be included in method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark.

2104 WORKMANSHIP

2104.1 Preparation of Foundations

Excavation for laying the foundation shall be carried out in accordance with Section 300 of these specifications. The last 300 mm of excavation shall be done just before laying of lean concrete below foundation.

In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M15 concrete in case of foundation resting on soil and foundation grade concrete for foundations in rock, at the cost of the Contractor and shall be considered as incidental work. Special care shall be taken not to disturb the bearing surface. Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements to the satisfaction of the Engineer.

2104.2 Setting Out

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to Original reference line and axis. It shall be ensured that at no point the bearing surface is higher am the founding level shown on the drawing or as directed by the Engineer.

2104.3 Construction

Where the bearing surface is earth, a layer of MIS concrete shall be provided below foundation concrete. The thickness of lean concrete layer shall be 100 mm minimum unless otherwise specified.

No formwork is necessary for the lean concrete layer. For foundation concrete work, side formwork shall be used. Formwork for top of the foundation concrete shall also be provided, if its top has slopes steeper than 1(vertical) to 3 (horizontal). When concrete is laid in slope without top formwork, the slump of the concrete shall be carefully maintained to ensure that compaction is possible without slippage down the slope of freshly placed concrete. In certain cases it may be necessary to build the top formwork progressively as the concreting proceeds up the slope. Reinforcement shall be laid as shown on the drawing.

Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. If any portion of the surface has been spoiled by over wetting, the same shall be removed. Concrete M15 shall be laid to the thickness as required. No construction joint shall be provided in the lean concrete.

Before laying foundation concrete, the lean concrete or hard rock surface shall be cleaned of all loose material and lightly moistened. Foundation concrete of required dimensions and shape shall be laid continuously up to the location of construction joint shown on the drawing or as directed by the Engineer.

Formwork and concrete shall conform to Sections 10.19 and 4.1 respectively of these specifications. Furnishing and providing steel reinforcement shall conform to Section 5.1.

The concrete surface shall be finished smooth with a trowel. The location of construction joint and its treatment shall be done as per requirements of Section 4.1. Formwork shall be removed not earlier than 24 hours after placing of concrete. Where formwork has been provided for top surface, the same shall be removed as soon as concrete has hardened. Curing of concrete shall be carried out by wetting of formwork before removal. After its removal, curing shall be done by laying not less than 10 cm of loose moistened sand, free from clod or gravel and shall be kept continuously moist for a period of 7 days.

Dewatering, where necessary for laying of concrete, shall be carried out adopting any one of the following procedures or any other method approved by the Engineer:

A pit or trench deeper than the foundation level as necessary may be dug beyond the foundation pit during construction so that the water level is kept below the foundation level.

Water table is depressed by well point system or other methods.

Use of steel/concrete caissons or sheet piling for creating an enclosure for the foundations, which can subsequently be dewatered.

Before backfilling is commenced, loose sand laid on foundation shall be removed and dispersed as directed by the Engineer.

All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground in accordance with Section 300 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress. In case of excavation in rock, the annular space around foundation shall be fined with M15 concrete up to the top of rock.

The protective works, where provided shall be completed before the floods so that the foundation does not get undermined.

2105 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

No point of the surface of the lean concrete in the case of foundation on soil or the surface of hard rock in the case of foundation of hard rock, shall be higher than the founding level shown on the drawing or as ordered by the Engineer. Levels of the surface shall be taken at intervals of not more than 3 metres centre to centre, subject to a minimum of nine levels on the surface.

2106 TOLERANCES

a)	Variation in dimensions	:	+50 mm - 10 mm
b)	Misplacement from specified position in plan	:	15 mm
c)	Surface irregularities measured with 3 in straight edge	:	5 mm
d)	Variation of levels at the top	:	± 25 mm

2107 MEASUREMENT FOR PAYMENT

Excavation in foundation shall be measured in accordance with Section 300 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress based on the quantity ordered or as shown on the drawing.

Lean concrete shall be measured in cubic metres in accordance with Section 4.1, based on the quantity ordered or as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with Section 4.1, based on the quantity ordered or as shown on the drawing.

Reinforcement steel shall be measured in tonnes in accordance with Section 5.1 based on the quantity ordered or as shown on the drawing.

2108 RATE

The contract unit rates for excavation in foundation, lean concrete and concrete in foundation and reinforcement steel shall include all works as given in respective sections of these specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section.

2200 SUB STRUCTURE

2201 DESCRIPTION

The work shall cover furnishing and providing of masonry or reinforced concrete sub-structure in accordance with the drawings and as per these specifications or as directed by the Engineer.

2202 MATERIALS

Materials shall conform to Section 1000 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

2203 GENERAL

A method statement for construction indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of sub-structure:

i) Sources of Materials
ii) Design, erection and removal of formwork
iii) Production, transportation, laying and curing of concrete
iv) Personnel employed for execution and supervision
v) Tests and sampling procedures
vi) Equipment details
vii) Any other point

Arrangements for execution under water wherever necessary, shall be included in method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark.

2204 PIERS AND ABUTMENTS

Masonry, formwork, concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications. In case of concrete piers, the number of horizontal construction joints shall be kept minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. The work shall conform strictly to the drawings or as directed by the Engineer.

In case of tan piers and abutments, use of slip form shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by, the Contractor. The concrete shall also be subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

The surface of foundation/well cap pile cap shall be scrapped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided in conformity with Section 9.8.9.

The surface finish shall be smooth, except the earth face of abutments, which shall be rough, finished.

In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed

by filling up of embankment in layers to the full height to allow for the anticipated movement during construction period before casting of superstructure.

2205 PIER CAP AND ABUTMENT CAP

Formwork, reinforcement and concrete shall conform to relevant sections of these specifications.

The locations and levels of pier cap/abutment cap/pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane, which shall not vary more than 1.5 min from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25 mm below the bottom level of bearings and as indicated on the drawings.

2206 DIRT/ BALLAST WALL, RETURN WALL AND WING WALL

Masonry, concrete and reinforcement shall conform to relevant sections of these specifications.

In case of cantilever return walls, no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of die ballast wall.

For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the Engineer, vertical construction joint may be provided. Vertical expansion gap of 20 mm shall be provided in return wall/wing wall at every 10-metre interval or as by the Engineer. Weep holes shall be provided as prescribed for abutments or as shown on the drawings.

Formwork, reinforcement and concrete in dirt/ballast wall shall conform to relevant sections of these specifications.

The finish of the surface on the earth side shall be rough while the front face shall be smooth finished.

Architectural coping for wing wall/return wall in brick masonry shall conform to section 1300 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

2207 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

2208 TOLERANCES IN CONCRETE ELEMENTS

Variation in cross-sectional dimensions	:	+10 mm, -5 mm
Misplacement from specified position in plan	:	10 mm
Variation of levels at the top	:	±10 mm
Variations of reduced levels of bearing areas	:	± 5 mm

Variations from plumb over full height	:	±10 mm
Surface irregularities measured with 3 in straight edge		
All surfaces except bearing areas	:	5 mm
Bearing areas	:	3 mm

2209 MEASUREMENTS FOR PAYMENT

Masonry in sub-structure shall be measured in cubic metres in accordance with Section 1300 or 1400 of Specifications for Road & Bridges Worksll (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress, based on the quantities ordered or as shown on the drawing.

Concrete in sub-structure shall be measured in cubic metres in accordance with Section 4.1, based on the quantity ordered or as shown on the drawing. No deduction shall be made for weep holes.

Steel in concrete of sub-structures shall be measured in tonnes, in accordance with Section 5.1, based on the quantity ordered or as shown on the drawing.

Weep holes shall be measured as per Section 9.8.9, based on the quantity ordered or as shown on the drawings.

2210 RATE

The contract unit rates for masonry, concrete, reinforcement and weep holes shall include all works as given in respective sections of these specifications and cover ail incidental items for furnishing and providing substructure as mentioned in this Section.

2300 CONCRETE FOR SUPERSTRUCTURE

2301 DESCRIPTION

The work shall cover furnishing and providing of concrete superstructure in accordance with the drawings as per these specifications or as directed by the Engineer.

2302 MATERIALS

Materials shall conform to Section 1000 of these Specifications.

2303 GENERAL

A method statement for construction, indicating the following, shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of the construction of superstructure:

i) Sources of Materials
ii) Design, erection and removal of formwork
iii) Production, transportation, laying and curing of concrete
iv) Prestressing system, if applicable
v) Personnel employed for execution and supervision
vi) Tests and sampling procedure
vii) Equipment details
viii) Any other point

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark so that the final product is in accordance with the drawings or as directed by the Engineer.

The work shall conform to the following sections besides stipulations in this section with regard to specific type of construction:

i)	Formwork	Section 1500
ii)	Steel Reinforcement	Section 1600
iii)	Structural Concrete	Section 1700
iv)	Prestressing	Section 1800

Additionally, some of the common types of superstructure construction shall have features as discussed in this Section.

2304 REINFORCED CONCRETE CONSTRUCTION

2304.1 Solid Slabs

Where adjacent span of slab has already been cast, the expansion joint and filler board shall be placed abutting the already cast span which shall form the shutter on that side of the new span to be cast. The whole of the slab shall be cast with reinforcement embedded for the road kerb and railings. No other construction joint shall be allowed except with the express permission of the Engineer.

Where wearing coat is required to be provided, after the deck slab has been cast, the surface of the slab shall be finished rough, but true to lines and levels as shown on the drawings, before the concrete has hardened. The areas of construction joints shall be treated in the prescribed manner.

The top of the slab shall be covered with clean moist sand as soon as the top surface has hardened. Curing shall be carried out as per Section 1700.

Where the slab is resting on bearings, the same shall be placed in position in accordance with the drawings, before casting of deck slab.

2304.2 RCC T-Beam and Slab

Provision of construction joint shall conform to the drawings or as per directions of the Engineer. No construction joint shall be provided between the bottom bulb and the web. If not indicated on the drawing, construction joint maybe provided at the junction of the web and the fillet between the web and the deck slab with the permission of the Engineer.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedment's for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface finish of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

2305 PRESTRESSED CONCRETE CONSTRUCTION

2305.1 PSC Girder and Composite RCC Slab

PSC Girder may be precast or cast-in-situ as mentioned on the drawing or as directed by the Engineer. Girders may be post-tensioned or pre-tensioned. Where precast construction is required to be adopted, selection of casting yard and details of methodology and of equipment for shifting and launching of girders shall be included in the method statement.

In case of cast-in~~situ construction, the sequence of construction including side shifting of girders, if applicable, and placing on bearings shall be in accordance with the drawings.

The PSC girder constituting the top flange, web and the bottom flange shall be concreted in a single operation without any construction joint.

The portions of deck slab near expansion joints shall be cast alongwith reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface finish of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened, Care shall be taken for setting of bearings as indicated on the drawings.

2305.2 Box Girder

Box girders may be simply supported or continuous. Simply supported box girders shall have minimum construction joints as approved by the Engineer. In the case of continuous box girders the sequence of construction and location of construction joints shall strictly follow the drawings.

The box section shall be constructed with a maximum of one construction joint located in the web below the fillet between the deck slab and web. If permitted by the Engineer, one additional construction joint may be permitted and this construction joint shall be located in the web above the fillet between the soffit slab and web.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedment's for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer. The surface finish of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

2305.3 Cantilever Construction

Continuity of untensioned reinforcement from one segment to the next must be ensured by providing full lap length as necessary.
The design of the superstructure shall take into account the following aspects which form an integral part of the construction operations:

a) Stability against overturning for each statical condition through which the assembly passes, shall be checked.
b) Stresses at each preceding segment joint with the addition of every segment or change of statical conditions shall be checked, The load of equipment as well as construction live load shall be taken into account
c) Pre-cambering of the superstructure during construction shall be done in such a manner that the finally constructed structure under permanent load attains the final profile intended in the drawings.

2306 TOLERANCES

2306.1 Precast Concrete Superstructure

Variation in cross-sectional dimensions

a)	Up to and including 2m	±5 mm
	over 2m	±5 mm
b)	Variation in length overall and length between bearings	shall not exceed ±10mm or ±0.1per cent of the span length, whichever is lesser
c)	Permissible surface irregularities when measured with a 3 m straight edge or template	

2306.2 Cast-in-Situ Superstructure

a)	Variations in thickness of top and bottom slab for box girders, top and bottom flange for T-girders or slabs	-5mm to +10mm
b)	Variations in web thickness	-5mm to +10mm
c)	Variations in overall depth or width	±5 mm
d)	Variation in length overall and length between	
e)	bearings	shall not exceed ±10mm or ±0.1per cent of the span length, whichever is lesser
f)	Permissible surface irregularities when measured with a 3 m straight edge or template	5mm

2307 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

2308 MEASUREMENTS FOR PAYMENT

Concrete in superstructure shall be measured in accordance with Section 1700, based on the quantity ordered or as shown on the drawings. Steel reinforcement (untensioned) in superstructure shall be measured in accordance with Section 1600, based on the quantity ordered or as High tensile steel (prestressing) in superstructure shall be measured in accordance with Section 1800, based on the quantity ordered or as shown on the drawings.

2309 RATE

The contract unit rates for concrete, steel reinforcement (untensioned) and high tensile steel (prestressing) shall include all works as given in respective sections of these specifications and cover all incidental items for furnishing and providing superstructure as mentioned in this section.

2500 RIVER TRAINING AND PROTECTION WORK

2501 DESCRIPTION

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

2502 GUIDE BUND

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

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

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

2502.3 Guide bunds shall generally be made of locally available materials from the river bed preferably cohesionless materials. Trial pits shall be taken in borrow holes to examine suitability of soil for construction and also to decide the types of earth moving machinery to be arranged. The borrow pits should be sufficiently away from the location of the launching apron. No borrow pits should be dug on the river side of the guide bunds.

Construction of guide bund shall be taken in hand alongwith the construction of the bride. Every effort shall be made to complete the work of the guide bund in one working season. Where there is any doubt about completion of the whole guide bund within one working season, suitable measures shall be planned and executed for protection of completed work. In such cases the construction of guide bund shall be started from abutment towards upstream.

2502.4 Construction of apron and pitching of the guide bunds shall generally conform to clause 2503 and 2504 of these Specifications. Sufficient length of pit along the guide bund shall be ready within one to two months of commencement of work so that the placing of stones in the apron and in the slope pitching can be commenced. As a guideline, earth work should be completed within 80 per cent of working season and about 70 per cent working season shall be available for laying apron and pitching. No portion of the guide bund should be left below HFL before the onset of monsoon. Bottom of apron pit shall be as low as permitted by sub-soil water/lowest water level. Sufficient labour and appropriate earth moving machinery and trained staff shall be deployed in construction.

2502.5 The Contractor shall furnish his planning for approval of the Engineer regarding transport of stones from the quarries to the site of work taking into account the quantities of stone required to be transported every day, train/truck, etc., deployed, available ferry or boats and labour available for loading and unloading and for laying within the time frame for construction of guide bund. Adequate reserve of stones should be maintained for major works as decided by the Engineer. Reserve stones shall be stacked far away from the main channel of the river.

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

2504 PITCHING / FILTER MEDIA

Pitching: The pitching shall be provided as indicated in the drawings. The thickness and the shape of the stone pitching shall be shown on the drawing.

The stone shall be sound, hard, durable and fairly regular in shape. Quarry stone should be used. Round boulders shall not be allowed. The stones subject to marked deterioration by water or weather shall not be accepted.

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

Where the required size stones are not economically available, cement concrete blocks in M15 grade conforming to Section 1700 or stones in wire crates may be used in place of isolated stones of equivalent weight. Cement concrete blocks will be preferred wherever practicable. Use of geosynthetics has been dealt with in Section 700.

Filter media: The material for the filter shall consist of sand, gravel, stone or coarse sand. To prevent escape of the embankment material through the voids of the stone pitching / cement concrete blocks as well as to allow free movement of water without creating any uplift head on the pitching, one or more layers of graded materials, commonly known as a filter medium, shall be provided underneath the pitching.

The gradation of the filter material shall satisfy the following requirements:

Provision of a suitably designed filter is necessary under the slope pitching to prevent the escape of underlying embankment material through the voids of stone pitching / cement concrete blocks when subjected to the attack of flowing water and wave action, etc. In order to achieve this requirement, the filter may be provided in one or more layers satisfying the following criteria:

$$\frac{D\ 15\ (Filter)}{D\ 85\ (Base)} < 5$$

$$4 < \frac{D\ 15\ (Filter)}{D\ 15\ (Base)} < 20$$

$$\frac{D\ 50\ (Filter)}{D\ 50\ (Base)} < 25$$

Notes :

1. Filter design may not be required if embankment consists of CH or Ch soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its D 85 size shall be at least twice the maximum void size in pitching
2. In the foregoing, D 15 means the size of that sieve which allows 15 per cent by weight of the filter material to pass through it and similar is the meaning of D 30 and D 85.
3. If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as base material for selection of coarser filter.
4. The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.

2504.3 Construction Operations

Before laying the pitching, the side of banks shall be trimmed to the required slope and profiles put up by means of line and pegs at intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

The filter granular material shall be laid over the prepared base and suitably compacted to the thickness specified on the drawings.

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

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

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

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

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

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

2504.4 Toe Protection

In conformity with clause 5.3.7. of IRC:89, a toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to protect the slope pitching from falling even when the apron is not laid at low water level. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 1405.3 in case of dry rubble pitching or pitching/revetment with stones in wire crates and in nominal mix cement concrete (M 15) conforming to Clause 1704.3 in case cement concrete blocks have been used in pitching. For protection of ties of bank slopes terminating either in short aprons at bed levels or anchored in flooring / rocky bed, the provision of clause 8.2.2 of IRC:89 may be complied with. The relevant specifications of the protective works for individual components will be followed.

2509 MEASUREMENTS FOR PAYMENT

The protection works shall be measured as set forth below. If directed by the Engineer for measurement, the materials may have to be stacked at site before laying and nothing extra will be paid to the Contractor for this stacking.

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

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

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

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

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

For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as given in Clause 304.

2510 RATE

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

The contract unit rate for one cubic metre of finished work of apron shall include the cost of all material, labour, tools and plant for completing the work according to above specifications. Excavation upto an average depth of 150 mm shall also be deemed to be included in the rate as dressing of the bed. Excavation this depth shall be paid for separately unless otherwise specified.

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

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

2600 EXPANSION JOINTS

2601 DESCRIPTION

The work shall consist of fabrication and installation of expansion joints. The filler joint, asphaltic plug joint, compression seal joint and reinforced elastomeric joint of slab seal, strip seal and box seal type shall conform to these Specifications.

2602 GENERAL

The type of expansion joint proposed to be used shall conform to the design and got approved by the Engineer.

Expansion joints shall be robust, durable, water-tight and easy for inspection, maintenance and replacement. Site fabricated expansion joints shall be prohibited. Expansion joints shall be procured from approved manufacturers and shall be of proven type.

Alternative proprietary type deck joints proposed by the Contractor in lieu of the type specified shall comply in all respects with the manufacturer's specifications and meet the required range of movements and rotations and be fit for the purpose of ensuring satisfactory long term performance. For such proprietary type deck joints the following information shall be provided.

i) Name and location of the proposed manufacturer.
ii) Dimensions and general details of the joint including material specifications, holding down bolt or anchorage details and installation procedures.
iii) Evidence of satisfactory performance under similar environmental conditions of similar joints being produced by the manufacturer.

Acceptance of any alternative type of expansion joint shall be at the sole discretion of the Engineer. Such deck joints shall be installed in accordance with the manufacturer's recommendations and to the requirements of these Specifications.

Vehicular traffic shall not be allowed over expansion joints after their installation for such period as may be determined by the Engineer.

The expansion joint shall be provided to cover the entire carriageway, kerb and footpath, wherever provided. It shall follow the profile of the deck including the kerb, footway and facia. The expansion joint for kerb, footway and facia may be of different type and specification from that used for the carriageway and it shall cater to all movements and rotations for which the carriageway expansion joint is designed and shall be water tight.

2603 PERFORMANCE REQUIREMENTS

The expansion joint proper and the transition zone (the zone of connection joint assembly and the adjoining deck) shall satisfy the performance requirements specic of herein. The expansion joint proper shall satisfy the performance requirements of both bridge structure and the road users.

Performance Requirements with Respect to Bridge Structure

The expansion joint shall:

i) withstand the imposed loads including the impact load from live load and other sources,
ii) allow expansion and contraction movement due to temperature, creep shrinkage, pre-stressing and structural deformations, '
iii) permit relative rotation in elevation and plan due to the causes mentioned above,
iv) be waterproof be properly sealed,
v) ensure long life by being resistant to corrosion,
vi) be easy to install,
vii) be easy to maintain.

viii) be easy to replace. and
ix) be resistant to the materials likely to collect/spill over the decl< in its normal service.

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viii) be easy to maintain.
ix) be easy to replace. and
x) be resistant to the materials likely to collect/spill over the decl< in its normal service.

Performance Requirements for Transition Zone

The expansion joint shall:

i) permit transfer of generated forces to the deck without distress, i.e., without getting uprooted, and
ii) ensure that surface in the transition zone stays undisturbed during long term service.

2604 FILLER JOINTS

Components

The components of this type of joint shall be corrugated copper plate at least 2 mm thick placed slightly below the wearing coat, 20 mm thick compressible fiber board to protect the edges, 20 mm thick pre-moulded joint filler filling the gap up to the top level of the wearing coat and sealant of suitable joint sealing compound.

Material

i) The material used for filling expansion joint shall be bitumen impregnated felt, elastomer or any other suitable material, as specified on the drawings. Impregnated felt shall conform to the requirements of IS:1838, and shall be got approved from the Engineer. The joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall be avoided.
ii) Expansion joint materials shall be handled with care and stored under cover by the Contractor to prevent damage.
iii) Any damage occurring after delivery shall be made good to the satisfaction of the Engineer and at the expense of the Contractor.

Fabrication and Installation

i) Joint gaps shall be constructed as shown on the drawings. Surfaces of joint grooves shall be thoroughly cleaned with a wire brush to remove all loose materials, dirt and debris, then washed or jetted out.
ii) Pre-moulded expansion joint filler shall not be placed in position until immediately prior to the placing of the abutting material. If the two adjacent faces of the joint are to be installed at different times, the joint filler shall be placed only when the second face is ready to be kept in position
iii) Sealants shall be installed in accordance with the manufacturer's recommendations.
iv) Sealants shall be finished approximately 3 mm below the upper surfaces joint.
v) Joint materials spilt or splashed onto finished surfaces of the bridge during joint filling operations shall be removed and the surfaces rnae good to the Engineer's approval.
vi) No joint shall be sealed until inspected by the Engineer and approval is given to proceed with the work.

2700 WEARING COAT AND APPURTENANCES

2701 DESCRIPTION

This work shall include wearing coat and bridge appurtenances such as railing, approach slab, drainage spouts, weep holes in conformity with details shown on the drawing and these specifications or as approved by the Engineer.

2702 WEARING COAT

2702.1 Bituminous Wearing Coat

Specifications for bituminous concrete/bitumen mastic in wearing coat shall conform to Section 500 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress except for the special requirements as stated hereinafter.

2702.1.1 Principles of Bituminous Wearing Coat Shall Comprise the Following:

i) A Layer of mastic asphalt, 6 mm thick after applying a prime coat over the top of the deck before the wearing coat is laid. The prime coat and the Layer of mastic asphalt shall be laid as per Clause 8.7 of these specifications and Clause 515 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress respectively.

ii) 50 mm thick asphaltic concrete wearing coat in two layers of 25 mm each as per Clause 512 of Specifications for Road & Bridges Worksǁ (Fourth Revision, August, 2001 issued by the Ministry of Shipping, Road Transport & Highways, Government of India and published by the Indian Roads Congress.

In case of high rainfall intensity areas, the, thickness of mastic asphalt layer may be increased to 12 mm.

For high traffic density, an alternative specification for wearing course comprising 40 mm bituminous concrete overlaid with 25 mm thick bitumen mastic layer can be adopted. The work shall be done in conformity with Section 500.

2702.2 Cement, Concrete Wearing Coat

Cement concrete wearing coat may be provided in case of isolated bridge construction or bridges located in remote areas. It shall not be laid monolithic with the deck.

The thickness of wearing coat shall be 75 mm. The minimum grade of concrete shall be M 30 with water cement ratio as 0.4.

Curing of wearing coat earlier than what is generally required may be resorted to, so as to avoid formation of shrinkage cracks in hot weather.

All carriageway and footpath surfaces shall have non-skid characteristics.

The cross slope in the deck shall be kept as 2.5 percent for decks, level in longitudinal profile.

For providing cross camber no variation in thickness of wearing coat shall be permitted.

2703 RAILING AND CRASH BARRIER

General:

a) Bridge railing/crash barrier includes the portion of the structure erected on and above the kerb.

b) Railing/crash barrier shall not be constructed until the centering false work for the

span has been released and the span is self-supporting.

c) For concrete with steel reinforcement, specifications for the items of controlled concrete and reinforcement mentioned under relevant Sections of these Specifications shall be applicable.

d) The railing/crash barrier shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled with non-shrink mortar.

e) The type of railing/crash barrier to be constructed shall be as shown on the drawings and shall conform to IRC:5 and IRC:6.

f) Care shall be exercised in assembling expansion joints in the railing/ crash barrier to ensure that they function properly.

g) The railing/crash barrier shall be of such design as to be amenable to quick repairs.

h) The material of metal railing/crash barrier shall be handled and stored with care, so that it remains clean and free from damage. Railing/crash barrier materials shall be stored above the ground on platforms, skids, or other supports and kept free from grease, dirt and other contaminants.

i) Any material which is lost, stolen or damaged after delivery shall be replaced or repaired by the Contractor. Methods of repairs shall be such that they do not damage the material or protective coating.

2703.2 Metal Railing/Crash Barrier

Materials, fabrication, transportation, erection and painting for bridge railing/crash barrier shall conform to the requirements of Section 1900 of these Specifications.

All steel railing elements, pipe terminal Sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint.

If galvanised, all elements of the railing/crash barrier shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done as per method approved by the Engineer.

Damaged galvanised surfaces, edges of holes and ends of steel railing/crash barrier cut after galvanising shall be cleaned and re-galvanised.

The railing/crash barrier shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout its length. Holes for field connections shall be drilled with the railing/crash barrier in place in the structure at proper grade and alignment.

Unless otherwise specified on the drawings, metal railing/crash barrier shall be given one shop coat of paint and three coats of paint after erection, if sections are not galvanised.

Railing/crash barrier shall follow the alignment of the deck. Where required as per the drawings, the rail elements shall be before erection.

2703.3 Cast In-Situ Concrete Railing/Crash Barrier

The portion of the railing/crash barrier or parapet which is to be cast in-situ shall be constructed in accordance with the requirements for Structural Concrete Section and reinforcement conforming to Sections 1600 and 1700 of these Specifications.

Forms shall be fabricated conforming to the shape of railing/crash barrier shown on the drawings. It shall be ensured that no form joint appears on plane surfaces. For bridges/ viaducts of length more than 500 m horizontal slip forms shall be used for casting of crash barriers.

All mouldings, panel work and bevel strips shall be constructed according to the details shown on the drawings. All corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects. Castings of posts shall be done in single pour.

2703.4 Precast Concrete Railing/Crash Barrier

Precast members for railing/crash barrier shall be of reinforced cement concrete and shall conform to Sections 1600 and 1700 of these Specifications. The maximum size of the aggregate shall be limited to 12 mm and minimum concrete grade shall be M30 for railings and

M40 for crash barriers. The precast members shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days, during which they shall be protected from sun and wind. Any precast member that becomes chipped, marred or cracked before or during the process of placing shall be rejected.

2704 APPROACH SLAB

Reinforced concrete approach slab covering the entire width of the roadway shall be provided as per details given on the drawings or as approved by the Engineer. Minimum length of approach slab shall be 3.5 in and minimum thickness 300 mm.

The cement concrete and reinforcement shall conform to Sections 4.1 and Section 5.1 respectively. The base for the approach slab shall be as shown on the drawings or as directed by the Engineer.

2705 DRAINAGE SPOUTS

This work shall consist of furnishing and fixing in position of drainage spouts and drainage pipes for bridge decks.

Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be of corrosive resistant material such as galvanized steel with suitable cleanout fixtures. The spacing of drainage spouts shall not exceed 10 in. The discharge from drainage spout shall be kept away from the deck structure. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located pipelines to discharge the surface run off to drains provided at ground level.

2705.1 Fabrication

The drainage assembly shall be fabricated to the dimensions shown on the drawings; all materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS: 226. The drainage assembly shall be seam welded for water tightness and then hot dip galvanized.

2705.2 Placement

The galvanized assembly shall be given two coats of bituminous painting before placement. The whole assembly shall be placed in true position, lines and levels as shown in the drawing with necessary cut out in the shuttering for deck slab and held in place firmly. Where the reinforcements of the deck are required to be cut, equivalent reinforcements shall be placed at the comers of the assembly.

2705.3 Finishing

After setting of the deck slab concrete, the shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per IS: 1834 and the excess sealant trimmed to receive the wearing coat. After the wearing coat is completed, similar sealant shall be finished to cover at least 50 mm on the wearing coat surface all-round the drainage assembly.

2706 WEEP HOLES

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall and return walls as shown on the drawing or directed by the Engineer to drive moisture from the back filling. Weep holes shall be provided with 100 mm dia AC pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be 80 mm wide, 150 mm high or circular with 150mm diameter. Weep holes shall extend through the full width of concrete/masonry with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes shall generally be 1m in either direction or as

shown in the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.

2707 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

2708 MEASUREMENTS FOR PAYMENT

The measurement for payment for wearing coat, railings and approach slab shall be made as given below:

i) Cement concrete wearing coat shall be measured in cubic meters. Asphaltic concrete wearing coat shall be measured in square meters.
ii) Railings shall be measured in running meters.
iii) Approach slab and its base shall be measured separately in cubic meters.
iv) Drainage spouts shall be measured in numbers.
v) Weep holes in concrete brick masonry structure shall be measured in numbers. For structures in stone masonry, weep holes shall be deemed to be included in the item of stone masonry work and shall not be measured separately.

2709 RATE

The contract unit rate for wearing coat shall include the cost of all labour, material, tools and plant and other cost necessary for completion A the work as per these Specifications.

The contract unit rate of railings shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications.

The contract unit rate for approach slab shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. The rate for base shall include cost of all labour, material, tools and plant required, including preparation of surface and consolidation complete in all respects.

The contract unit rate for each drainage spout shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. It shall also include the cost of providing flow drainpipes with all fixtures up to the point of ground drains wherever shown on the drawings.

The contract unit rate for weep hole shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications.

2900 PIPE CULVERTS

2901 SCOPE

2902 MATERIALS

All materials used in the construction of pipe culverts shall conform to the requirements of Section 1000.

Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the Engineer either at the place of manufacture or at the site before their incorporation in the works.

2903 EXCAVATION FOR PIPE

The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to levels as shown on the drawings. In case of high embankments where the height of fill is more than three times the external diameter of the pipe, the embankment shall first be built to an elevation above the top of the pipe equal to the external diameter of the pipe, and to width on each side of the pipe of not less than five times the diameter of pipe, after which a trench shall be excavated and the pipe shall be laid.

Where trenching is involved, its width on either side of the pipe shall be a minimum of 150 mm or one-fourth of the diameter of the pipe whichever is more and shall not be more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

The pipe shall be placed where the ground for the foundation is reasonably firm. Installation of pipes under existing bridges or culverts shall be avoided as far as possible. When during excavation the material encountered is soft, spongy or other unstable soil, and unless other special construction methods are called for on the drawings or in special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with approved granular material which shall be properly shaped and thoroughly compacted upto the specified level.

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

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

2904 BEDDING FOR PIPE

The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be of one of the following two types as specified on the drawings:

i) First Class Bedding: Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for at least ten percent of its overall height or as otherwise shown on the drawings. The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted/rammed. The compacted thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75 mm.

ii) Concrete Cradle Bedding: When indicated on the drawings or directed by the Engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M 15 conforming to Section 1700. The shape and dimensions of the cradle shall be as indicated on the drawings. The pipes shall be laid on the concrete bedding before the concrete has set.

2905 LAYING OF PIPE

No pipe shall be laid in position until the foundation has been approved by the Engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

The arrangement for lifting, loading and unloading concrete pipes from factory/yard and at site shall be such that the pipes do not suffer any undue structural strain, any damage due to fall or impact. The arrangement may be got approved by the Engineer.

Similarly, the arrangement for lowering the pipe in the bed shall be got approved by the Engineer. It may be with tripod-pulley arrangement or simply by manual labour in a manner that the pipe is placed in the proper position without damage.

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

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

2906 JOINTING

The pipes shall be jointed either by collar joint or by flush joint. In the former case, the collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be so placed that its center coincides with the joint and an even annular space is left between the collar and the pipe.

Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar, 1 cement to 2 sand, mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

For jointing pipe lines under light hydraulic pressure, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

2907 BACKFILLING

Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, excessive amounts of sods or other vegetable matter, and lumps and shall be approved by the Engineer. Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used.

Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of high embankment, after filling the trench upto the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.

2908 HEADWALLS AND OTHER ANCILLARY WORKS

Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer. Masonry for the Walls shall conform to Sections 1300, 1400 or 1700 as applicable. Aprons shall conform to Section 2500.

2909 OPENING TO TRAFFIC

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

2910 MEASUREMENTS FOR PAYMENT

RCC pipe culvert shall be measured as complete work in linear metres along its length between the inlet and outlet ends. Culverts with multiple rows of pipes shall be measured as one unit, irrespective of the number of rows.

2911 RATE

The Contract unit rate for the pipe culvert shall include the cost of pipes including loading, unloading, hauling, handling, storing, laying in position and jointing and all ancillary works such as excavation, bedding for pipes, backfilling, concrete, masonry and aprons and incidental costs to complete the work as per these Specifications.