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Quality Control Manual for Provincial Roads, Bagmati Province

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Hetauda, Makawanpur, Nepal

Quality Control Manual for Provincial Roads

Hetauda, Nepal
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FOREWORD

It is obvious that quality is one of the key factors in the success of construction projects. Project Success at any level can be viewed as whether the project meets the expectations (i.e. satisfaction) of the people. In order to fulfill expectations of people, construction projects must follow standards and specifications. This Quality Control Manual for Provincial Roads aims to maintain standards and specifications in construction and maintenance of road projects. This manual will serve as a working guide to guide engineers and sub-engineers in the development of sustainable transportation infrastructures. Any conflict between this manual and the contract documents shall be resolved in favor of the contract documents.

A very special gratitude goes to Mr Rameshwar Phuyal Minister of Ministry of Physical Infrastructure Development of Bagmati Province and Mr Sanjeeb Baral Secretary, Ministry of Physical Infrastructure Development who gave suggestion about the preparation of this Manual. **Mr. Aashish Khadka and Mr. Rambabu Paudyal**, Road Experts of the Transport Infrastructure Directorate deserves special thanks for their contribution who have prepared this manual. For their contribution, I am grateful to all the staffs who have worked on this document Senior Divisional Engineer Mr. Pushkar Prasad Pokharel, Engineer Hari Prasad Ojha, all IDOs, PRDOs, Account Officer Mr. Rajesh Thapa and Computer Operator Anupa Lama.

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ABBREVIATIONS

AADT	Annual Average Daily Traffic
AASHTO	The American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ACV	Aggregate Crushing Value
ASTM	American Society for Testing and Materials
BC	Bituminous Concrete
BM	Bituminous Macadam
BOQ	Bill of Quantity
BS	British Standard
AIV	Aggregate Impact Value
CBR	California Bearing Ratio
Cl	Chloride
CR	Crushing Ratio
CRCP	Continuous Reinforced Concrete Pavement
CRM	Crusher Run Macadam
CSB	Crushed Stone Base
Cum	Cubic Meter
CVPD	Commercial Vehicle Per Day
DBM	Dense Bituminous Macadam
Dia	Diameter
DFID	Department for International Development
DoLI	Department of Local Infrastructure
DoLIDAR	Department of Local Infrastructure and Agricultural Roads
DoR	Department of Roads
DPR	Detailed Project Report
FD	Field Density
FI	Flakiness Index
GC	Clayey Gravel
GI	Galvanized Iron

GoN	Government of Nepal
GP	Poorly Graded Gravel
GSB	Granular Sub-Base
GW	Well Graded Gravel
HDPE	High-Density Polyethylene
HSPC	High Strength Portland Cement
IDO	Infrastructure Development Office
IRC	Indian Road Congress
IS	Indian Standard
JPCP	Jointed Plain Concrete Pavement
JRCP	Jointed Reinforced Concrete Pavement
LAA	Los Angles Abrasion
LL	Liquid Limit
MC	Medium Curing
MDD	Maximum Dry Density
MoPID	Ministry of Physical Infrastructure Development
MS	Mild Steel
NS	Nepal Standard
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
ORN	Overseas Road Notes
PI	Plasticity Index
PL	Plastic Limit
PM	Project Manager
PPC	Portland Pozzolana Cement
PPCP	Precast Panel Concrete Pavement
PRDO	Provincial Road Division Office
PSC	Portland Blast Furnace Slag Cement
PVC	Polyvinyl Chloride
QA	Quality Assurance

QAP	Quality Assurance Plan
QC	Quality Control
QCM	Quality Control Manual
RC	Rapid Curing
RCC	Reinforced Cement Concrete
RR	Research Report
RS	Rapid Setting
SM	Special Mix
Sq m	Square Meter
SS	Slow setting
SSS	Sodium Sulphate Soundness
SW	Well Graded Sand
TID	Transport Infrastructure Directorate
VFB	Void Filled with Bitumen
VMA	Voids in Mineral Aggregate
VG	Viscosity Grade
VMA	Voids in Mineral Aggregate
WBM	Water Bound Macadam
WMM	Wet Mix Macadam

Chapter 1. INTRODUCTION

1.1 BACKGROUND

Transport Infrastructure Directorate (TID) was established in 2018 under the Ministry of Physical Infrastructure Development in order to develop transport infrastructures including roads and bridges in Bagmati Province The main aim of the organization is to develop plans, policies, programs, guidelines, and specifications for the construction of transport infrastructure and implement the design, construction and maintenance works of roads, bridges, trail bridges etc. with efficiencies and effective way self or through the under offices. The TID is the central authority of Bagmati Province Government charged with the responsibilities for enhancing the economic and social development of the Province by linking various geographical and economic regions through the provincial strategic transport network. It is responsible for linking rural areas of the Province with markets to support various economic activities and projects related with tourism, agricultural, electrical, and industrial and other sectors of Nepal.

Moreover, the key role of the Directorate lies with preparing plans, policies, and programs regarding the development of physical infrastructures such as roadways, railways, waterways, subways, flyovers, and ropeways; transport and transit management and its operation related plans, policies, and programs; its implementation; monitoring and evaluation; inspection.

For qualitative and sustainable development of roads and uniformity and consistency in construction and maintenance process of road projects, this Quality Control Manual (QCM) for Provincial Road is prepared by TID.

This Quality Control Manuals aims to present technical advice and guideline to set the basic principle governing the construction of all roads within the Bagmati Province.

1.2 PROVINCIAL ROAD NETWORK OF BAGMATI PROVINCE

As per the Provincial Transport Master Plan (PTMP) of Bagmati Province, the total number of identified Provincial Highways are 18 and the total length is 1516.20 Km. Out of it, 176.54 Km is Blacktopped road, 198.04 Km is Graveled and 1142.62 Km is Earthen.

The total numbers of identified Provincial Roads are 155 and the total length of road is 4067.30 Km. Out of it, 601.10 Km road is Blacktopped road, 420.40 Km road is Graveled and 3045.80 Km road is Earthen.

Similarly, the total number of identified Provincial Urban and Rural Roads are 72 and its total length is 1427.19 Km. Out of it, 219.69 Km road is Blacktopped road, 128.90 Km road is Graveled and 1078.60 Km road is Earthen.

The Bagmati province is developing, upgrading and maintaining province road networks to the higher standard rapidly, hence it is very essential and important to establish comprehensive, consistent and common system for quality assurance and control during implementation. The TID has prepared this document with meeting all requirements with respect to good quality.

1.3 OBJECTIVE OF MANUAL

The purpose of this document is to provide a structured approach to Quality Control of Road Construction and to ensure that the works are being carried out in accordance with the requirements of the Specification. In order to do this and provide documentary evidence that the employer is carrying out adequate surveillance a suite of checklists have been prepared. These checklists form the backbone of surveillance of construction activities and are intended to be used on a daily basis during supervision of the works.

The main objective of this manual is to guide TID, IDOs and PRDOs in achieving timely completion of the Project in conformity with the Contract documents and to inherent quality construction practices. The success of Project implementation is measured both on the quality of construction and its timely completion within the budgeted cost. For example; if the structures or roads fail prematurely and if the drainage system does not function effectively, then Project will be judged as a failure. Likewise, if the costs escalate unchecked to the extent that Client cannot meet its Contractual payment obligations, or if slippages reach unreasonable levels and project funds are withdrawn, project implementation will be fail.

It is vital therefore, that construction supervision requirements are treated as a matter of highest priority in the Project implementation cycle. It is important for all users of this manual to understand that Contract conditions, Specifications and construction Drawings are the controlling documents in the construction of the Project.

1.4 COVERAGE OF THE MANUAL

Specific Quality Assurance (QA) / Quality Control (QC) procedures and instructions for individual activities are covered by the QCM. This QA / QC Manual focuses on the implementation activities of the project following primarily on supervision and quality control of construction works. Other aspects of project implementation are also covered but in less detail. The QC Manual is intended to be used primarily by the TID, IDOs and PRDOs staffs as well as contractors. The QC Manual does not attempt to suggest technical specifications, since these are stated in the contract documents. Its aim is to ensure that the works are executed as per specifications, i.e. it is a means to achieve the desired results. The Project will apply and interpret quality control and test results for different packages, in accordance with the contract conditions.

It is the Project Manager's and Engineer in Charge responsibility to ensure specific activity QA/QC procedures and instructions are conveyed to the contractors performing the specified activities.

The subsequent chapters of this Manual are as follows:

Chapter 2. QUALITY CONTROL SYSTEM
Chapter 3. GENERAL QUALITY REQUIREMENT
Chapter 4. SITE CLEARANCE
Chapter 5. EARTH WORK AND DRAIN CONSTRUCTION
Chapter 6. SUB-BASES, BASES & SHOULDER

Chapter 2. QUALITY CONTROL SYSTEM

2.1 INTRODUCTION

Quality is one of the important aspects that are used to assess cost and efficiency of any product, but in civil engineering field quality deals with safety of a structure and serviceability. Hence, it is necessary to ensure that any structure is at an acceptable level of quality and in order to that, a new science called quality control is introduced. In simple terms, Quality control (QC) is a procedure or set of procedures intended to ensure that construction works or performed service adheres to a defined set of quality criteria i.e. specification or meets the requirements of the client.

The Contractor is overall responsible for achieving the overall quality standards specified in the contract agreement. The Engineer in Charge is responsible for ensuring that the works are constructed in conformance to those standards.

It is mandatory that at prescribed frequencies, a system of procedures for the sampling and testing of materials prior to placing and following completion that ensures that specified standards are achieved. Each procedure relates to a specific aspect of the works and usually involves a test or combination of tests to determine compliance or otherwise with a Specification. QC does not specify “who, where and how” the procedures will be implemented.

The quality control system is designed to:

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identify and address errors and omissions;
- Document and archive inventory material and record all quality control activities

2.2 QUALITY CONTROL

Majority of Road Projects under the Province are small in size and constructed in remote area where access to heavy plant and equipment are limited. In addition, locally available materials are widely used to economize road construction. Keeping in view of above constrains and factors such as quality of materials and workmanship, reliable “Quality Control System” for supervision & monitoring of works are essential for the construction and maintenance of provincial roads.

Supervision and Monitoring is an important tool for the quality control whereas quality control system deals with establishment of functional material testing laboratory, inspection and testing the construction materials according to the specified standard, checking the work methodology and workmanship including design for the road works. Quality of end product depends upon the quality of materials and construction workmanship. Poor workmanship lead to inferior quality of end product even if the materials used are of good quality. With poor quality material, it is almost impossible to attain desired strength. Therefore, utmost care is needed to ensure that proper material is used in the construction work. Hence, the design strength and function can only be

attained if the specification is strictly followed while selecting/approving material and performing the work.

During developing of a suitable Quality Control System the above constrains should be considered for the Construction and Maintenance of road works. The types and frequency of the tests for such projects should be specified carefully so that they are attainable during the prevailing conditions.

2.3 QUALITY CONTROL SYSTEM IN ROAD PROJECTS

The Quality Control System comprises the methods, procedures and organization for the Quality Control of the works. The implementation of the Quality Control System is in the following order:

A. Sequence

I. Compliant testing for materials including laboratory trials,
II. Compliant testing for methods and equipment prior to the commencement of the work
III. Control testing during construction,
IV. Acceptant testing on completed works or parts of the works.

The Contractor is overall responsible for carrying out all the necessary tests for materials and works and submit report of such tests to the Project Manager or Engineer in charge of TID/IDOs for approval in accordance with the Specification. In certain circumstance, tests may be required to be carried out at the place of manufacture as specified in the contract.

For acceptance of the quality of the works, quality control tests shall be conducted by the Engineer himself or by any other agencies deemed fit by the Engineer. Additional tests may be conducted where in the opinion of the Engineer when such tests are needed.

Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down specification requirements and tolerances to the satisfaction of the Engineer.

B. Supply, Testing and Monitoring

The supply, testing and monitoring shall be in compliance with a Quality Assurance Plan, as per the provisions made in the contract. The list of sources of materials and/or manufactured article, their main characteristics, their identification mode as provided by the supplier when required; the program of supply and procurement of material and/or manufactured articles in accordance with the program submitted by the contractor.

The Quality Control on road construction and maintenance shall be exercised as follows:

1. Quality Control Tests on Materials before incorporation in the Works

All materials before incorporation in the work shall be tested by the Contractor for the tests indicated under 'Tests to be carried out prior to Construction'. The tests shall be carried out from each source identified by the Contractor. The test samples shall be representative of the material available from the source. Any change/variation in the quality of material with depth of strata shall be reported. Important tests like the Moisture-Density Relationship (Proctor Compaction),

Aggregate Impact Value Plasticity Index, California Bearing Ratio (CBR) and any other tests specified by the Engineer shall always be carried out in the presence of a representative of the Engineer, who will not be below the rank of Sub- Engineer. The test results shall form the basis for approval of the source and the material for incorporation in the work and shall be approved by the Engineer. For manufactured items, however, such as concrete pipes, elastomeric bearings etc a test certificate obtained by the Manufacturer from an approved Test House shall be accepted.

2. Quality Control Tests during Construction

During execution of the work, quality control for ensuring conformance to specification and shall be exercised on the basis of the tests indicated under 'Field Quality Control Tests during Construction'. The tests shall be carried out by the Contractor independently or in the presence of Employer's representative, normally a Sub- Engineer, when available at site or where association of the Employer's representative in test is prescribed. The Sub-Engineer shall record the results in his own handwriting. The Contractor shall be fully responsible for all the tests carried out for the work. The Engineer/Senior Divisional Engineer during their site visits shall have a few tests carried out in their presence and sign the Quality Control Register

3. Stage Passing

The field supervisory officers of the level of site engineer and project manager shall exercise quality control checks and certify the work of various stage on the basis of tests and frequencies indicated in "Quality Assurance Plan" (QAP). The officers certifying the work at various stages as prescribed shall be responsible for the quality and quantity of the work certified by him.

4. Procedure to form part of Contract

The prescribed tests, frequencies and the procedure for stage passing by Supervisory Officers shall be mandatory and shall form the part of the Contract.

5. Random Checks

For purposes of Quality Monitoring, only random checks are envisaged. For soils and other road materials being used at site, a representative sample from the borrow pit in use or stockpiled material can be collected at random. Similarly, while checking placement moisture content during compaction, a random sample can be collected and its moisture content determined using a Rapid Moisture Meter. For in-situ density determination by sand replacement method, the location of the test can be selected at random. A similar approach can be adopted during bituminous and cement concrete construction. However, where a completed section is to be checked, the entire completed section should be divided into 10 sub-sections, of equal length. Two such sub-sections may be selected at random for carrying out the identified tests.

Where random checking has been recommended, the procedure to be adopted for random checking shall be as follows:

I. The complete section to be checked shall be divided into ten sub sections of equal length viz. 0-100 m, 100-200 m, 200-300 m. Of these, only two sub-sections shall be selected for carrying out tests by draw of lots.

II. Longitudinal profile shall be tested by a 3 m straight edge in a stretch of at least 9 m length.
III. Transverse profile viz. camber/cross fall/ super elevation shall be tested using camber templates at two or three locations for each 100 m length.

6. Simple/Hand-Feel Tests

For monitoring the quality of work, generally it may not be possible to carry out the detailed quality control tests and therefore, for the purpose of quality monitoring simple/hand feel tests can be performed. Normally various simple tests have been used by the experienced practicing engineers in the field to make a quick assessment of the quality of the materials. However, these procedures have not been standardized and involve human judgment. Therefore, these tests which provide useful guidance for supervisory officers during inspections should not be used as a replacement of the specified quality control tests.

7. Laboratory

The requirement of a quality control organization will vary for different projects depending on size of the project. The essential mechanism for quality control is laboratory set-up at Field, District and Provincial level shall be as follows;

a) Field Laboratory

The Contractor shall be responsible to set up and maintain an adequately equipped Field Laboratory for routine tests for quality control required to be conducted on a day to day basis. The field laboratory will have normally those test equipment that do not require electric power supply and are relevant to the project specifications. Field Laboratory will be managed by suitably trained personnel in material testing and quality control works, as specified in the contract document.

b) Laboratory at IDO

The tests which are required to be done during the project planning stage such as those pertaining to suitability of construction materials, selection of quarries etc. to be carried out before incorporation in the work as part of quality control or the tests which cannot be carried out in the Field Laboratory shall be conducted in the District Laboratory. The District Laboratory will cover the testing requirements for the entire District. Such a Laboratory shall be equipped with facilities for most of the tests, including those required for Detailed Project Report (DPR) preparations.

c) Laboratory at TID

Tests requiring high level of skills and sophisticated test equipment and those tests which cannot be conducted in IDO level laboratory will be carried out at the Laboratory under the control of the Director or In-charge Quality Control of Transport Infrastructure Directorate.

Any special or sophisticated tests, for which the necessary equipment and expertise are not available in the Laboratory at TID or IDO, shall be outsourced only after approval from the client to National Laboratories approved by Government of Nepal or Higher Technical (academic) Institutes or Research Laboratories.

2.4 ROLES AND RESPONSIBILITIES FOR QUALITY OF WORKS

Both the Client and Contractor are required to engage adequate number of personnel with required knowledge, experience and expertise to control quality. Right type of quality control personnel with Contractor and Engineer is a must to achieve desired quality of the project. This gives an outline of the type of personnel and their responsibilities for the project.

A. Client Representative

1. Project Manager (PM)
2. Site Engineer

1. Project Manager

The PM is responsible for the administration, and control of contract, and in particular the supervision of the works to ensure that the contractor fulfill the requirement of contract. All the power under the contract remain with the PM, although he/she may usually delegate some or most of his/her duties to Engineer in Charge.

2. Site Engineer

The site engineer is responsible for quality control and quality assurance of works. His/her major responsibilities are:

- Day to day planning of site works
- Review construction method statements submitted by contractor
- Review site specific working drawing
- Ensure setting out of works and carry out construction in accordance with working drawing
- Monitor all test specified in QAP.
- Implement QAP and control of quality of work and workmanship
- Ensure effective use of work request form, daily site diary, site instruction and other checklist for individual items.
- Ensure adaptation of safety measure during works.
- Ensure construction activities are carried out in accordance Method Statement.
- Immediate information to the PM for any obstruction to the progress of the work and or any fact found in the drawing.
- Supervise and execute all works according to specifications, client procedure and instructions etc.
- Ensure adequate supply of all materials, arrangement of plants and labor well in advance.
- Take jointly measurement of the work done or supply and to record in the measurement book and submit them to PM for payment.
- Keep note of important points on works in note book during the inspection of works and he has to keep his not book up- to date.
- Ensure environmental and social safeguard.

B. Contract Representative

1. Contract Manager
2. Site Engineer
3. Lab Technician

1. Contract Manager

The contract manager is responsible for contract management, communication and coordination and construction of works in accordance to standard specification and contract document. His/her major responsibilities are:

- Planning, scheduling, monitoring and controlling of tasks.
- Conformity of all materials and all workmanship performed strictly with the requirements of specifications.
- Prepare QAP
- Set up of laboratory with adequate laboratory equipment operated by competent staff for carrying out tests for selection and control and quality of material and workmanship in accordance of specification.
- Inspect materials upon receipt.
- Prepare Monthly Progress Report, S-Curve, Bar Charts etc. and submit to Client.
- Define activities affecting quality of works
- Prepare and submit working drawing for approval.
- Ensure compliance with drawing, specification and environmental provision.
- Implement site instruction given by the client.
- Establish and maintain quality management system.
- Carry out construction activities in accordance Method Statement
- Correspondence with client
- Monitoring and Implementation of QAP.
- Maintain coordination with stakeholders and own staffs.
- Timely instruction and decision.

2. Site Engineer

His/her major responsibilities are:

- Day to day planning of site works
- Prepare construction method statements
- Prepare site specific working drawing
- Setting out of works and carry out construction in accordance with working drawing
- Carry out and Monitor all test specified in QAP.
- Implement QAP and control of quality of work and workmanship
- Implement work request form and site instruction
- Carryout construction activities in accordance Method Statement.

- Inform immediately to the client/PM for any obstruction to the progress of the work and or any fact found in the drawing.
- Execute all works according to specifications, departmental procedure and instructions etc.
- Arrange all materials, plants and labor well in advance and has to see that progress of work does not suffer for want of material
- Take measurement of the work done or supply and to record in the measurement book
- Keep note of important points on works in note book during the inspection of works and he has to keep his not book up- to date.

3. Lab Technician

- Set up laboratory and testing facilities
- Carry out quality control test and process control
- Supervise compaction of subgrade, subbase and base likewise asphalt work.
- Prepare day to day testing of materials and maintain documentation of lab reports systematically.
- Prepare laboratory and site testing Records and register
- Provide data to material engineer to maintain site record
- Jointly sampling of materials
- Carry field test such as FD, MC etc.
- Maintain test register
- Fully accountable to Engineer
- Supply test report to client

2.5 QUALITY ASSURANCE PLAN

The Contractor shall submit to the Engineer for his approval, the Quality Assurance Plan (QAP) which shall be based on the detailed testing program for the works as per specified in the Specifications. The Quality Assurance Plan shall include the following:

I. The Quality Control Schedule: It contains

a) Recapitulative test schedule and testing program detailing the list of tests for compliance, laboratory trials, site trials and trials Sections, construction control tests and their frequencies, tests for acceptance of the completed works with their dates.
b) Recapitulative list of "critical" acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Program.
c) Estimate of the number of tests to be carried out, list and number of appropriate equipment required to conduct them, list of tests to be conducted outside the site laboratory, if any, identification of the outside laboratory where proposed to carry out the test.

d) List of staff assigned to the laboratory, their position and responsibilities in the quality control procedures, their qualification and experience, general description and detailed organization of the laboratory activities.

II. The list of sources of materials and/or of manufactured articles, their main characteristics, their identification mode as provided by the supplier when required; the program of supply and procurement of material and/or manufactured articles in accordance with the Program submitted by the Contractor.

III. The list of tests and quality control procedures to be implemented by the Sub-contractors, if any, pointing out the "critical" acceptance testing procedures relating to the Sub-contracted works, which correspond to the tasks on the Critical Path included in the Sub-contracted works.

The Contractor shall implement the Quality Control in compliance with the approved QAP. Engineer's approval of the QAP shall not relieve the Contractor from his responsibility of the quality of the Works as per the Conditions of Contract and the Specifications nor shall the Engineer's approval of the QAP exempt the Contractor of any procedure to inform the engineer in writing or request for the Engineer's approval or re-approval as specified in the Conditions of Contract and/or in the Specifications.

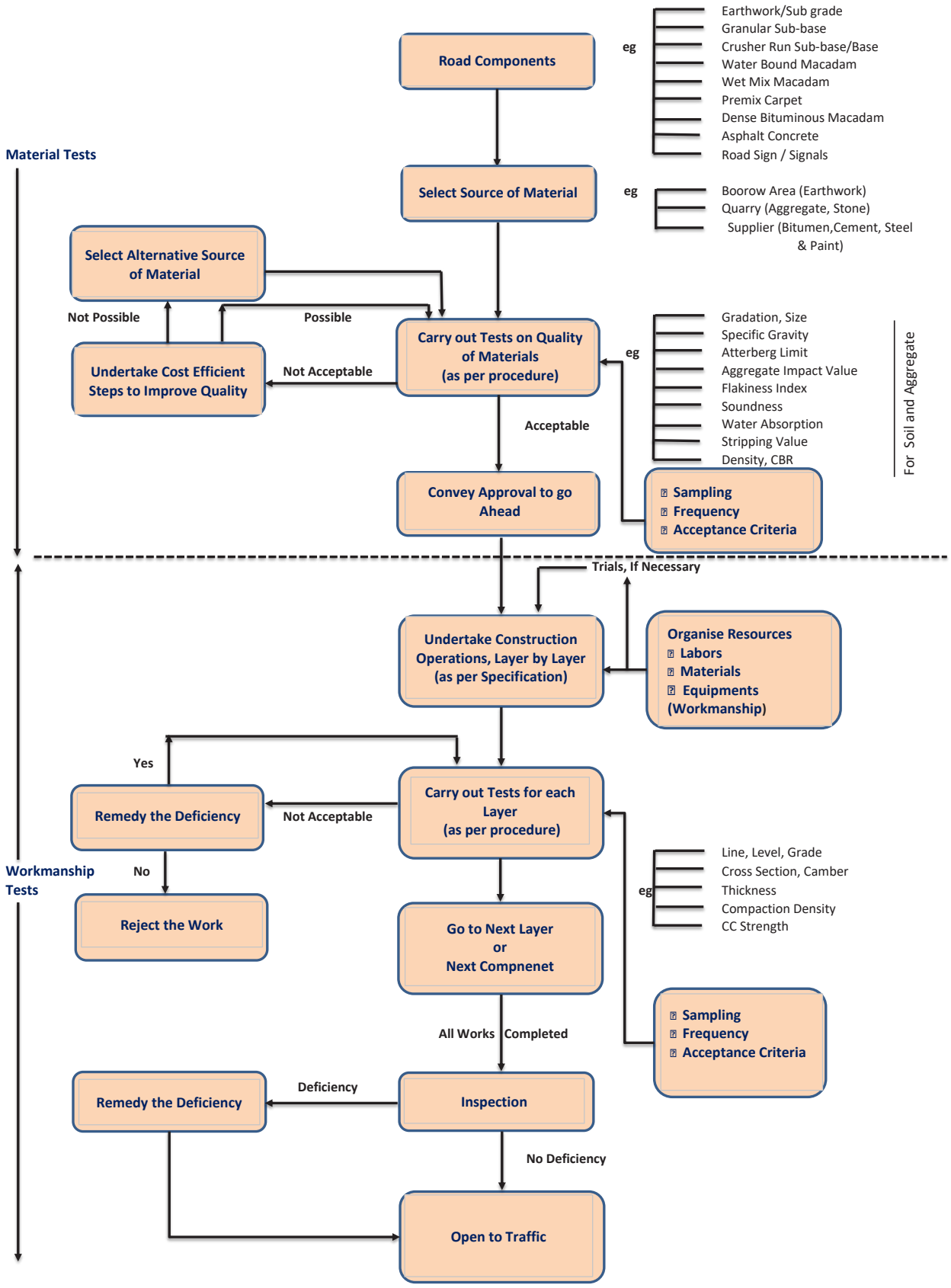
The Contractor shall monitor and update the QAP on the basis of the decisions taken at the periodic review meetings or as directed by the PM/Engineer in charge and in accordance with the program of the works as per the Conditions of Contract.

The content of QAP is attached in Annex 1 of this manual.

2.6 FLOW CHART FOR QUALITY ASSURANCE

A typical flow chart for quality assurance checks during the construction of roads is given as an illustration in figure 2.1

Figure 2 1 Typical Flow Chart for Quality in Road Works



Chapter 3. GENERAL QUALITY REQUIREMENT

3.1 ACCOMMODATION OF TRAFFIC

The contractor shall manage the traffic as efficiently and safely as possible under all work conditions and ensure the safety of workers at site undertaking the construction. The contractor shall provide traffic management plan to engineer for approval for those section of road, where chances of obstruction in traffic movement. The plan should include:

- Construction and maintenance of the necessary detours, diversion and barricades.
- Provision of traffic safety devices and road sign in construction zones.
- Provision of flag person.
- First aid tool and emergency response arrangements.
- Flow of information to public through public media regarding the disturbance.
- Removal of diversion after they become redundant.

After an approval of traffic management plan, the contractor shall implement plan taking all measure for ensuring safety of traffic and workers during construction.

3.2 PUBLICLY & PRIVATELY OWNED SERVICES

Public and private utilities like water pipes, sewers, electric lines, telephone cables etc. as included in contract document should be identified at site by the contractor for the accuracy of the information prior to the commencement of any works. The contractor shall follow the following methodologies:

- The contractor shall schedule work in such a manner as to protect the existing utilities facilities until they are relocated abandoned or replaced.
- Arrange and conduct regular meetings with various agencies owning utilities before the commencement and during the period of the works.
- Provide temporarily support to the utilities affected by the works. Protect utility services during construction period.
- Any services affected by the works shall be restored immediately 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.
- Assist agencies owning the utilities in carrying out the works with approval of the Engineer.
- Carry out the removal or shifting of the certain services/utilities on specific instruction from Engineer.
- No clearance or alternation of utilities shall be carried out unless instructed by Engineer.

3.3 SURVEY AND SETTING OUT

The following methodology shall be adopted for survey and setting out of provincial roads

I. Before the Commencement of works the Contractor shall carry out the construction survey jointly with the engineer soon after taking possession of the site.

II. The design survey data i.e. Bench Mark Stations and Lay out datas shall be obtained from the Project Manager and all required data can be obtained from the design drawing developed during preparation of Detailed Project Report (DPR) and provided during the procurement of contract.

III. The survey works i.e. setting out of lines and Benchmark Stations shall be carried out by the use of standard instruments such as DGPS, Total Station, Theodolite, and Automatic Levels with approval from engineer.

IV. The coordinates and levels of stations must be checked and verify in accordance design drawing at the field. Any discrepancies observed during the survey such difference in level, coordinates of stations and missing of stations shall be informed immediately to the engineer and shall be amended after the approval from the engineer.

V. The contractor shall check, replace and supplement necessary the station points and agree any revised or additional station points with the approval of Engineer.

VI. The working bench marks shall be established at the rate of four per kilometer and also at or near drainage structures, over-bridges. The levels of working bench marks should be approved by the Engineer. All the bench marks should be tied with the Reference Bench Mark in the area.

VII. Where a station is likely to be disturbed during construction, the Contractor shall check, replace and supplement as necessary station points and agree any revised or additional station details with the engineer and get approval.

VIII. All the line of the carriageway shall be accurately established with pegs and chainage boards set in the right of way as per the design drawing and accurately at an interval of 30 m in plain and rolling terrain and 10 m in hilly terrain respectively and approved by the Engineer. In all curves the beginning of curve, end of curve and apex points shall also be referenced to the satisfaction of engineer and approved.

IX. For hill roads, the valley side top edge of reference pillar shall be at ground level. The top levels of reference pillars should be tied with the level of Bench Mark adopted in the DPR.

X. For hill roads, back cutting line shall be demarcated on the hill face by digging, taking into account the designed slope of hill cutting. Back pillars showing the requisite information should be located at about 1.5 m away (towards hill side) from the back cutting line. Alternatively, back pillars can also be fixed on any permanent existing structures in difficult terrain. Check distance of back cutting line from reference pegs.

XI. The markers/ reference pegs should be maintain after preparing a schedule of reference dimensions until the works reach finished formation level and are accepted by the Engineer.

XII. The existing profile and cross-sections shall be taken jointly by the representative of engineer and the Contractor. These shall form the basis for the measurements and payments.

XIII. The lines and levels of formation, side slope, drainage works, etc. shall be carefully set out and referenced accurately to the satisfaction of engineer. Care shall be taken to ensure that correct gradients and cross-sections are obtained everywhere as per the design drawing.

XIV. Jointly prepare the inventory of Structure required including cross drainages and also the dismantling of the existing structure required.

XV. Prepare the list of the trees to be removed or cut, shifting or removal of the public utilities and private property to be dismantle.

XVI. Prepare the construction drawing as per the collected data recorded during the construction survey which shall be the working drawing for the construction period. The prepared drawing shall follow the same gradient for the longitudinal profile as per the design drawing. Any change in the longitudinal profile shall be agreed by the engineer and approved by him.

XVII. In the opinion of the engineer, design modifications of the lines and/or grade advisable, the engineer shall issue detailed instructions to the Contractor and the Contractor shall perform modifications in the field, as required, and modify the levels on the cross-sections accordingly.

XVIII. The Engineer shall review the working drawings submitted by the contractor as per COC, revise the drawings, if required, approve and issue to the Contractor for the construction purpose.

XIX. Calculate the quantity of items as per the joint survey works and if the quantity exceed than the original quantity as mentioned in BOQ, the joint survey report shall be the basis for the variation.

XX. Wherever necessary, especially after completion of sub-grade, sub-base and base re-establish the line pegs at sufficiently close intervals to determine the edges of base and surfacing accurately.

XXI. The sectional dimensions of the foundations for culverts shall be set out at the bottom of foundation trench as per drawing and checked with reference to original line of reference and axis.

XXII. The Contractor shall provide the engineer with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the Engineer needs to carry out in connection with the contract during the entire period of contract. Such assistance shall include:

- Provision of suitably qualified surveyors to work under the direction of the engineer as required provision of all necessary support for these surveyors including assistant, chainmen, labors, hand tools, pegs and materials.
- Provision of survey equipment (Precision automatic levels, Total station) as required by the engineer for survey works.

XXIII. No separate measurement and/or payment shall be made for the work required under this work. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities

XXIV. Examination and/or approval of the construction drawing or any other documents submitted by the Contractor by the engineer shall not relieve the Contractor of his responsibilities or liabilities under the Contract.

Note:

- *Don't commence work until the initial line is established by marker pegs and cross sections at specified intervals have been approved by the Engineer.*
- *Frequently check the working bench marks as work proceeds.*

3.4 PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

I. Stand for and follow all laws, rules and regulations in force governing pollution and environment and wild life protection, applicable in the area.
II. Get the approval from concerned authorities for obtaining materials from quarries.
III. Safely dispose the cut materials and unused materials at designated dumping site.
IV. Take care to prevent the pollution of natural water source, pools, tanks and reservoirs.
V. The quarry shall be restored as per the contract document.
VI. The contractor must take all reasonable steps to minimize dust nuisance during the construction of works along the haul road and the work site by sprinkling water at a frequency specified by engineer.

3.5 CONSTRUCTION METHOD STATEMENT

Method Statement is a descriptive document that explains execution methods and procedures of individual tasks involved in a construction project, often listed in a project tender. A method statement explains how the work carried out, involvement of labor & other staffs, plant & machinery, time required, and output expected. For more clarity of the description, method statement must contain sketches, small drawings, schemes and flow charts to avoid misconceptions from both client and contractor.

Method Statement is widely used in the construction industry to control identified quality, health and safety risks, time and money. Method statements outline the safe way of performing a specific job or accomplishing a project and ensure that necessary precautions or control measures are communicated to those involved.

Method statements must be clear and should not be too complicated. They should be easy to understand by those who carry out the work and their immediate supervisors to avoid any confusion.

Prior to start of the construction activities at site, the Contractor shall submit to the Engineer for approval, the detailed method statement. The method statement shall be submitted in two parts.

A. General Part

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:

a) Sources of materials like coarse aggregates and fine aggregates, quantity and quality of materials available in different sources.
b) 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.
c) Locations of the site facilities such as batching plant, hot mix plant, crushing plant, etc.
d) Details of facilities available for transportation of men/material and equipment.
e) Information on procedure to be adopted by the Contractor for prevention and mitigation of negative environmental impact due to construction activities.
f) Safety and traffic arrangement during construction.
g) Implementation of activities provided in environment management plan.
h) Any other information required by the Engineer.

B. Special part

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:

a) Details of the personnel both for execution and quality control of the work;
b) Equipment deployment with details of the number of units, capacity, standby arrangement.
c) 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, and products and equipment to be deployed. Wherever required technical literature, design calculations and drawings shall be included in the method statement.

Testing and acceptance procedure including documentation; 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.

Chapter 4. SITE CLEARANCE

4.1 CLEARING AND GRUBBING

I. All the unacceptable materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness and all other objectionable material should be cleared from the roadway by cutting, trimming, removing and disposing of all materials. This should be carried out well in advance of earthwork operations.

II. The contractor should mark the boundaries of the area for clearing and grubbing and seek the approval of the Engineer before the commencement of work.

III. During clearing and grubbing of site, if soil is suitable for re-use then it shall be transported to suitable site and stacked for re-use with the approval from Engineer.

IV. All trees, stumps, etc. that falls within the excavation and embankment lines should be removed to a depth of less than 900 mm below the finished road level and a minimum of 500 mm below the original ground level whichever is lower.

V. The depressions below the ground level arising out of removal of trees, stumps, etc., shall be filled in layers with suitable material and compacted to the specified density as per the specification.

VI. Measurement of trees having girth more than 300 mm should be done as per sizes given in the Bill of Quantities (BOQ). For this purpose, girth shall be measured at a height 1 meter above the ground.

VII. Ant-hills within the roadway shall be excavated to a depth of not less than 750 mm below the finished road level as directed by the Engineer. Cavities/holes in the ground after removal of ant-hills shall be filled with suitable material and properly compacted to the required density as specified.

VIII. The material after cutting tree shall be stocked at suitable locations

IX. All materials that arises from clearing and grubbing operations shall be disposed in suitable disposal site and be covered with soil or gravel as instructed by engineer

4.2 DISMANTLING CULVERTS, BRIDGES, PAVEMENTS AND OTHER STRUCTURES

I. Only those structures designated/approved by the Engineer, or shown on the drawing/BOQ shall be demolished or removed.

II. Existing structures such as bridges, building and other structures within the roadway and proposed for removal should be dismantled carefully so that it shall not cause any damage to the adjacent pavement, structure to be retained and any other adjoining properties and utilities.

III. Holes and depressions caused by dismantling operations or caused by rats etc. shall be backfilled with approved material and compacted to the required density.

IV. All the unsuitable materials obtained after dismantling operation that cannot be used or auctioned shall be disposed to the designated spoil pit.

V. Unless otherwise specified in the design drawing the superstructure portion of the culvert/bridge shall be entirely removed and other parts removed up to at least 600 mm below the sub grade, slope face or original ground level whichever is the lowest or as necessary depending upon the interference they cause to new structure.

VI. Where existing culvert/bridge are to be extended or otherwise incorporated in the new works only such part or parts of the existing structure shall be removed as are necessary and directed by the engineer to provide a proper connection with the new works.

VII. In removing pavements, kerbs, gutters, walls and structures like catch pits, outlets, 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 face perpendicular to the surface of existing structure. Sufficient removal shall be made to provide connections with the new work as directed by the Engineer.

VIII. All pavements, base courses in carriageway and shoulders, etc. designated for removal shall be broken to pieces whose volume shall not exceed 0.02 cubic meters and stockpiled at designated locations if the materials are to be used later or otherwise arrange for disposal.

IX. The connecting edge shall be cut chipped and trimmed to the required line and grade without weakening or damaging any part of the structure to be retained.

X. Pipes in pipe culvert shall be carefully removed in such a manner as to avoid damage to the pipe.

Note:

- *Take appropriate measures to protect soil erosion and water pollution.*
- *Stock the top soil for reuse if found suitable.*
- *Take care of existing poles, fences, signs, monuments, buildings, pipelines, sewers, and trees etc. which do not interfere the work and are to be retained.*

Chapter 5. EARTH WORK AND DRAIN CONSTRUCTION

This chapter covers the works related to the roadway excavation, roadway filling, excavation for foundation, backfilling, excavation for drains, channels, intercepting drains etc.

5.1 ROADWAY AND DRAIN EARTHWORK (EARTHWORK CUTTING)

5.1.1 Methodology

1. Cleaning and grubbing shall be performed as specified in Chapter 4.1
2. Set out the line of excavation after clearance of site to its line, level, slope, grade and cross section as per the drawing by providing reference pillars/pegs for back cutting lines 1.5 m away from edge of formation on both hill and valley side.
3. The top soil shall be stripped to specified depths and stockpiled for reuse if suitable,
4. Excavation shall be done manually or mechanically. After excavation, the sides of excavated area should be trimmed such as to minimize erosion and ponding, allowing drainage of water naturally.
5. Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction
6. When completed, the excavation slopes shall be true to the lines and levels as shown on the drawing or as directed by the Engineer. When completed, no point on 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, no point shall vary more than 300 mm from the designated slope.
7. If water is encountered in excavations due to seepage, springs, or other causes, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, 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.
8. Cross drainage works like scuppers/pipe culverts/small culverts 1 to 2 m span and side drains, shall be so constructed along the formation cutting work, such that there shall least interference with the existing drainage.
9. The sub-grade prepared after cutting the formation should be checked for field density, if the field density of the material in the top 150 mm portion is less than 95 per cent of maximum Proctor density, then the formation material shall be loosened to a depth of 300 mm and compacted in layers (not exceeding 150 mm compacted layers) to 95 per cent of Modified Proctor Density.
10. Cutting should be carried out from top to bottom in hill areas. Special care should also be taken to side slopes and side drains in cutting.

5.1.2 Quality Control Requirements

1. Horizontal Alignment

The horizontal alignment should be reckoned with respect to the center line of the carriageway as shown on the drawings. The edges of the roadway as constructed should be correct within a tolerance limit of (±) 25 mm.

2. Finishing

Any point on the slopes shall not vary from the design slopes by more than 150 mm measured at right angles to the slope (300 mm in case of rock excavation).

3. Surface Levels

The tolerance of surface level for sub-grade will be (+) 0 mm and (–) 25 mm.

4. Surface Regularity

The maximum allowable difference between the sub-grade surface and underside of a 3 m straight edge shall be 20 mm for the longitudinal profile and ±0.5 mm for the cross profile.

5. Quality Control Tests

Subgrade material shall be tested as per tests given in Table 5.4 (B). If the material in the subgrade has a density of less than 95% of maximum dry density (IS:2720 Part 7), the same shall be loosened to a depth of 300 mm and compacted in layers (not exceeding 150 mm compacted layers) to 95% of maximum dry density.

5.2 BLASTING OPERATION

5.2.1 Methodology

For the blasting operations ensure that-

I. All the statutory laws, regulations, rules, etc. pertaining to the acquisition, transport, storage, handling and use of explosives are followed and information describing pertinent blasting method and procedures is furnished by the Contractor prior to starting the work.
II. The magazine for the storage of explosive is built to the designs and specifications of concerned authority as per clause 904 of Standard specification for Road and Bridge Works – DOR 2073
III. No unauthorized person is allowed to enter the magazine.
IV. No match sticks or inflammable material shall be allowed in the magazine store.
V. All explosives are stored in a secure manner and such storage places shall be clearly marked and provided with no smoking, handle with care signs.
VI. The blasting operation shall be carried out with the written approval of engineer in presence of police personal and as per the prior arrangement made with all the authorities concerning national security.

VII. The blasting operations remain in the charge of competent and experienced licenses holder supervisors and workmen who are thoroughly familiar with the details of handling explosives and blasting operations.

VIII. The blasting is carried out during fixed hours of the day, preferably during the mid-day luncheon hour or at the close of the work.

IX. All public utility companies near by the proximity of the site of work are notified sufficiently in advance of the blasting work.

X. During the blasting operation red danger flags are displayed and placed at 200 m away from the blasting site in all directions.

XI. Safety arrangements shall be made sufficiently, including positioning of manpower at proper locations to ensure that all persons including workmen are outside from the flagged area at least 10 minutes before the firing.

XII. A warning siren shall be blown 10 minutes before the firing.

XIII. Blasting should be as light as possible, consistent with thorough breakage of material.

XIV. When blasting is done with powder or dynamite, the procedure outlined in Clause 904 of Standard specification for Road and Bridge Works DOR 2073 shall be followed.

XV. Not more than 10 charges are prepared and fired at a time.

XVI. After blasting operations, all loose residual material below sub-grade is compacted and any material removed from below sub-grade is replaced with suitable material.

XVII. In case of misfire, follow the procedure laid down in clause 904 (5) of Standard specification for Road and Bridge Works DOR 2073

XVIII. Carefully maintain a day-to-day account of the explosives in an approved register. Such account shall be open to inspection at all times.

XIX. Position sufficient guards at proper locations to avoid entrance of persons in the area of influence during the blasting operations.

5.2.2 QUALITY CONTROL REQUIREMENTS

I. All the materials, tools and equipment used for blasting operations shall be approved in advance by the concerned authority.

II. Excavation by blasting shall be to the lines indicated in drawings, with the least disturbance to the adjacent material.

III. The magazine shall have a lightning conductor.

IV. The fuse to be used in wet locations shall be fully water-resistant for at least 30 minutes after immersing in water.

V. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach a safe point before explosion takes place.

VI. Detonators shall be capable of giving effective blasting of the explosives.

VII. The blasting powder, explosives, detonators, fuses, etc. shall be fresh and not damaged due to dampness, moisture or any other reason.

VIII. The charge holes shall be drilled to required depths and at suitable places

5.3 PRE-SPLITTING ROCK SLOPES

5.3.1 Methodology

I. Prepare an operation plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be separated by pre-split blasting. Then the separated portion shall be removed by mass blasting

II. All the overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the blasting limits shall be removed, before commencement of drilling operation of the pre-splitting holes.

III. Make sure that the slope holes for pre-splitting are drilled along the line of the planned slope within the specified tolerances. The drill holes shall be within the range of 60 mm to 70 mm in diameter. No hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-thirds of the planned horizontal spacing between holes. The length of pre-split holes shall not exceed 900 mm on s.

IV. The maximum diameter of explosives used in presplit hole shall not be greater than one-half the diameter of the pre-split hole. Ammonium nitrate composition blasting agents shall not be permitted in pre-splitting operations.

V. Where stemming is required to achieve satisfactory pre-split face, stemming material shall be dry free-running passing 10 mm sieve and 90 percent of which is retained on 2.36 mm sieve. Stemmed pre-split holes shall be completely filled to the collar.

5.3.2 Quality Control Requirements

I. Quality control requirements for rock cutting mentioned in Chapter 5.2 above shall apply.

II. Drilling operations shall be controlled by the use of proper equipment and technique.

III. Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in pre-split holes.

IV. The presplit face shall not deviate by more than 300 mm from the plane passing through adjacent holes.

V. When completed, the average plane of the slope shall conform to the slopes indicated on the drawings and at no point shall the completed slopes vary from the designated slopes by more than 300 mm as measured perpendicular to the plane of the slope.

VI. In no case shall any portion of the slope encroach on the side drains.

5.4 EXCAVATION FOR STRUCTURES

5.4.1 Methodology

I. Set up the line, length and breadth of the structure on the ground with reference pillars 1.5 m away from the line of excavation.

II. Excavation shall be carried out to the length and width of the footing and sides shall be left vertical where the nature of slope permits it. When the nature of slope does not permit vertical sides, adopt necessary shorting, shuttering and planking or cut the slope to a safer angle or both with regards to the safety for men at work.

III. The excavation shall be carried out to the line and dimensions as shown on the design drawing or as instructed by the Engineer.

IV. The depth to which the excavation is to be carried out shall be as shown on the design drawing. Where the blasting is to be carried, the same should be carried out in accordance to Sub Chapter 5.2 of this Manual

V. The bottom of the foundation shall be leveled both longitudinally and transversely. The surface shall be slightly watered and rammed, if the surface is not sufficiently wet before the laying of footing.

VI. At any point, the foundation material is found unsuitable, remove all such material and refill with suitable material and compact thoroughly in layers not exceeding 150 mm.

VII. Where water is encountered during the excavation due to stream flow, seepage, spring, rain or other means adequate measure shall be taken to protect the excavation from coming water by constructing diversion channels, bunds, cofferdams and remove the water-hall be by pumping.

VIII. When rock or other harder strata is encountered during excavation, the base shall be cut to a firm and level or stepped surface or as instructed by the Engineer, The base shall be cleaned and kept free from all soft and loose material. The rock seams shall be cleaned and filled with cement mortar or grout to the satisfaction of Engineer.

IX. The structural works shall be carried out only after approval of the excavated foundation dimension by the engineer.

5.4.2 Quality Control Requirement

I. The inner slope of the foundation shall be maintained as per the design drawing.

II. The bottom part of foundation shall be excavated in box cutting and the minimum depth of the outer edge shall be 800 mm from the existing ground level or as shown in the design drawing.

III. When the excavation is made deeper than the level shown on the drawings, the extra excavated depth shall be filled with concrete or masonry having the same grade as of foundation No ordinary filling by soil shall be allowed in such cases.

5.5 EMBANKMENT CONSTRUCTION

5.5.1 Methodology

1. Clearance of embankment site is carried out as per Chapter-4, Site Clearance.
2. The materials (soil) for embankment are obtained from approved sources. Suitable materials available at nearby road excavation are given the preference or any other excavation sites approved by engineer under the contract. The maximum size of the coarse material in the mixture shall not exceed 75 mm for general earth fill.
3. After clearing the site, setup the boundaries of embankment by fixing batter pegs and marking toe lines on both sides at regular intervals as directed. The embankment shall be built/constructed 300 mm wider on either side of roadway than the specified formation width so that to get proper compaction of the edges and side slopes after trimming the excess width
4. Remove stagnant/pounding water, if any, from the foundation of the embankment.
5. The top soil of the existing ground is stripped to the specified depth not exceeding 150 mm and stored for covering the embankment slope if the available embankment material (soil) is not suitable for plant growth.
6. Foundation for embankment construction after removing the top soil/ unsuitable material, shall be prepared as follows:
   i. For embankment height less than 1.0 m over natural ground, the ground surface should be loosened up to a minimum depth of 150 mm by ploughing or scarifying and compacted to the specified density as per Table 5.3
   ii. For embankment height less than 0.5 m over an existing black-topped or gravel road, the black-topping shall be removed and the pavement/ gravel road should be scarified to a minimum depth of 150 mm. All particles shall be reduced to a maximum size of 75 mm and compacted according to Table.5.3.
   iii. If the granular/ black topped surface lies within 0.50 m - 1 m of the new sub-grade level, the same should be scarified to a depth of at least 50 mm for achieving bond between old and new material.
   iv. If the existing surface is of cement concrete type and lies within 1 m of the new sub-grade level, the same shall be removed completely.
   v. For embankment over ground not capable of supporting equipment, successive loads of embankment materials shall be spread in a uniformly distributed layer of adequate thickness to support the equipment and to construct the lower portion of the embankment.
7. The soil shall be spread over the entire width of the embankment in layers not exceeding 150 mm compacted thickness. The clods shall be broken to less than 75 mm size. Each layer is thoroughly compacted by roller at moisture content within (±) 2 % of the optimum moisture content, to the specified requirements as per Table 5.3 and finished parallel to the final cross-section of the embankment. (Compacted layer thickness can be increased up to 200 mm if heavy vibratory rollers are used and satisfy the result to the engineer).

8. Compaction of soil shall be done at OMC with a tolerance limit of (±) 2 percent. If the moisture content of soil is outside these limits, it shall be made good by adding water or drying by aeration and exposure to sun till the moisture content is acceptable for compaction.
9. Each layer below 500 mm shall be compacted to at least 93 percent of the Modified Proctor Density. The top 500 mm of the embankment constituting the sub grade should be compacted to 95 percent Modified Proctor Density according to Table 5.3.
10. Ensure that longitudinal and cross profiles shall be in conformity with the approved drawings.
11. Approval of the Engineer shall be obtained for each finished layer. Subsequent layers shall be placed only after the finished layer has been tested and accepted by Engineer. (Such an approval would require surface level and compaction control tests).
12. When an existing embankment and/ or sub-grade is to be widened and its slopes are steeper than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, should be cut into the old slope for ensuring adequate bond with the fresh embankment/ sub-grade material to be added.
13. When 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 compacters/ power rammers or any other equipment approved by the Engineer.
14. The filling around culverts and bridges, for forming approaches up to a distance of twice the height of the road from the back of abutment should be done with granular materials and should not be placed until the concrete or masonry has been in position for 14 days. Approval for the sequence of work and equipment should be obtained from the Engineer before taking up the work.
15. The material used for back filling (filling on the back of structures) should free from organic content and having the plasticity index not more than 20 and liquid limit of more than 40. The material shall be filled in layers not exceeding 150mm compacted thickness and compacted to required density as per Table 5.3

5.5.2 Quality Control Requirements

1. Materials

The material used in embankment, sub-grade, shoulders, etc. shall be soil, moorum, gravel, a mixture of these or other material approved by the Engineer. It shall be free from logs, stumps, roots, rubbish, etc.

The following types of material shall be considered unsuitable:

I. Material from swamps, marshes and bogs
II. Peat, log, stump and perishable material; soil classified as OL, OI, OH or Pt as per IS: 1498.
III. Materials susceptible to spontaneous combustion

IV. Material having liquid limit exceeding 40 and plasticity index exceeding 20
V. Material with salts resulting in leaching action e.g. sodic soils (pH > 8.5)
VI. Expansive clay with free swelling index exceeding 50 per cent
VII. Materials in a frozen condition
VIII. Fill materials with a soluble sulphate content exceeding 1.9 gm of sulphate, (expressed as SO3) per liter, if deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementaneous materials forming part of permanent works.
IX. Material with a total sulphate content (expressed as SO3) exceeding 0.5 per cent by mass, if deposited within 500 mm or other distance described in the Contract, of metallic items forming part of permanent works.
X. The size of coarse material shall not ordinarily exceed 75 mm when placed in embankment and sub-grade.
XI. Only the materials satisfying the density requirements given in Table 5.1 should be used for the embankment.

Table 5.1: Minimum Density Requirement for Suitability of Embankment Grade Material

S.No	Type of Work	Max. Laboratory Dry Unit Weight
(A)	Embankment	IS:2720, Part 7
	Height Up to 3 m	Not less than 14.4 KN/m3
	Height More Than 3 m not Subject to Flooding	Not less than 15.2 KN/m3
(B)	Sub-Grade, Earthen Shoulder, Back Filling	Not less than 16.5 KN/m3

2. Horizontal Alignment

The alignment shall be considered with respect to the center line of the carriageway as shown on the drawings. The edges of the roadway as constructed shall be within the following tolerances indicated in Table 5.2.

Table 5.2: Permitted Tolerances for Edges of Carriageway and Roadway

Description	Plain and Rolling Terrain	Hilly Terrain
Edges of carriageway	(±) 25 mm	(±) 25mm

3. Surface Levels

The permitted tolerance in surface level for sub-grade will be +0 mm and (-) 25 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and underside of a 3 m straight edge shall be 20 mm for the longitudinal profile and ±0.5 mm for the cross profile.

5. Degree of Compaction

The embankment shall be compacted to satisfy the density requirements given in Table 5.3.

Table 5.3: Compaction Requirements for Embankment/Sub-Grade/Expansive Clays

Type of work	Relative Compaction as percentage of maximum laboratory dry density
Embankment below 500 mm	Not less than 93 percent of Standard Proctor Density (IS: 2720 Part 7)
Sub-grade (Top 500 mm of embankment and shoulders)	Not less than 95 percent of Standard Proctor Density (IS: 2720 Part 7)
Expansive clays Sub-grade and 500 mm portion just below Remaining portion of Embankment	Not less than 95 percent of Standard Proctor Density Not less than 90 percent of Standard Proctor Density (IS: 2720 Part 7)

6. Quality Control Tests and their Frequency

6.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction and their frequency shall be as given in Table 5.4.

Table 5.4: Quality Control Tests and their Frequency for Borrow Material, Earthwork for Embankment and Subgrade

Type of Test	Frequency
A. Earthwork for Embankment	
1. Soil Classification as per IS:1498 i) Sieve Analysis (IS 2720 Part 1) ii) LL, PL and PI (IS 2720 Part 5)	One test from each source
2. Modified Proctor Compaction Test (IS: 2720 Part 7). Test results to ascertain Dry Density-Moisture Content Relationship.	-do
3. Free Swell Index Test (IS:2720 Part 40).[(a)]	-do
4. Deleterious Content [(b)] (i) Organic matter content by loss-on-Ignition method or as per IS 2720-Part 22	-do
B. Earthwork for Subgrade (Cutting or Filling)	
i) Test 1 to 4, under A above. In case the soil for embankment meets the prescribed requirement for the Subgrade, the above	One test for each source or change of material

Type of Test	Frequency
four tests not be repeated. ii) CBR Test (IS:2720 Part 16) soaked/unsoaked as Specified.	

Notes:

a) Test for free swell index to be conducted only in case of expansive soils.

b) Presence of deleterious content can be initially detected through color, odour and existence of any organic matter. Where such observations justify need for further testing, simple tests at (i) above shall be carried out. Detailed testing as per IS:2720-Part 22 and Part 27 shall be done only after presence of deleterious content is confirmed by simple tests.

6.2 Tests during Construction

The quality control tests to be carried out during construction and their frequency shall be as given in Table 5.5.

Table 5.5: Field Quality Control Tests During Construction of Embankment

S.No	Type of Test	Frequency
1.	Maximum Dry Density/ Optimum Moisture Content:	For each new source and One test for each 1500 m^3
2.	Insitu Density Measurements (IS:2720 Part 28) (Each layer)	-do- (i) One set in each 1000 m^2
3.	Thickness of subgrade layer.	At random

Note:

- *Do not allow borrow pits within a distance equal to the height of the embankment subject to a minimum of 1.5 m from the toe of the road embankment.*
- *The depth of borrow pits should 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 0.30 to 0.50 m.*
- *For widening of existing embankment start earth work from toe line.*

5.6 SUBGRADE CONSTRUCTION

The sub-grade is top 500 mm compacted layer in embankment or cutting just beneath the pavement crust. The sub-grade in embankment is compacted to a higher standard than the lower layers of the embankment. In cutting, the cut formation, which serves as the sub-grade, is treated similarly to achieve the specified density to provide a suitable foundation for the pavement.

5.6.1 Methodology

I. Setting out, dewatering, stripping of top-soil etc. for sub-grade construction shall be the same as for embankment construction described in Sub Chapter 5.5.

II. Ensure that the soil for sub-grade meets the specified requirements in terms of physical properties and the specified CBR value for pavement design.

III. Materials for use in the subgrade shall not contain particles larger than 60 mm. In addition, the material shall have a CBR of not less than 5% measured after a 4-day soak on a laboratory mix compacted to 95% MDD (heavy compaction), a swell of less than 1%, a plasticity index of less than 40% and an organic matter content less than 3%. In-situ material in the subgrade in cutting that does not meet these requirements shall either be spoiled or, if suitable, placed in the embankment. The spoiled material shall be replaced with material meeting the requirements for loose material in the subgrade.

IV. If the sub-grade soil does not possess the requisite engineering properties like highly plastic black cotton soil and other weak soils yielding very low soaked CBR values, the same should be improved in strength (CBR) and workability by replacing suitable material having high CBR value as instructed by the engineer.

V. In fill areas and cutting, compact each layer of the loose materials of embankment or cutting in layers of 150 mm compacted thickness/depth in the sub-grade at OMC (±) 2% to at least 95% of Maximum Dry Density. Each layer shall extend reasonably more than full width of embankment or cutting.

VI. In fill areas and cutting, if the difference between the sub-grade level (top of the sub-grade on which the pavement rests) and ground level is less than 300 mm and the ground does not have the needed 95% relative compaction, loosen the ground up to a level 500 mm below the subgrade level, correct moisture content to OMC (±) 2% and compact in layers of 150 mm depth to 95% of the maximum dry density.

VII. For a road in cutting, prepare the sub-grade in accordance with Sub Chapter 5.1 to receive a sub-base course.

VIII. Ensure that the sub-grade is compacted and finished to the design strength consistent with other physical requirements.

IX. Maintain the surface of sub-grade, at all times during construction, at such a cross fall as will shed water and prevent ponding.

5.6.2 Quality Control Requirements

1. Materials

The material used for sub-grades shall be soil, moorum, gravel, a mixture of these or any other approved material. Material considered unsuitable for embankment construction as per Sub-Chapter 5.5.2 shall not be used for sub-grade.

I. The material for sub-grade shall be non-expansive in nature.

II. Where an expansive clay with acceptable “free swelling index” value is used as a fill material in embankment, the sub-grade and top 500 mm portion of the embankment just below the sub-grade shall be non-expansive in nature.

III. Any fill material which yields a maximum dry laboratory unit weight of less than 16.5 KN/ m^3 shall be considered unsuitable for use in sub-grade.

IV. The size of coarse material in the soil shall ordinarily not exceed 75 mm when placed in the sub-grade.

2. Surface Level

The permissible tolerances in surface levels of sub-grade shall be (+) 0 mm and (-) 25 mm.

3. Surface Regularity

The maximum allowable difference between the sub-grade and underside of a 3 m straight edge shall not exceed 20 mm for longitudinal profile and ±0.5 mm for cross profile.

4. Quality Control Tests

The Quality Control Tests on Earthwork for Sub-grade (in cutting or filling) and their frequency, prior to construction, shall be as per Table 5.4.

The Field Quality Control tests during construction shall be as per Table 5.5.

5.7 CAPPING LAYER

If in-situ material in the subgrade in cutting does not meet the requirements, in-situ materials shall be replaced with selected material from cuttings or borrow pits. Where materials of differing quality are available for placing in the embankments, the Engineer may also instruct that certain materials should be excluded from the subgrade and that certain materials should be set part, or obtained from borrow pits for use in the upper layers.

When materials for subgrade are extracted from borrows to form the capping layers they shall be natural material complying with the following requirements:-

1. Material classification

Materials used for use in capping layers shall be selected among soils classified as GW, GP, GC, SW in the General Classification of Soils

2. Material Requirements

Material for use in the capping layers shall not contain particles larger than 75 mm and their percentage passing by weight the 0.075 mm sieve shall be less than 15%. The material shall have a CBR of not less than 15% measured after a 4-day soak on a laboratory mix compacted to 95 % MDD (heavy compaction), a swell of less than 1%, a plasticity index of less than 12%.

3. Laying and Compaction

The material shall be deposited in the layer of 150 mm compacted depth. Each layer shall extend over the full width of the embankments or cutting and shall be compacted in accordance with the requirements specified in Sub- Chapter 5.6 Subgrade construction.

4. Proof rolling and Tolerances

Proof rolling and tolerances of capping layers shall be in accordance with Sub- Chapter 5.6 for requesting the Engineer's approval and protecting the layer.

5.8 SURFACE DRAIN

5.8.1 Methodology

I. Ensure that the surface drains/roadside ditches are provided strictly according to the Design Drawing.
II. Excavate to the specified lines, grades, levels and dimensions.
III. Remove all excavated material from the area adjoining the drains. If the excavated material is found suitable, utilize in embankment/sub-grade construction, otherwise dispose of the material away from the road site.
IV. Ensure that the excavated bed and sides of the drains are in conformity with the specified dimensions, levels and slopes.
V. Provide proper gradients and fix the invert for quick disposal of water to the outfall.
VI. For any stretch of the rural road passing through a built-up area, ensure that any water coming from the adjacent habitations discharges only into the drain and is not allowed to flow over the road surface.
VII. Any sharp edges, where cut/fill surfaces meet the ground level, should be rounded off to prevent erosion and promote turffing.
VIII. Provide safe outlets to natural or artificial water courses.
IX. Provide catch water/intercepting drains on hill slopes to intercept water from upper reaches, such drains to be provided over stable slopes only, outside any slide or unstable areas.

5.8.2 Quality Control Requirements

1. Materials

a) For, line the drain with random masonry coursed M 7.5 grade of cement sand mortar, should be used
b) For unlined drain turf and variety of grass shall be used for erosion control.
c) The materials used for other types of linings like brick masonry, stone masonry etc. must meet the relevant specifications given in Chapter 9 & 10 respectively.

2. Dimensions

The cross-section and side slopes should conform to the specified dimensions.

Note:

- *Ensure that the gradients are adequate for free flow of water to the outlet without overflowing or pounding or undue siltation.*

- *Do not allow the bottom of roadside ditch/drain to be below the bed of the cross-stream at an outlet and do not provide any catch water/ intercepting drain in any slide area/unstable area.*
- *In high gradient more than 7%, provide scour blocks on the surface of the side drain to reduce the velocity of water flow.*

5.9 SUB-SURFACE DRAIN

5.9.1 Methodology

I. The drains shall be either main or tributary or of other types as shown on the Drawing.
II. Mark the area to be excavated as per the drawing by reference pegs 1.50m away from the cut line.
III. Excavate the trench for sub-soil drain as per the specified lines, grade and dimensions on the design drawings. The sides of the trench shall be as vertical as could be.
IV. The excavation shall started from outlet end of the drain and proceed towards the upper end.
V. If unsuitable material is found at the trench bed, such material shall be removed and refill the trench by suitable material with required compaction.
VI. Before laying the pipe, filter material of the required grading shall be placed on full width of the trench bed in a layer not more than 150 mm thickness (or as shown on the drawings) and compacted to specified density or to the satisfaction of the Engineer. The pipe shall then be firmly embedded on the bed.
VII. 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 Geo-synthetics and approved by the Engineer can also be used
VIII. Perforated pipes, unless otherwise specified, shall be placed with perforated holes facing upwards wrapped with geo-textile in order to minimize clogging. Pipes shall be joined securely with appropriate couplings, fittings or collars.
IX. 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 D85 size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm. D85 stands for the size of the sieve that allows 85 percent of the material to pass through it.
X. Drain pipes shall be provided with holes of minimum 5 mm diameter. The pipes shall be perforated by drilling minimum 50 holes per meter length on the upper half of the pipe in a staggered pattern uniformly distributed. The Engineer might adjust these specifications according to the site conditions.
XI. Jointing of pipes shall be done by fine-cutting and heating following with equipment complying with the prescription of the HDP /HDPE pipe manufacturer. Pipes may be jointed with angles to fit the requirements of the terrain, but angles shall not exceed

the maximum specified by the manufacturer. The joints shall be watertight and develop the same strength as unjointed HDP/HDPE material. The method of jointing shall be approved by the Engineer prior to starting the works.

XII. After completion of the pipe laying, filter material of the required grading as specified shall be placed over the pipe to the required level in layers, each having maximum compacted thickness of 150 mm. The minimum thickness of material above the top of pipe shall be 300 mm.

XIII. 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. The backfill material shall be meet following requirement:

- 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 1 grading set out in-Table 5.8
- 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 5.8
- Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class III grading of Table 5.8

XIV. Outlets of pipes shall be carefully positioned to avoid any possible blockage. For a length of 0.5 m from the outlet end, the trench shall not be filled with filter material. Instead, such section shall be backfilled with excavated soil or sealed with dry stone/ stone masonry depending on the condition of the site. Further, the pipe in this section shall not have any perforations.

XV. The finished slope shall be reshaped to facilitate proper surface drainage towards the drain.

5.10 QUALITY CONTROL REQUIREMENTS

1. Tests Prior to Construction

Table 5.6: Field Quality Control Tests Prior to Construction of Sub Surface Drain

S. No	Material/Work	Test/Check	Frequency
1	Filter Material	Gradation	One test per source
2	PVC Pipe (Perforated)	Diameter of pipe; Manufactures defects	At factory before delivery & Manufacture's Certificate
3	Geotextile	Manufactures defects , Strength, Ultraviolet Stability, Hydraulic Requirements	At factory before delivery & Manufacture's Certificate

2. Tests/Check During Construction

Table 5.7: Field Quality Control Tests During Construction of Sub Surface Drain

S. No	Material/Work	Test/Check	Frequency
1	Bedding	Length, Breadth and thickness of bedding material	While laying
2	Laying and Jointing of pipe	Invert level, Longitudinal gradient Jointing of Pipes	While laying, before back filling
3	Backfilling by filter material	Gradation Filling of trench on both side of pipe	One set of test for every 50 m^3 and part of it After laying the pipe

Table 5.8: Grading for Filter Material

Sieve Size	Class I	Class II	Class III
53 mm			100 mm
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

Chapter 6. SUB-BASES, BASES & SHOULDER

6.1 GRANULAR SUB-BASE

6.1.1 Methodology

I. The material shall be used from approved sources.

II. The material should be natural sand, moorum, gravel, crushed or broken stone, over burnt brick aggregate, or a combination thereof and it shall conform to grading and physical requirements indicated in Table 6.1 and Table 6.2.

III. When the sub-base material consists of a combination of materials from different sources, mixing shall be done mechanically at stock piled yard.

IV. Before laying the sub-base material remove all vegetation and other extraneous material etc. from the sub-grade already prepared, lightly sprinkle with water, if necessary, and roll with two to three passes of 80-100 KN road roller or any other suitable compactor/vibratory roller. Repair/correct any defect on prepared sub-grade prior to laying the sub-base.

V. The sub-base material shall be spread in layers not exceeding 150 mm compacted thickness.

VI. If the thickness of the sub-base is more than 150 mm, successive layer shall be laid after obtaining approval of the Engineer for previous layer. Such an approval would require surface level and compaction control tests.

VII. Each layer shall be uniformly spread and thoroughly compacted as specified.

VIII. Compaction shall be carried out at OMC, with a tolerance limit of (±2) two per cent. If the loose material is dry, as compared to OMC, water should be added by sprinkling and thoroughly mixed for uniform wetting. If water content is higher than the optimum, it should be left exposed to sun and dried till the moisture content is acceptable for compaction. Each layer should be compacted to 95 per cent maximum dry density as per Modified Proctor Test.

IX. Rolling shall be carried out longitudinally commencing from outer edge and progressing towards in straight portion of road. In Curves rolling shall be commence from lower level edge (inner edge) towards upper level edge (outer edge) by moving the roller parallel to the line.

X. The shoulders shall be constructed simultaneously with the sub-base construction.

6.1.2 Quality Control Requirements

1. Materials

The material shall be free from organic matter or other deleterious matter constituents.

A. Grading

The grading for Granular Sub-base (GSB) shall conform to the requirements given in Table 6.1.

Grading I and II are used as sub-base layer and does not perform as drainage layer. Where the sub-base is laid in two layers as upper sub-base and lower sub base, then Grading I and II is used uppers sub base and Grading III and IV is used as lower sub base. Grading V and VI shall be used as sub-base cum drainage layer. Grading to be adopted for project shall be as specified in contract.

Table 6.1: Grading for Granular Sub-Base Materials

Sieve Size As per IS designation(mm)	Percentage passing by weight					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75	100				100	
53	80-100	100	100	100	80-100	100
26.5	55-90	79-90	55-75	50-80	55-90	75-100
9.5	35-65	50-80			35-65	55-75
4.75	25-55	40-65	10-30	15-35	25-50	30-55
2.36	20-40	30-50			10-20	10-25
0.85					2-10	
0.425	10-15	10-15			0-5	0-8
0.075	<5	<5	<5	<5		0-3

B. Physical Requirements

The physical requirements for Granular Sub-base (GSB) shall conform to the requirements given in Table 6.2.

Table 6.2: Physical Requirement for Material for Granular Sub-base

Physical Properties	Test Method	Requirement for Class I and II, V and VI	Requirement for Class III and IV and maintenance of work
Aggregate Impact Value	IS 2386-4 or IS 5640	Maximum 40	Maximum 45
Liquid Limit	IS 2720-5	Maximum 25	Maximum 25
Plasticity Index	IS 2720-5	Maximum 6	Maximum 6
CBR at 95% density (at IS 2070- part 8)	IS 2720-5	Minimum 30 unless specified in contract	Minimum 25 unless specified in Contract

2. Horizontal Alignment

The edges of the sub-base shall be correct within a tolerance limit of (±) 25 mm.

3. Surface Levels

The tolerance in surface level for granular sub-base will be restricted to ± 15 mm. A grid of 10 m by 2.5 m may be formed to check the surface level. The cross profile should conform to the required camber.

The average thickness of any sub-base layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness.

4. Surface Regularity

The maximum permitted difference between the sub-base and 3 m straight edge shall be 15 mm for longitudinal profile and ± 0.50 mm for cross profile. The cross profile should conform to the required camber.

5. Degree of Compaction

Density shall be 95 per cent of maximum dry density for the material determined as per modified proctor density test (IS: 2720 part 8)

6. Quality Control Tests

6.1. Tests Prior to Construction.

Table 6.3: Quality Control Tests Prior to Construction of Granular Subbase

S.No	Type of Test	Frequency
1.	Soil Classification i) Sieve Analysis, except for cohesion less soils ii) Liquid and Plastic Limits iii) Flakiness Index	One test on the material from each source or on the combined material, as the case may be.
2.	Combined Grading and Plasticity tests on materials from different sources, mixed in the design proportions. This shall be done when materials from more than one source are combined.	One test on the material from each source or on the combined material, as the case may be.
3.	Modified Proctor Compaction Test MDD & OMC (IS:2720 Part 8)	One test on the material from each source or on the combined material, as the case may be.
4.	Aggregate Impact Value Test where soft/marginal aggregates are used (IS:5640)	One test from each source identified by the Contractor.
5.	CBR test on representative sample(IS:2720 Part 16)	One test. (Average of a set of three compacted at 95% Proctor dry density. specimens).

6.2. Tests During Construction

The field quality control tests during construction are indicated in Table 6.4.

Table 6.4: Quality Control Tests During Construction of Granular Subbase

S.No	Type of Test	Frequency
1	Sieve Analysis on the GSB material combined in the design proportions from various sources.	Once per 400 m^3 or part of it and change of source (new source)
2	Liquid and Plastic Limit tests	-do-
3	MDD, OMC	Once per 1000 m^3 or part of it and change of source.
4	Field Density	Once per 1000 m^2 of each layer
5	Thickness of Compacted layer at interval of Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

Notes:

- *Do not permit organic or other deleterious materials, and do not use materials which do not conform to the specified requirements.*
- *Do not allow rejected material to remain at site to prevent its reuse. The rejected material shall be marked with lime.*

6.2 WATER BOUND MACADAM SUB-BASE/BASECOURSE/WEARING COURSE

6.2.1 Methodology

I. Prepare the surface on which the WBM course is laid to the lines, grade and cross fall. It should be made free of dust and extraneous material. Large irregularities, where predominant should be made good by providing profile corrective course.

II. If the WBM is laid over a fine grained soil sub-grade, a layer of 25 mm thick intervening layer of course of screenings (Table 6.7) shall be spread on the prepared sub-grade before laying of course aggregates.

III. Any existing bituminous surface over which WBM is to be laid shall be completely removed before laying WBM layer.

IV. The coarse aggregate should meet the physical and grading requirements laid down in Table 6.5 and Table 6.6. Coarse aggregate can be crushed or broken stone, crushed slag, over burnt brick aggregate, kankar, laterite meeting the prescribed requirements.

V. The spreading of coarse aggregate shall be done from stockpiles along the side of the roadway or directly from vehicles. The aggregate shall not be dumped in heaps directly on the surface prepared for laying the aggregates nor shall hauling over un-compacted or partially compacted base be permitted.

VI. The coarse aggregate shall be spread uniformly on the prepared sub-grade, sub-base or base, as the case may be, to proper profile (by using templates placed across at 6.0 m intervals) in such quantities that would give the required compacted thickness. The thickness of compacted layer should be 75 mm. The surface should be checked with templates and all high or low spots remedied.

VII. Roll the surface with suitable road rollers till aggregates are partially compacted with sufficient void space left for application of screenings. However, where screenings are not to be applied as in the case of crushed aggregates, compaction shall be continued until the aggregates are thoroughly keyed. If necessary, water shall be sprinkled slightly during rolling.

VIII. Rolling shall proceed from inner edge to outer edge at the super-elevated portions and from the edges towards in the other portions. The edge should be first compacted with roller running forward and backward.

IX. Check the rolled surface transversely and longitudinally with templates/ straight edge. Correct their regularities if any by loosening the surface, adding or removing the needed amount of aggregates and re-rolling until the entire surface conforms to the specified camber/ cross fall and grade.

X. After rolling the course aggregate, apply screenings to completely fill the interstices maintaining a slow and uniform rate, in three or more applications. The screenings should not be damp at the time of application.

XI. Do not apply screenings as fast and thick as to form cakes or ridges on the surface.

XII. Continue dry rolling and brooming till no more screenings can be forced into the voids of coarse aggregates.

XIII. Sprinkle water on the surface taking care that the underlying layer is not damaged.

XIV. Sprinkling, sweeping and rolling should continue till aggregates are thoroughly keyed, well bonded and firmly set in its full depth and a grout has been formed of screenings.

XV. If it is necessary to add binding material (PI between 4 and 6) after application of screenings. The binding material should be applied in two or more layers at a slow and uniform rate. Generally, the quantity required for 10 m^2 of 75 mm thickness of WBM is 0.06 to 0.09 m^3.

XVI. The process of water sprinkling, sweeping and rolling should continue till the resulting slurry forms a wave ahead of roller.

XVII. The compacted WBM course should be allowed to completely dry and set before the next pavement course is laid or traffic is allowed.

XVIII. The shoulders should be constructed simultaneously with the WBM construction in accordance with Sub- Chapter 6.3.

XIX. The finished surface of WBM should conform to the prescribed tolerances given in Sub-chapter 6.2.2. Where the surface irregularity exceeds the tolerances, the WBM layer should be scarified to its full depth over the affected area and corrected by adding or removing and replacing with fresh material.

6.2.2 Quality Control Requirements

1. Materials

(i) Coarse Aggregate

(a) Physical requirements

Physical requirements of coarse aggregate for water bound macadam for sub-base, base and wearing course should conform to the requirements given in Table 6.5. If the water absorption of aggregate is greater than 2 per cent, Soundness test should be carried out.

Table 6.5: Physical Requirements of Coarse Aggregates for WBM

Test	Sub-base	Base	Wearing course
Aggregate Impact value or Los Angeles Abrasion value	Less than 40 Less than 45	Less than 30 Less than 40	Less than 30
Combined Flakiness and elongation index	Less than 35	Less than 35	Less than 35
LL	< 20	<20	

Test	Sub-base	Base	Wearing course
PI	<6	NP	NP
Soundness	< 12%	< 12%	< 12%
CBR	>30	>80	

Aggregates like brick bats, kankar, laterite etc. which get softened in presence of water shall be tested for Aggregate Impact Value under wet conditions in accordance with IS: 5640.

(b) Grading:

The coarse aggregates should conform to the grading specified in the Contract and meet the requirements given in Table 6.6.

Table 6.6: Grading Requirements of Coarse Aggregate for WBM

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
I	63 mm to 45 mm	75 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
II	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65- 90 0-10 0-5

(ii) Screenings

The use of screenings shall be omitted in the case of soft aggregates like brick metal, kankar, laterite etc.

(a) Physical Requirements

Screenings should normally consist of same material as the coarse aggregate. However, where economic considerations so warrant, non-plastic material such as moorum or gravel with LL less than 20 and PI less than 6 may be used. Fraction passing 75 micron should not exceed 10 percent.

(b) Grading

The screening shall conform to the grading specified in Table 6.7

Table 6.7: Grading for Screenings for WBM

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

(iii) Binding Material

Application of binding material may not be necessary when the screenings used are of crushable type. Binding material if used as a filler material shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) of value 4- 6 in accordance with IS: 2720 part 5. The quantity of binding material will depend upon the type of screenings. For estimation of quantities, the following may be adopted: Quantity for 75 mm compacted thickness WBM 0.06 – 0.09 m^3 / 10 m^2.

2. Horizontal Alignment

The edge of carriageway with WBM surfacing shall be correct within a tolerance limit of (±) 25 mm.

3. Surface Level

The tolerance in surface levels of the WBM would be as under:

(a) Sub-base course (±) 15mm,

(b) Base course (±) 10 mm

(c) Surfacing Course (±) 10 mm

(A grid of 10 m by 2.5 m may be formed to check the surface levels).

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum allowable difference between the road surface and 3 m straight edge shall be as per Table 6.8.

Table 6.8: Maximum Permitted Undulations Measured with 3 M Straight Edge to WBM

Type of Construction	Maximum permissible difference	
	Longitudinal Profile	Cross Profile
WBM	10 mm	±0.5 mm

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 6.9.

Table 6.9: Quality Control Tests Prior to Construction of WBM

Type of Test	Frequency
1. Aggregate Impact Value Test (IS:2386 Part4) for base 30 max, Sub base 40 max	One test from each identified source.
2. LAA for base 40 max, Sub base 45 max	-do-
3. Aggregate Water Absorption (IS:2386 Part3): max 2%	-do-
4. Soundness Test of Aggregates (where water absorption, as at 2 above, exceeds 2%) (IS:2386 Part5)	-do-
5. Grading, LL and PI of Crushable Screenings (IS: 2720 Part5)(where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed).	-do-
6. LL and PI of the Binding Material, when used LL max 20 , PI less than 6	. -do-
7. MDD, OMC, CBR	. -do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 6.10.

Table 6.10: Quality Control Tests During Construction of WBM

Type of Test	Frequency
1. Grading of Stone Aggregates and Screenings (IS:2386 Part1)	Once per 400 m^3 or part of it and change of source.
2. Flakiness Index of Stone Aggregates (IS:2386 Part1)	-do-
3. PI of Crushable Screenings/binding material (IS:2386 Part5)	-do-
4. Aggregate impact value (IS:2386 Part4)	-do-
5. MDD; OMC (IS:2720 Part 8) CBR (IS:2720 Part 16)	Once per 1000 m^3 or part of it and change of source.

Type of Test	Frequency
6. Field Density (IS:2720 Part 28)	Once per 1000 m^2 of each layer
7. Thickness of Compacted layer	20 m
Surface Level	20 m
Width	200 m
Smoothness	40 m^2

6.3 SHOULDER CONSTRUCTION

6.3.1 Methodology

I. The construction of shoulders (whether paved or granular material/gravel or earth with brick or stone block edging) on either side of the road pavement, should be in conformity with the specified lines, grades and cross-sections.

II. The shoulders with specified dimensions should be constructed in layers, each layer matching the thickness of adjoining pavement layer. Shoulders shall be constructed concurrently with construction of adjacent pavement layers and with the same materials. Contractor shall ensure that the method of construction is such that at no time water gets prevented from draining off the pavement layers.

III. After a pavement layer and the corresponding layers in hard and earth shoulder portion have been laid and compacted, the construction of next pavement layer and shoulder should be taken up.

IV. The adjacent layers having same material should be laid and compacted together. However, where the materials in adjacent layers are different, these should be laid together, but the pavement layer should be compacted first.

V. Where hard/gravel shoulders have to be provided alongside the existing carriageway, the existing shoulders should be excavated in full width and to the required depth to ensure proper compaction.

VI. Paved shoulder shall consist of sub-base, base and wearing course as per drawing and material shall conform to relevant specification.

VII. For earth shoulders with brick/stone/concrete edging, the bricks/stone /concrete blocks should be laid on edge, with the length parallel to the transverse direction of the road. These should be laid on a bed of 25 mm sand, set carefully, rolled into position by a light roller/hand compaction and made flush with the finished pavement level.

VIII. Earth/gravel shoulder should be compacted to at least 95 per cent of maximum dry density.

IX. In order to shed off surface water, the required cross-fall should be maintained during all stages of construction. Normally cross-fall on shoulder should be 1 per cent higher than the camber on the main carriageway.

6.3.2 Quality Control Requirements

1. Materials

I. The shoulder material should be selected earth with maximum laboratory dry unit weight not less 16.5 kN/$m^3$and LL and PI not to exceed 50 and 25 respectively or granular material quarry waste conforming to the requirements of GSB as per Sub- Chapter 6.1.

II. For earth shoulders with brick or stone block edging, the bricks should conform to Sub-Chapter 9 and should be of size 225 mm x 110 mm x 75 mm. The stone blocks should conform to Sub- Chapter 10.

2. Horizontal Alignment

The edges of the shoulders should be correct within a tolerance limit of (±) 25 mm.

3. Surface Levels

The tolerance in surface levels of the shoulders should be (±) 10 mm. A grid of 10 m x 2.5 m may be formed to check the surface level.

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum permitted difference between the shoulder and 3 m straight edge will be 10 mm for longitudinal profile and ±0.5 mm for cross profile.

5. Quality Control Tests

The quality control tests and their frequency for earth/hard shoulders should be exercised in accordance with the requirement of the following Chapters:

Earth Shoulders	-	Sub- Chapter 5.5 and 5.6
Granular/ Hard Shoulders	-	Sub- Chapter 6.1
Paved Shoulder	-	Chapter 7
Brick Edging	-	Chapter 9
Stone Edging	-	Chapter 10

Note:

- *Construct shoulders simultaneously with the pavement layers such that each layer of the shoulder matches the thickness of adjoining pavement layer*
- *Do not compact the shoulder layer before the compaction of the adjoining pavement layer.*

- *The material for earth shoulders should be good quality, ordinarily not inferior to the subgrade material.*

6.4 CRUSHER RUN MACADAM SUB BASE

6.4.1 Methodology

I. Prepare the existing surface (sub grade) on which the crushed sub-base is to be laid to the specified lines, grade and cross-section. All ruts, deformations and soft spots should be repaired and the surface compacted to the required density before placing the aggregate sub-base thereon.

II. The aggregate should be uniformly deposited on the prepared surface and spread over the surface covering full width of carriageway to the specified depth.

III. After spreading of materials, the material shall be blade mixed to full depth by alternately blading the entire layer to center and back to the edge of the road. Then grading shall be done to the specified lines, grade and cross-section by means of a motor grader.

IV. Water shall be applied to moisten the material sufficiently prior to and during mixing and processing operations so as to prevent segregation of the fine and coarse particles and assist compaction.

V. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 KN or vibratory roller. The roller must follow close up behind the grader, but only on the section where grading is completed. The rolling shall be started from the edge to center at straights and from lower end to higher end on curves. The speed of the roller shall not exceed 5 Km/hr.

VI. The compacted thickness of any layer laid, processed and compacted at a time should not be more than 150 mm, where a greater thickness is required the graded crushed stone shall be laid in two or more layers. Compaction is done until at least 98% of MDD is achieved for each layer.

VII. Successive layers shall be laid only after the approval of the previous layer by the engineer. The approval shall be of level and compaction of such layer. For a compacted single layer upto 200 mm, the compaction shall be done with help of vibrating roller.

VIII. The hole made for field density tests shall be covered with M15 concrete with required compaction.

6.4.2 Quality Control Requirements

1. Materials

The material shall be crushed rock. The aggregate shall conform to the physical requirements and grading indicated in Tables 6.11 and 6.12.

Table 6.11: Physical Requirements of Aggregates for CRM Sub-base

Test	Value
1. LAA (IS:2386 Part4)	40 max
2. Aggregate Impact Value (IS:2386 Part4)	30 max
3. SSS % (IS 2720 Part 27) if water absorption exceed 2%	12 max
4. Combined Flakiness and Elongation Index (IS 2386 Part1)	35 max
5. Water Absorption*% (IS:2386 Part3)	2 max
6. CBR % (IS:2720 Part 16)	80 min
7. CR %	90 min
8. Plasticity Index of material passing 425 micron Maximum(IS:2720 Part 5)	6 max

Table 6.12: Aggregate Grading Requirements for CRM Sub-base

IS Sieve Designation (mm)	Percentage passing by weight 53 mm nominal size
63.0	100
45.0	87 - 100
22.4	50 – 85
5.6	25 – 45
0.71	10- 25
0.09	2 – 5

2. Horizontal Alignment

The edges of CRM sub-base will be correct within the tolerance of (±) 25 mm.

3. Surface Level

The tolerance in surface levels of crusher run macadam sub-base shall be (±) 10 mm.

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 6 mm for longitudinal profile and ± 0.25 mm for cross profile respectively.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality Control tests for Crusher Run Macadam sub-base prior to construction shall be as per Table 6.13

Table 6.13: Quality Control Tests Prior to Construction of CRM Sub Base

Type of Tests	Frequency
Aggregate Impact Value Test, (IS:2386 Part4) Loss Angles Abrasion value (IS:2386 Part4)	One test on representative sample from each source identified
Flakiness Index Test (IS:2386 Part1)	-do-
Water Absorption Test	-do-
Soundness Test, if the water absorption exceeds 2% (IS:2386 Part5)	-do-
Grading Test (IS:2720 Part4)	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Proctor Compaction Test (MDD, OMC)	-do-
CBR	-do-
Crushing Ratio (CR) Test	-do-

5.2 Tests During Construction

The quality Control tests for Crushed stone Macadam Sub-base prior to construction shall be as per Table 6.14

Table 6.14: Quality Control Tests During Construction of CRM Sub-base

Type of Tests	Frequency
Aggregate Impact Value Test	Once per 200 m^3 or part of it and change of source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Crushing Ratio (CR) Test	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Soundness Test, if the water absorption exceeds 2%	Once per 500 m^3 or part of it and change of source
CBR	As required
Proctor Compaction Test (MDD, OMC)	Once per 1000 m^3 or part of it and change of source

Type of Tests	Frequency
Field Density test	Once per 1000 m^2 or part of it and change of source
Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

Note

- *Ensure that the quantity of water applied is sufficient to prevent segregation of the fine and coarse articles and to achieve the requisite compaction with maximum dry density.*
- *Use templates at about 6 m apart to check surface to profile.*

6.5 CRUSHER RUN MACADAM BASE

6.5.1 Methodology

I. Prepare the existing surface (sub base) on which the improved base is to be laid to the specified lines, grade and cross-section. All ruts, deformations and soft spots should be repaired and the surface compacted to the required density before placing the aggregate base thereon.

II. The aggregate should be uniformly deposited on the prepared surface and spread over the surface covering full width of carriageway to the specified depth.

III. After spreading of materials, the material shall be blade mixed to full depth by alternately blading the entire layer to center and back to the edge of the road. Then grading shall be done to the specified lines, grade and cross-section by means of a motor grader.

IV. Water shall be applied to moisten the material sufficiently prior to and during mixing and processing operations so as to prevent segregation of the fine and coarse particles and assist compaction.

V. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 KN or vibratory roller. The roller must follow close up behind the grader, but only on the section where grading is completed. The rolling shall be started from the edge to center at straights and from lower end to higher end on curves. The speed of the roller shall not exceed 5 Km/hr.

VI. The compacted thickness of any layer laid, processed and compacted at a time should not be more than 150 mm, where a greater thickness is required the graded crushed stone shall be laid in two or more layers. Compaction is done until at least 98% of MDD is achieved for each layer.

VII. Successive layers shall be laid only after the approval of the previous layer by the engineer. The approval shall be of level and compaction of such layer. For a compacted single layer upto 200 mm, the compaction shall be done with help of vibrating roller.

VIII. The hole made for field density tests shall be covered with M15 concrete with required compaction.

6.5.2 Quality Control Requirements

1. Materials

The aggregate shall conform to the physical requirements and grading indicated in Table 6.15 and 6.16.

Table 6.15: Physical Requirements of Aggregates for CRM Base

Test	**Value**
1. LAA (IS:2386 Part4)	40 max
2. Aggregate Impact Value (IS:2386 Part4)	30 max
3. SSS % (IS 2720 Part 27) if water absorption exceed 2%	12 max
4. Combined Flakiness and Elongation Index (IS 2386 Part1)	35 max
5. Water Absorption*% (IS:2386 Part3)	2 max
6. CBR % (IS:2720 Part 16)	80 min
7. CR %	90 min
8. Plasticity Index of material passing 425 micron Maximum(IS:2720 Part 5)	6 max

**If the water absorption is more than 2 percent, the Soundness test should be carried out as per IS: 2386 (Part 5)*

Table 6.16: Aggregate Grading Requirements for CRM Base

IS Sieve Designation (mm)	**% passing by wt.** **37.5 mm nominal size**
45	100
22.4	90-100
5.6	35-55
0.71	10-30
0.09	2-5

2. Horizontal Alignment

The edges of CRM Base will be correct within the tolerance of (±) 25 mm.

3. Surface Level

The tolerance in surface levels of crusher run base shall be (±) 10 mm.

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 6 mm for longitudinal profile and ± 0.25 mm for cross profile respectively.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality Control tests for Crusher Run Base prior to construction shall be as per Table 6.17.

Table 6.17: Quality Control Tests Prior to Construction of CRM Base

Type of Tests	Frequency
Aggregate Impact Value Test	One to two tests on representative sample from each source identified
LAA	-do-
Combined Flakiness and elongation Index Test	-do-
Water Absorption Test	-do-
Soundness Test, if the water absorption exceeds 2%	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
.Proctor Compaction Test (MDD, OMC)	-do-
CBR	-do-
Crushing Ratio (CR) Test	-do-

5.2 Tests During Construction

The quality Control tests for Crusher Run Base prior to construction shall be as per Table 6.18

Table 6.18: Quality Control Tests During Construction of CRM Base

Type of Tests	Frequency
Aggregate Impact Value Test	Once per 200 m^3 or part of it and change of source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Crushing Ratio (CR) Test	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Soundness Test, if the water absorption exceeds 2%	Once per 500 m^3 or part of it and change of source
CBR	As required
Proctor Compaction Test (MDD, OMC)	Once per 1000 m^3 or part of it and change of source
Field Density test	Once per 1000 m^2 or part of it and change of source
Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

6.6 WET MIX MACADAM BASE AND SUBBASE

This covers procuring, furnishing and placing of approved crushed graded aggregate and granular material, premixed with water on top of the complete subgrade or subbase and constructing a subbase or base, as the case may be, in accordance with the requirement of this Specification.

6.6.1 Methodology

I. Prepare the existing surface on which the improved base is to be laid to the specified lines, grade and cross-section.

II. The crushing, screening and proportioning of materials and their subsequent mixing shall be carried out using methods machines or Batching plant acceptable to the Engineer. To avoid segregation, graded crushed stone shall be moistened when being handled and shall not be stockpiled in heaps higher than 5m. Unless otherwise instructed, crushing shall be carried out at least in two stages.

III. The mixed material shall be transported and dumped in such a way that no segregation occurs.

IV. After spreading of materials, the grading shall be done to the specified lines, grade and cross-section by means of a motor grader.

V. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 KN or vibratory roller. The roller must follow close up behind the grader, but only on the section where grading is completed. The rolling shall be started from the edge to center at straights and from lower end to higher end on curves. The speed of the roller shall not exceed 5 Km/hr.

VI. The moisture content shall be adjusted as necessary and, during compaction, care shall be taken to maintain the moisture content evenly at the specified value. Unless otherwise instructed by the Engineer, the moisture content at the time of compaction shall be between 95 and 100% of the Optimum Moisture Content determined as per IS: 2720.

VII. The compacted thickness of any layer laid, processed and compacted at a time should not be more than 150 mm, where a greater thickness is required the graded crushed stone shall be laid in two or more layers.

VIII. Compaction is done until at least 98% of MDD is achieved for each layer for base and 95% of MDD for sub-base.

IX. Successive layers shall be laid only after the approval of the previous layer by the engineer. The approval shall be of level and compaction of such layer. For a compacted single layer upto 200 mm, the compaction shall be done with help of vibrating roller.

X. The compacted thickness of any base layer shall not be less than 3 times the maximum size of the graded crushed stone and the compacted thickness of any subbase layer shall not be less than 2 times the maximum size of the graded crushed stone.

XI. On completion of the compaction the surface shall be well closed, mechanically stable, free from visible movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material.

XII. After final compaction of wet mix macadam course, the road shall be allow to dry for 24 hours. No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

XIII. The hole made for field density tests shall be covered with M15 concrete with required compaction.

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

6.6.2 Quality Control Requirements

1. Material

The aggregate shall conform to the physical requirements and grading indicated in Table 6.19 and 6.20.

Table 6.19: Physical Requirement of Materials for Wet mix macadam subbase/base

Physical Properties	Test Method	Requirement for class I & II (Max %)		Requirement for class III, IV (max %)	
		Base (B1)	Sub base (S1)	Base (B2)	Sub base (S2)
Los Angeles Abrasion value (LAA) or Aggregate Impact Value (AIV)	IS: 2386-4 IS: 5640	40 30	45 35	40	45
Combined Flakiness and Elongation index (Total)	IS: 2386-1	35			

B1, B2, S1 and S2 are classes of materials.

Table 6.20: Grading Envelopes for Wet Mix Macadam

Sieve Size	Percentage Passing by Weight		
(mm)	Base	Sub base	
		S1*	S2*
53	100	100	100
45	95-100	75-100	85-100
26.5		42-75	75-95
22.4	60-80	25-60	60-87
11.2	40-60	15-45	50-80
4.75	25-40	12-37	12-32
2.36	15-30	6-25	7-21
0.60	8-22	5-21	6-17
0.075	0-5	3-12	3-10

**S1and S2 are classes of subbase*

2. Horizontal Alignment

The edges of base, sub base will be correct within the tolerance of (±) 25 mm.

3. Surface Level

The tolerance in surface levels shall be (±) 10 mm.

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 6 mm for longitudinal profile and ± 0.25 mm for cross profile respectively.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality Control tests for materials prior to construction shall be as per Table 6.17.

5.2 Tests during Construction

The quality Control tests during construction shall be as per Table 6.18.

Chapter 7. BITUMINOUS COURSES

7.1 PREPARATION OF BASE FOR BITUMINOUS COURSE

This Subchapter deals with preparing an existing granular (WBM) or black-topped surface to specified lines, grades and cross-sections prior to laying a bituminous course.

7.1.1 Methodology

1. Preparing an existing granular surface

I. All loose and extraneous materials should be removed and surface shall be cleaned where a granular profile corrective course is to be provided prior to laying a bituminous course; the existing granular surface after cleaning should be loosened to a depth of 50-75 mm and slightly watered and the granular course laid with required compaction.

II. The surface of all granular layers on which a bituminous course is to be laid should be cleaned of all loose material and dust by air jet or wire brushes or other approved means and should be correct to line, level and camber within the tolerances specified for base course. Prior to laying the bituminous course the existing surface shall be approved by the engineer for line, level and density.

III. Where a profile corrective course of bituminous material is to be laid, the granular surface after removal of all loose material and dust should be primed with a suitable bituminous primer as per Sub- Chapter 7.2 and a tack coat as per Sub- Chapter 7.3.

2. Scarifying an existing bituminous surface

I. Where an existing bituminous layer is required to be removed, it should be done without causing undue disturbance to the underlying layers. Any underlying material which may have been disturbed should be loosened to a depth of 50 – 75 mm and removed from road bed and screened for used in renewal course by adding supplementary fresh base material if necessary and compact to line and level.

II. The compacted granular surface, finished to line, level and cross-slope should be primed as per specified procedure after getting approval from the engineer for the existing surface.

3. Preparing an existing bituminous surface

The surface shall be cleaned and any pot holes and cracks should be repaired before laying bituminous treatment as described below:

(a) Pothole and Patch Repairs

I. The existing bituminous surface should be inspected and all pothole and patch areas should be marked and measured the area to be repaired. The edges of all potholes shall be cut / trimmed with hand tools vertically to form rectangular shape and shall be thoroughly cleaned with wire brush, compressed air or other approved means. All dust, loose and defective materials should be removed from site. Layers below the level of bituminous

construction should be replaced using material of equivalent specification to the original construction and degree of compaction. The area of bituminous construction should be primed and/or tacked with an emulsion/ bitumen cut-back meeting specified requirements depending on whether the lower area is granular or bituminous in nature.

II. The bituminous patching material should be either a hot mix or a cold mix, adopting the respective specification. The bituminous mixture, prepared in a plant of suitable capacity should be placed in layers of not more than 100 mm (loose) and compacted in layers with roller/plate compactor/hand roller/rammer to the desired compaction standard.

III. In the final layer, the mix should be spread slightly above the adjoining surface so that after rolling, the surface shall be flush with the adjoining surface.

IV. Where required, a Seal Coat should be applied as per the specified procedure. The surface levels should be checked using a 3 m straight edge.

(b) Crack Sealing

I. The fine cracks (less than 3 mm in width) should be sealed by Fog Spray, which is a very light application of low viscosity Slow Setting Emulsion. Prior to this treatment, it is important that the surface is thoroughly cleaned, preferably with compressed air. The Fog Spray should be applied at a rate of 0.5-1.0 liter/$m^2$of the specified emulsion, using an approved hand-held sprayer. For sites in sub-zero temperatures, Medium Curing Cutback as per IS 217 can be used.

II. The wide cracks (more than 3 mm in width) should be filled with crusher dust or approved course sand passing 4.75 mm IS sieve to a level about 5 mm below the road surface level. After sweeping the surface clear of dust, prior to the application of binder or premix. Binder shall be poured into the cracks with minimum spillage. Dust shall be applied to the excess bitumen on the road surface until it is blotted up.

III. Isolated areas, with wide cracks, shall be cut and patched as per Sub- Chapter 7.1.1 patch repair.

4. Profile Corrective Course

i. Where specified, a profile corrective course should be provided to thickness as per design drawing.

ii. After preparing the surface as explained above, the profile corrective course with the specified material should be laid and compacted to the requirements of the particular specification.

iii. Any high spot in the existing black top surface shall be removed to the satisfactory of the engineer.

iv. A tack coat as per Sub- Chapter 7.3 should be applied over a primed granular surface or an existing bituminous surface prior to laying the bituminous profile corrective course.

v. The maximum thickness of the profile corrective course will not be more than 40 mm the profile corrective course shall be constructed as an integral part of overlay course. In other case the profile corrective course shall be constructed as separate layer adopting appropriate construction procedure and equipment approved by the engineer.

vi. The profile corrective course shall be laid to the tolerance and densities as specified for wearing course.

7.1.2 Quality Control Requirements

1. Material

I. Crusher stone dust for crack filling or course sand should be a material, passing 4.75 mm sieve.

II. The bituminous mixture to be used for patching should be either a hot mix or cold mix in accordance with appropriate specifications.

III. The material for profile corrective course should meet relevant specifications.

IV. The binder for prime coat and crack filling should be a Medium Curing (MC) Cutback conforming to IS: 217 can be used. Prime coat should be applied as per Sub- Chapter 7.2.

V. The binder for tack coat and its application should be as per Sub- Chapter 7.3.

2. Tolerance

The prepared surface should comply with the permitted tolerances in respect of horizontal alignment, surface levels and surface regularity specified for base course.

- Horizontal Alignment Edges of the pavement layer (±) 25 mm
- Surface levels:
  - Granular Surface (±) 10 mm
  - Bituminous Surface (±) 10 mm
- Surface Regularity
  - Granular/Bituminous Surface
  - Longitudinal Profile 6 mm
  - Transverse Profile ± 0.25 mm

7.2 PRIME COAT

A prime coat means a thin layer of low viscosity bituminous binder applied to an absorbent non-bituminous surface. If the prime coat is to be trafficked, it shall be covered with blinding material.

7.2.1 Methodology

A. Preparation of Surface

I. The prime coat should be applied only on the top most granular base layer, over which bituminous treatment is to be applied. The granular base surface should be cleaned by sweeping with mechanical brooms and/or washing or other approved means and all laitance of soil or binder material, loose and foreign material shall be removed.

II. The surface to be sprayed shall be checked for line, camber and level, and the surface corrected if any, made good as necessary and approved by the Engineer before bituminous spray is applied

III. In order to bring the surface to be primed to the condition required, water shall be applied in small increments by a water distributor to damp the surface but in no case the surface shall be made saturated. If water applied is more, the surface shall be allowed to dry until dampness is uniform over entire surface. Any water on the surface after spraying shall be allowed to drain away before the prime coat is applied.

IV. Mark the area to be applied of prime coat with a line of string by pegging at an interval of 15 m on straights and 7.5 m on curves

B. Spraying of Prime coat

I. The primer should be sprayed uniformly over the dry surface of absorbent granular base, using suitable bitumen distributor or sprayer capable of spraying primer at specified rates and temperature so as to provide a uniformly unbroken spread of primer. No hand spraying is permitted except in very small area.

II. The application rate of cutback bitumen and percentage of cut back to be used shall be instructed by the Engineer on Site after field trials. The object of the trials is to achieve the optimum penetration (8 - 10 mm) of prime coat and the minimum rate of spread at which this penetration can be achieved. However, the nominal rate of application of prime coat is 1 Kg per square meter. The type and quantity of cutback bitumen for various types of granular surface is given in Table 7.1

III. The temperature for storage and spraying for Prime Coat is given in Table 7.2

Table 7.1: Type and Quantity of Cutback for Various Types of Granular Surface

Type of Surface	Type of Cutback	Rate of Spray (Kg/sqm)
WMM/WBM	MC 30	0.6-0.9
Stabilized Soil Bases/Crushed Run Macadum	MC 70	0.9-1.2

Table 7.2: Temperature for Storage of Cutback Bitumen for Prime Coat

Type of Prime	Maximum Storage Temperature ° C		Spraying Temperature
	Up to 24 hours	Over 24 hours	
Cutback Bitumen			
MC-30	65	40	50 - 80° C
MC-70	80	50	

IV. When, in the opinion of the Engineer, blinding to the primed surface is required due to failure of bituminous material to penetrate within the specified time or the road must be used by traffic, blinding aggregate shall be spread evenly over the full width of the primed surface such that no bituminous prime material will be picked up by passing traffic.

V. The surface should be allowed to cure preferably for 24 hours.

7.2.2 Quality Control Requirements

1. Material

i. Binder

The prime coat shall consist of cutback bitumen (35 to 45% cutter) or medium curing cutback bitumen MC-30, MC-70 or MC-250 or cationic bitumen emulsion SS1 grade conforming to IS: 8887. Kerosene is used as the cutter.

ii. Aggregate for sand blending

The blinding layer, if any, shall be crushed rock or river sand having a grading within the limits of the Table 7.3. The aggregate shall be clean, hard and free from excessive dust. It shall contain no clay, loam or other deleterious material.

Table 7.3: Grading Envelope for Sand (Blinding layer) for Prime Coat

Sieve size (mm)	Percentage Passing (by mass)
4.75	100
2.36	80 - 100
1.18	60 - 95
0.6	30 – 80
0.3	20 – 55
0.075	10 – 30

2. Quality Control Tests

2.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.4. These tests shall be carried out on the bitumen binders brought on the site by the Contractor for use in the work.

Table 7.4: Quality Control Tests for Bitumen Prior to Construction

S.No	Type of Test	Frequency
1	Penetration at 25° C (100g - % s) in 0.1 mm	One test for every 50000 litres or part of it and change of source& certificate from suppliers
2	Softening Point (Ring & Ball), °C	-do-
3	Absolute and Kinematic Viscosity	-do-
4	Flash point (Cleveland open cup)°C (min)	-do-

5	Ductility at 25° C	-do-
6	Loss on heating (5 h at 163° C) % (max)	-do-
7	Penetration of residue from loss on heating at 25° C (100 - 5 s) % of initial penetration (min)	-do-
8	Specific Gravity at 25° C	-do-
9	Water, % by weight (max)	-do-
10	Solubility in Trichloroethylene, % by weight (min)	-do-
11	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-

2.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table7.5.

Table 7.5: Quality Control Tests of Bitumen During Construction

S.No	Type of Test	Frequency
1	Temperature of Binder, when cutback is to be used	Regularly
2	Rate of Spread of Binder	At least two tests per run
3	Percentage of cutter for making cutback	During making cutback

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

7.3 TACK COAT

The tack coat is the application of single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix.

7.3.1 Methodology

I. Use a suitable grade of bitumen as binder in the form of cutback. Rapid setting bitumen emulsion may be used as binder to areas having sub-zero temperature or for emergency applications. The surface should be prepared as per Sub- Chapter 7.1.

II. If the paving bitumen is used for tack coat it should be heated to the required temperature according to the grade of bitumen to achieve the viscosity less than 2 poise and sprayed uniformly over the surface using suitable bitumen pressure sprayer capable of spraying

bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen.

III. The surface should be allowed to cure until all the volatiles have evaporated.

IV. The surface on which tack coat is to be applied should be clean, free from dust, dirt and any extraneous materials and dry.

7.3.2 Quality Control Requirements

1. Materials

(i) Binder for Tack Coat

The binder shall be an either Cationic bitumen emulsion (RS 1) complying with IS: 8887 or suitable low viscosity paving bitumen of VG10 grade conforming to IS: 73. The use of cutback bitumen RC: 70 as per IS: 217 shall be restricted only for sites at sub-zero temperature or emergency applications as directed by Engineer.

(ii) Rate of application of Binder is provided in Table 7.6

Table 7.6: Rate of Application of Binder for Tack Coat

Type of Surface	Quantity of Cutback per sqm area (Kg)
Normal Bituminous surfaces	0.40 to 0.60
Granular surface treated with primer	0.50 to 0.60
Cement Concrete Pavement	0.60 to 0.70

2. Quality Control Tests

2.1. Tests Prior to Construction

As stated in Table 7.4

2.2. Test during Construction

As Stated in Table 7.5

7.4 BITUMINOUS MACADAM (BM)

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

7.4.1 Methodology

I. Prepare the base on which bituminous macadam course is to be laid and shape to the specified lines, grade and cross-section as per the design drawing. Get approval from the engineer before laying tack coat.
II. Apply tack coat over the base prepared for laying of the bituminous macadam.
III. Bituminous Macadam should be prepared in a Hot Mix Plant of adequate capacity. Ensure manufacturing and rolling temperatures for Bituminous Macadam as given in Table 7.7.

Table 7.7: Manufacturing and Rolling Temperatures for Bituminous Macadam

Bitumen	Bitumen Mixing (^oC)	Aggregate Mixing (^oC)	Mixed Material (^oC)	Laying (^oC)	Rolling (^oC)
VG 30 (Daily Mean Air Temperature > 20^0C	150-165	150-170	150-165	Min. 140	Min.90
VG 10 Mean Air Temperature > 10^0C	140-160	140-165	140-160	Min 130	Min 80

IV. Transport the mixed material quickly to site of work and lay by means of an approved self-propelled mechanical paver.
V. Initial rolling is done with 80-100 KN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the center longitudinally. On super elevated portions, rolling should progress from lower to upper edge parallel to center line of pavement. Thereafter, do intermediate rolling with pneumatic tyred road rollers. This should be followed by final rolling while the material is still workable.
VI. Any high spots or depressions noticed after the roller has passed over the whole area once should be corrected by removing or adding premixed material. Rolling should recommence thereafter.
VII. Each pass should have an overlap of at least one-third of the track made in the preceding pass.
VIII. Rolling should be continued till all roller marks have been eliminated.
IX. For single lane roads no longitudinal joint is required, while for double-lane roads longitudinal joints may be required depending on the paver width.

X. For making longitudinal or transverse joint, cut the edges of the bituminous layer laid earlier to their full depth vertically so as to expose fresh surface and apply a thin coat of binder. Lay adjacent new layer and compact flush with the existing layer.

XI. Cover the bituminous macadam with the wearing course within a period of 48 hours. If there is any delay in providing wearing course the bituminous macadam surface should be covered with a seal coat before opening to traffic.

7.4.2 Quality Control Requirements

1. Material

The Bituminous Macadam shall be composed of aggregate meeting the physical requirements indicated in Table 7.8 and a paving bitumen of viscosity grade complying with IS 73 or as specified in the Contract. The grading and binder requirements shall be in conformity with the requirements indicated in Table 7.9

Table 7.8: Physical Requirements for Aggregates for Bituminous Macadam

Test	**Specification**
Grain Size Analysis	5 % Maximum Passing 0.075 micron
Aggregate Impact Value Test	30 % maximum
Los Angeles Abrasion Value	40 % maximum
Combined Flakiness and Elongation Index Test	35 % maximum
Coating and Stripping of Bitumen Aggregate	95% minimum retained coating
Water Absorption	2 % maximum
Soundness Test(SSS), if water absorption of aggregate exceeds 2%	12 % maximum
Soundness Test(Magnesium Sulphate), if water absorption of aggregate exceeds 2%	18% Maximum

Table 7.9: Grading Requirement of Aggregates and Bitumen Content for Bituminous Macadam

Grading	**Grading I**	**Grading II**
Nominal maximum Aggregate size	40 mm	19 mm
Layer Thickness	80- 100 mm	50 - 75 mm
Sieve Designation	Percentage by Weight Passing the Sieve	
45 mm	100	-
37.5 mm	90-100	-
26.5 mm	75- 100	100
19 mm	-	90-100
13.2mm	35 – 61	56 -88
4.75 mm	13 – 22	16 - 36
2.36 mm	4 – 19	4 - 19
0.300 mm	2 - 10	2 - 10
0.075 mm	0- 8	0 - 8
Bitumen Content % by mass of total Mix	3.3	3.4

Note

- *The specific gravity of the aggregate is taken as 2.7. In case the specific gravity of aggregate is more than 2.7, bitumen content shall be reduced proportionately.*
- *In the regions where the mean daily air temperature is 30^0 C or lower and lowest daily mean air temperature is -10^0 C or lower, the bitumen content shall be increased by 0.50 percent.*

2. Horizontal Alignment

The edges of the bituminous macadam base should be correct within a tolerance limit of (±) 25 mm .

3. Surface Level

The tolerance in surface level of the bituminous macadam would be (±) 10 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge would be 6 mm for longitudinal profile and ± 0.25 mm for cross profile.

5. Quality Control Tests

5.1. Tests Prior to Construction

The quality control tests for testing of materials to be carried out prior to construction are indicated in Table 7.10

Table 7.10: Quality Control Tests of Materials for BM

Materials/work	Type of Test	Frequency
Bitumen straight run	AS per Table 7.4	
Aggregates	Aggregate Impact Value Test (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value(IS:2386 Part 4)	-do-
	Flakiness Index Test (IS:2386 Part 1)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Stripping Value of aggregate Test (IS:6241)	-do-
	Gradation	-do-

5.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.11

Table 7.11: Quality Control Tests During Construction of BM

S.No	Type of Test	Frequency
1	Grading of Aggregate	Two tests per day
2	Quality of Binder	One set of test for each 50,000 litres of supply and part of it
3	Density of Compacted Layer	One test per 700 m^2.
4	Aggregate impact value or LAA	Once per 200 m^3 or part of it
5	Combined Flakiness and elongation Index	Once per 400 m^3 or part of it
6	Temperature of Binder before mixing	Regularly
7	Temperature of mix during laying and compaction	Regularly
8	Thickness of compacted layer	Regular, at close intervals
9	Rate of spread of mixed material	Regular control through checks on layer thickness

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

7.5 SURFACE DRESSING

Surface dressing comprises a thin film of binder, generally bitumen or tar, which is sprayed onto the road surface and then covered with a layer of stone chippings. The thin film of binder acts as a waterproofing seal preventing the entry of surface water into the road structure. The stone chippings protect this film of binder from damage by vehicle tyres, and form a durable, skid-resistant and dust-free wearing surface. In some circumstances the process may be repeated to provide double or triple layers of chippings.

This chapter covers the application of one or more coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a based prepared previously, followed by a cover of stone chipping properly rolled to form a wearing course to the requirements of these Specifications.

7.5.1 Methodology

I. Design the surface dressing following the guidelines given in TRL Overseas Road Note 3 to determine the rate of spread of binder and stone chippings for actual conditions covering traffic categories, type and size of chippings, existing surface and climatic condition. Any deviation between the quantities and spread rates as specified in the contract and those as

per actual design will be brought out and got approved from the competent authority before making any change during construction.

II. Prepare the base on which surface dressing is to be laid to the specified lines, grade and cross-section as per Sub- Chapter 7.1. If the base is of granular material, a prime coat should be applied as per Sub- Chapter 7.2.

III. Prepare the cutback bitumen binder comprising of viscosity grade bitumen and cutter which shall be diesel or kerosene or a mixture of both prepared on Site ranging between 1% to 10% as required and instruction of Engineer.

IV. Apply the binder (at specified temperature) as per rate of spread of binder as per the designed rate by an appropriate bitumen distributor fitted with a spray bar. Binder shall be sprayed/distributed uniformly over the prepared base, with self-propelled or towed sprayer capable of supplying the binder at specified rate to provide a uniformly unbroken spread of binder.

V. The range of spraying temperature for binders is normally within the range 140°C to 170°C (normally 150°C). The minimum temperature of the surface during the spray of binder shall not be less than 15° C.

VI. Spray runs will be limited to 300 m length initially until the Contractor demonstrates his ability to plan and execute longer lengths. Spray widths shall be calculated allowing for 150mm longitudinal overlap with adjoining passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joints will not be permitted.

VII. Immediately after application of binder, spread clean slightly moist stone aggregate at the rate as designed with the help of a mechanically operated chip spreader, in a single layer.

VIII. Immediately after spreading of aggregates, roll the surface with the help of pneumatic tire road rollers with the with the wheel load in the range of 1-2 tonnes. The roller shall follow directly behind the spreader and shall continue to roll at speed of approximately 8-10 Kph, so as to provide minimum of 6 passes over the entire treated area.

IX. Commence rolling from the edges and progress towards the except in super elevated portions where it shall proceed from the lower edge to the higher edge. Each pass should have an overlap of not less than half width of previous pass. Spread additional stone chips to make up irregularities, if any. Rolling should continue until all aggregate particles are firmly embedded in the bituminous binder and present a uniform closed surface.

X. The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the stones being whipped off.

XI. The road may be opened to traffic 24 hours after the work of rolling is complete. In exceptional circumstances, traffic may be allowed immediately after rolling provided the traffic speed is limited to 30 km/h until the following day.

XII. Where a second surface dressing is specified, the first surface dressing shall be left open to traffic for a minimum period of 2-3 weeks and preferably a longer period before applying the second surface dressing unless special approval is obtained from the Engineer for a shorter period. Surplus chippings shall be removed by firm hand-brooming before applying the second surface dressing. Procedures stated here-in-above will apply.

XIII. Back rolling of at least 15 pass by pneumatic roller covering whole width of road shall be carried out on the following day of spreading of aggregates. The back rolling shall be continued for three days in case of low traffic volume.

7.5.2 Quality Control Requirements

1. Materials

(a) Stone Chippings

(i) Physical requirements

Stone chippings should satisfy the requirements given in Table 7.12

Table 7.12: Physical Requirements of Chippings for Surface Dressing

Chipping Class	Specification
LAA Max	35%
AIV Max	27%
SSS Max SMS Max	12% 18%
Stripping min retained coating	95%
Combined FI and Elongation index Max	35%
Polished Stone Value	Min 60
Water Absorption Max	1%

(ii) Grading

The stone chippings should conform to the Grading given in Table 7.13

Table 7.13: Grading Requirements for Chips for Surface Dressing

IS Sieve Designation (mm)	**Cumulative percent by weight**			
	Nominal Size			
	19	**13**	**10**	**6**
26.5	100			
19.5	85-100	100		
13.2	0-40	85-100	100	
9.5	0-7	0-40	85-100	100
5.6		0-7	0-35	85-100
4.75			0-10	
3.35				0-30
2.36	0-2	0-2	0-2	
0.6				0-10
0.075	0-1.5	0-1.5	0-1.5	0-1.5

(b) Bitumen

The binder shall be either bitumen conforming to IS: 73 or rapid setting cationic bitumen emulsion (RS-2) conforming to IS: 8887. Cutter which shall be diesel or kerosene or a mixture of both prepared on Site. The type and proportion of cutter if required shall be instructed by the Engineer on Site, in the range 1% to 10% after design of the surface dressing in accordance with the procedures set out in Chapter 5 of TRRL-ORN 3. The preparation of cutback bitumen shall be carried out in accordance with TRRL Research Report RR 104 "Preparation of Cutback Bitumen" (Hitch and Stewart).

Where aggregate fails to pass the stripping test, an approved adhesion agent may be added to the binder, in accordance with the manufacturer's instructions.

2. Horizontal Alignment

The edges of the Surface Dressing should be correct within a tolerance limit of (±) 20 mm

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and (±) 0.25 mm for cross profile respectively.

5. Quality Control Tests

5.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.14

Table 7.14: Quality Control Tests Prior to Construction of Surface Dressing

Materials/work	Type of Test	Frequency
Bitumen straight run	AS per Table 7.4	
Aggregates	Aggregate Impact Value Test (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value	-do-
	Flakiness Index Test (IS:2386 Part 1)	-do-
	Bituminous Stripping of Aggregate Test (IS:6241)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Degradability	-do-
	Gradation	One test per source identified

5.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.15

Table 7.15: Quality Control Tests During Construction of Surface Dressing

Type of Test		Frequency
1	Rate of spread of Binder	At least two tests per run
2	Rate of Spread of Aggregate	At least two tests per run
3	Quality of Binder (Straight Run Bitumen)	One set of test for each 50,000 ltr or part of it; certificate from suppliers
4	Flakiness Index Test (IS:2386 Part 1)	One test per 100 m^3
5	Grading of Aggregate	Once per 50 m^3 or part of it
6	Aggregate Impact Value , or LAA, CR	Once per 250 m^3 or part of it
7	Temperature of Binder During Spraying	At close Interval.

Note

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

7.6 PREMIX CARPET

Close Graded Premix Surfacing shall consists of preparation, laying and compaction of a close/open graded premix surfacing material composed of *graded aggregates* premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

Open Graded Premix Surfacing shall consist of preparation, laying and compaction of an open-graded premix surfacing material composed of *small-sized aggregate* premixed with bituminous binder on a previously prepared base, in accordance with the requirements of these Specifications to serve as a wearing course

7.6.1 Methodology

1. Close Graded Premix Surfacing / Mixed Seal Surfacing

I. Prepare the base on which premix carpet is to be laid to the specified lines, grade and cross-section and get approval from engineer before applying prime coat.

II. Apply a prime coat over the prepared base as per Sub- Chapter 7-2

III. The tack shall be applied over primed surface as per Sub- Chapter 7-3 prior to laying of the carpet.

IV. Mixing should be thorough to ensure that a homogenous mixture is obtained. The temperature of bitumen at the time of mixing should be in the range of 150^0C to 165^0C and that of aggregates 150^0C to 170^0C, provided that the difference between the temperature of aggregate and the binder should not exceed 14^0C. The

temperature at the time of discharge of the mixture should be between l30°C and 160°C.

V. Locate hot mix plant near the work site. The mixed material should be transported quickly to the site of work and laid uniformly by suitable means.

VI. The premixed material shall be spread on the road surface with rakes.

VII. Commence rolling with 80-100 KN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the center longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to center line of pavement). Continue rolling operations till a smooth uniform surface is achieved and all roller marks are eliminated. Each pass should have an overlap of at least one-third of the track made in the preceding pass.

VIII. Correct any high spots or depressions noticed after the roller has passed over the whole area once by removing or adding premixed material and re-compacting.

2. Open Graded Premix

IX. For Open graded premix carpeting, do Steps from I to VIII and then Provide a seal coat to the surface immediately after laying the carpet as per details in Sub-Chapter 7.7

X. Ordinarily, the road may be opened to traffic after laying the seal coat with restrictions given in Sub- Chapter 7.7

7.6.2 Quality Control Requirements

1. Materials

(a) Aggregates

(i) Physical Properties

a) For Close and Open Premix Carpeting

Aggregates shall conform to the physical requirements for close and open premix carpeting indicated in Table 7.16

Table 7.16: Physical Requirements of Stone Aggregate for Closed and Open Premix Carpeting

Test	Specification
Combined Flakiness and Elongation index	Max. 35 %
Aggregate Impact Value	Max. 30 %
Loss Angles Abrasion value	Max. 40%
Soundness Sodium Sulphate Magnesium Sulphate	 12 % 12 %
Water Absorption	Max. 2 %
Coating and stripping of bitumen aggregate mixture.	Minimum retained coating 95 %

(ii) Grading and Proportion of Materials

a) Close Grade Premix Carpeting

Grading

The gradation of aggregate for close graded premix surfacing shall be as in Table 7.17

Table 7.17: Gradation of Stone Aggregate for Close Graded Premix Carpeting

IS Sieve Designation (mm)	Cumulative percent by weight of total aggregate passing	
	Type A	Type B
13.2	-	100
11.2	100	88 - 100
5.6	52 – 88	31 - 52
2.8	14 - 38	5 - 25
0.090	0 - 5	0 - 5

Type A grading is recommended for use in areas having rainfall more than 150 cm per year. In other areas Type B grading may be used

Proportioning of Materials

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

b) Open Grade Premix Carpeting

Grading

Nominal Stone size 13.2mm (passing 22.4mm sieve and retained on 11.2 mm sieve) and Nominal Stone size 11.2mm (passing 13.2mm sieve and retained on 5.6mm sieve).

Proportioning of Materials

The material shall be proportioned in in accordance with Table7.18

Table 7.18: Quantities of Materials for 10 m^2 of Road Surface for 20 mm Thick Open-graded Premix Surfacing

Material		Quantity
Aggregates		
a	Nominal Stone size 13.2mm (passing 22.4mm sieve and retained on 11.2 mm sieve)	0.18 m^3
b	Nominal Stone size 11.2mm (passing 13.2mm sieve and retained on 5.6mm sieve)	0.09 m^3
	Total	**0.27 cum**

Material		Quantity
Binder		
a	For 0.18m^3 of 13.2 mm nominal size stone of 52 kg bitumen per m^3	9.5 kg
b	For 0.09m^3 of 11.2 mm nominal size stone of 56 kg bitumen per m^3	5.1 kg
	Total	**14.6 kg**

(b) Binder

The binder shall be a viscosity grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract.

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±)

20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25 mm the cross profile.

5. Quality Control Tests

5.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.19

Table 7.19: Quality Control Tests Prior to Construction of Premix Carpeting

Type of Test		Frequency
1	Quality of Binder (Straight-run Bitumen)	As per Table 7.4
2	Aggregate Impact Value Test	One test per each source identified
3	Flakiness Index Test	-do-
4	Water Absorption	-do-
5.	Soundness Sodium Sulphate Max	-do-
6	Gradation	-do-
7	Bitumen Stripping of Aggregate Test	One set of 3 specimen for each source of supply

5.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.20

Table 7.20: Quality Control Tests During Construction of Premix Carpeting

Type of Test	Frequency
1. Grading of Aggregates (IS:2386 Part 1)	Once per 100 m3 or part of it
2. Flakiness of Aggregate	- do -
3. LAA or AIV,	Once per 200 m3 or part of it or change of source
4. Quality of Binder	One set of test for each 50 Kl of supply and part of it
5. Binder Content before seal coat	At least two tests per day
6. Temperature of Binder	Regular close intervals
7. Thickness of layer	Regularly at close intervals

Note: *Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed*

7.7 SEAL COAT

The seal coat shall be any of the two types mentioned below:

Type A : **Liquid seal coat** comprising of an application of layer of bituminous binder followed by a cover of stone chips.

Type B : **Premixed seal coat** comprising of a thin application of fine aggregate premixed with bituminous binder.

7.7.1 Methodology

Apply seal coat immediately after laying the bituminous course. The surface should be clean and free of dust and extraneous material before application of the seal coat.

1. **Type A Seal coat with bitumen:**
   - I. Apply heated bitumen with a temperature between 150°C and 163°C uniformly with the help of a bitumen sprayer.
   - II. Immediately thereafter, spread stone chips over the bitumen layer at a uniform rate, preferably, with the help of a mechanical grit spreader so as to cover the surface completely.
   - III. Commence rolling with suitable and appropriate rollers (3-wheel or tandem type or pneumatic), rolling should progress from lower to upper edge parallel to center line of pavement. If required, spread additional chips by hand to make up irregularities. Continue rolling operations until all aggregate particles are firmly embedded and present a uniform closed surface.

IV. The traffic shall be open on following day. In special circumstances, however, the engineer may open the road to traffic immediately after the rolling with a maximum speed limit of 20 Km/hr until the following day.

2. **Type B Pre-mixed seal coat**

I. Mixing should be thorough to ensure that a homogenous mixture is obtained. The temperature of bitumen at the time of mixing should be in the range of 140^{o}C to 160^{o}C and that of aggregates 140^{o}C to 165^{o}C, provided that the difference between the temperature of aggregate and the binder should not exceed 14^{o}C. The temperature at the time of discharge of the mixture should be between 140°C and 160°C. The temperature at the time of laying 130°C.

II. Locate hot mix plant near the work site. The mixed material should be transported quickly to the site of work and laid uniformly by suitable means.

III. The premixed material shall be spread on the road surface with rakes.

IV. Commence rolling with 80-100 KN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the center longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to center line of pavement). Continue rolling operations till a smooth uniform surface is achieved and all roller marks are eliminated. Each pass should have an overlap of at least one-third of the track made in the preceding pass. The rolling should be completed before the mat pulls to the temperature of 80°C.

V. Traffic may be allowed after completion of rolling operations and the surface is at ambient temperature.

7.7.2 Quality Control Requirements

1. Materials

(a) Aggregates

Aggregate shall conform to the physical requirements indicated in Table 7.21

Table 7.21: Physical Requirements of Stone Aggregate

Test	Specification
Flakiness index	Max. 35 %
Aggregate Impact Value	Max. 25 %
Loss Angles Abrasion value	Max 35 %
Soundness (Sodium Sulphate) Max.	12 %
Water Absorption	Max. 2 %
Coating and stripping of bitumen aggregate mixture.	Minimum retained coating 95 %

Quantities and grading requirements for aggregates are given in Table 7.22

Table 7.22: Quantity and Gradation Requirement of Aggregate for Seal Coat

Type of seal coat	Quantity of aggregate required per 10 sqm area	Graduation requirement	
		100% passing sieve designation	100% retained sieve designation
Type A	0.09 cum	11.2 mm	2.36 mm
Type B	0.06 cum	2.36 mm	180 microns

(b) Binder

The binder shall be a penetration grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract. The quantities required for seal coat are given in Table7.23

Table 7.23: Quantities of Binder Required for Seal Coat

Type of seal coat	Bitumen in kg per 10 m^2
Type A	9.8
Type B	6.8

2. Quality Control Tests

2.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.24

Table 7.24: Quality Control Tests Prior to Construction of Seal Coat

Materials/work	Type of Test	Frequency
Bitumen	AS per Table 7.4	
Aggregates	Aggregate Impact Value Test (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value	-do-
	Flakiness Index Test (IS:2386 Part 1)	-do-
	Bituminous Stripping of Aggregate Test (IS:6241)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Gradation	One test per source identified

2.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.25

Table 7.25: Quality Control Tests During Construction of Seal Coat

Type of Test		Frequency
1	Rate of spread of binder	At least two tests per run
2	Rate of Spread of aggregate	At least two tests per run
3	Quality of binder (Straight Run Bitumen)	One set of test for each 50000 ltrs or part of it; certificate from suppliers
4	Grading of Aggregate	Once per 100m^3 or part of it
5	Aggregate impact value or LAA,	Once per 200 m^3 or part of it
6	Temperature of binder during spraying	At close Interval.

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

7.8 SAND SEAL

7.8.1 Methodology

Preparation of surface

I. Before laying seal coat, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or by use of compressors or by any other acceptable methods. All hardened mud or other foreign matter shall be loosened by scraping before sweeping.
II. Cover all Road furniture including manholes covers etc with adhesive paper or similar materials to prevent from coating of binder while spraying.
III. The surface to be sand seal shall be checked for line, camber and level, and the surface corrected if any, made good as necessary and approved by the Engineer before sand seal is applied.

Application of Sand Seal

IV. Immediately after preparation of the surface, spray the binder uniformly at specified rate using suitable the bitumen distributor. Spray width shall be calculated allowing for 150 mm longitudinal overlap with adjoining spray passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joint shall not be permitted. The rate of spray of binder shall be 1.4 Lit/m^2 for MC 3000 cut-back bitumen and 1.6 Lit/m^2 for Emulsion, 60% cationic

V. Immediately after the binder has been sprayed, the fine aggregate shall be uniformly spread and rolled. The elapsed time between the spraying of binder and the spreading of fine aggregates shall in no case exceed one minute. Any excess of chipping shall be removed by hand and any insufficiently chipped area shall be chipped over by hand, so that adequate coverage is obtained.

VI. The rate of spread of the fine aggregate shall be 13 – 19 kg/ m^2.

VII. Rolling shall begin immediately after the chippings have spread and, in no case, later than two minutes after the application of binder. Rolling shall continue until all aggregates are firmly embedded into the binder and until all excess aggregates have been removed or insufficiently chipped areas have been chipped over. Rolling shall be begin from the edge and progressing towards the center longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to center line of pavement). The number of passes shall usually be, at least 6 passes at each point by a pneumatic tyred roller or as directed by the engineer.

7.8.2 Quality Control Requirements

1. Materials

a) Fine Aggregate

The aggregate shall consist of sand, or fine screenings free from organic matter, clay and other deleterious materials. The fines (passing a 0.425 mm sieve) shall be non-plastic. The grading shall be as specified in the Table 7.26

Table 7.26: Grading of Aggregate of Sand for Sand Seal

Sieve (mm)	Percentage passing by weight
10.00	100
4.75	70-90
2.36	45-70
0.60	15-35
0.15	0-2

b) Binder

The binder shall be a medium-curing cut-back MC-800 or MC-3000 or K1-60 cationic emulsion as specified.

2. Quality Control Tests

2.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.27

Table 7.27: Quality Control Tests Prior to Construction of Sand Seal

Material	Type of Test	Frequency
Bitumen	As per Table 7.4	One test for every 50000 litres or part of it and change of source & certificate from suppliers
Aggregate	Grading	One test for each source
	Plasticity	-do-

2.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.28

Table 7.28: Quality Control Tests During Construction of Sand Seal

S.No	Type of Test	Frequency
1	Grading	One test per every 50 m^3 or part of it or change of source
2	Plasticity	-do-
3	Temperature of Binder,	At regular interval
4	Rate of Spread of Binder (Including Dip Check)	Two tests per run
5	Curing of Primer	Before any subsequent treatment

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

7.9 PENETRATION MACADAM, SEMI – GROUT

This consist of compacted crushed coarse aggregates with application of bituminous binder and choke aggregate in accordance with the requirements of these Specifications.

7.9.1 Methodology

1. Preparation of Existing Surface

I. Clean the existing surface by removing all loose materials and potholes if any shall be repair with suitable patching mixture. Any wave and bumps shall be corrected by scarifying and re-compacting and the surface shall be prepared to the required grade and cross fall as specified. Then the base shall be broomed and cleaned of all loose and foreign materials.

II. Prepare the shallers at the outer edges of road width to support the loose course aggregate and helps to let the roller to roll the edge of loose course aggregate and edge of shallers.

2. Spreading of Coarse Aggregates

III. Immediately after preparation of base spread the coarse aggregate covering full width to such thickness that after compaction the specified thickness, cross slope and grade is

achieved. The aggregate is spread by hand or an approved spreading machine. Do not allow to dump mass on the prepared base. The surface of the loose aggregate is carefully shaped and all high and low spots are maintained by removing or adding aggregate.

IV. Take precautions to prevent the coarse aggregate from becoming mixed or coated with earth or other deleterious matter both before and after spreading.

V. The coarse aggregate is then be dry rolled with a three wheel roller weighing not less than 8.00 tones. Rolling is started longitudinally from the outer sides and proceed towards the of the pavement in straight and from lower edge to higher edge on curves overlapping on successive passes by at least one half the width of the rear wheel.

VI. Check the cross section of the compacted coarse aggregate with a help of straight edge and camber plate.

3. Application of Binder

Apply the binder to the rolled crushed aggregate at specified quantity and temperature with the approved bitumen distributor. The quantity and temperature of binder during application is given in Table 7.29 and 7.30 respectively.

4. Application of Key Aggregate

Immediately after the binder has been applied to the coarse aggregate, key aggregate is sprinkled lightly over the surface in sufficient quantity to prevent sticking of the roller wheels. Then it is rolled and simultaneously with the rolling, additional key aggregate are added in small quantities and lightly broomed over the surface while rolling continues until the surface interstices between the coarse aggregate have been filled but without covering the crushed aggregate itself. Roll the surface until the stone is thoroughly imbedded into the binder and anchored in place. Continue rolling until the surface is hard and smooth and shows no perceptible movement under the roller.

Table 7.29: Rate of Application of Binder and Rate of Spread of Aggregate per sq.m for Penetration Macadam

Compacted thickness	Binder	Coarse Aggregate	Key Aggregate
75 mm	5.2 liters	0.09 m^3	0.018 m^3
50 mm	3.5 liters	0.06 m^3	0.015 m^3

Table 7.30: Spraying Temperature of Binder for Penetration Macadam

Binder	Spraying Temperature °C	Maximum Heating °C
VG 30	150-165	170
VG 20	140-160	170

Seal Coat

Before application of seal coat the surface is cleaned by brooming and removed all loose material and treated with a second coat of binder at the rate of 1.4 ltr per square meter and immediately after application of the binder, cover aggregate will be spread and broomed uniformly over the surface as specified. Then rolling is carried out covering the whole paved area.

7.9.2 Quality Control Requirements

1. Materials

i. Aggregates

The aggregate is the product of crushed rock or crushed gravel having angular shape with a character that let it compact and interlock under rolling. All the aggregates must be of reasonably uniform quality throughout, clean and free from plastic fines and other foreign material or other deleterious matter. It shall comply with the following requirements given in Table 7.31, 7.32 and 7.33

Table 7.31: Physical Requirements Aggregate for Penetration Macadam

Test	Specification
Los Angles Abrasion value	40 % (Max)
Aggregate Impact value	30 %(Max)
Water absorption	2 % (Max)
Sodium Sulphate Soundness (SSS)	12% (Max)

Table 7.32: Grading of Aggregate for Penetration Macadam

Sieve Size (mm)	Percentage passing by weight			
	Coarse aggregate (Course 75mm thick)	Coarse aggregate (Course 75mm thick)	Key Aggregate (type I)	Key Aggregate (type II)
75.00	100	-	-	-
63.00	90-100	100	-	-
53.00	20-55	90-100	-	-
37.50	0-15	40-75	-	-
26.50	-	15-35	-	-
19.00	0-15	0-15	100	100
11.20	-	0-5	90-100	90-100
9.5	-	-	40-70	40-75
4.75	-	-	0-15	5-25
2.36	-	-	0-5	0-10
1.18	-	-	-	0-5

Table 7.33: Composition of Aggregate for Penetration Macadam

Compacted thickness of layer	Nominal single sized aggregate	Percentage
50 mm	37.5 mm 26.5 mm 13.2- 19 mm	60% 30% 10%
65 mm – 75 mm	53 mm 37.5 mm 13.2-19 mm	60% 30% 10%

ii. Binder

The binder shall be VG 10 grade bitumen or similar or MC 3000 cutback bitumen.

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±)

20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25 mm the cross profile.

5. Quality Control Tests

5.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.34

Table 7.34: Quality Control Tests Prior to Construction of Penetration Macadam

S.No	Type of Tests	Frequency
1	Quality of Binder (Bitumen) As per Table 7.4	One set of test for every 50000 litre or part of it and change of source & certificate from suppliers
2	Gradation	One test for each source
3	LAA	-do -
4	Aggregate Impact Value	-do -
5	Stripping Value test	One set of three specimens from each source
6	Water absorption	One test for each source

5.2. Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.35

Table 7.35: Quality Control Tests During Construction of Penetration Macadam

S.No	Type of Test	Frequency
1	Quality of bitumen	One set of test for every 50000 liters or part of it and change of source& certificate from supplier
2	Grading	One test per every 50 m^3 or part of it or change of source
3	LAA or	One test per every 500 m^3 or part of it orchange of source
4	AIV	-do-
5	Sodium Sulphate Soundness (SSS)	do-
6	Stripping value	Subsequently when warranted by change in source
7	Temperature of Binder,	At regular interval
8	Rate of Spread of Binder (Including Dip Check)	Two tests per run
9	Surface level	Every 20 m or at close interval
10	Width	Every 200 m or at close interval
11	Smoothness	All apparently rough area to be checked
12	Thickness of layer	Every 500 m or at close interval

Note

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

7.10 ASPHALT CONCRETE / BITUMINOUS CONCRETE

This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick

1. **Material**

a) Bitumen

The bitumen shall be Viscosity Grade (VG) paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with IS: 15462 or as otherwise specified in the Contract

b) Coarse Aggregates

Coarse aggregates shall satisfy the physical requirements of Table 7.36 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 7.36: Physical Requirements for Coarse Aggregate for Asphalt Concrete

Test	Specification
Grain size analysis	Max 5% passing 0.075 mm sieve
Combined Flakiness and Elongation Indices	Max 35%
Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%
Soundness either: Sodium Sulphate or Magnesium Sulphate	Max12% Max18%
Polished Stone Value	Min 55
Water Absorption	Max 2%
Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%
Retained Tensile Strength	Min 80%

(c) Fine Aggregates

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

(d) Filler

The requirement of filler in bituminous concrete shall normally material passing 75 –micron sieve. Filler shall consist of finely divided mineral matter such as rock or stone dust, hydrated lime or cement approved by the Engineer. The filler shall be free from organic impurities and have a plasticity Index not greater than 4. The Plasticity index requirement shall not apply if filler is cement or lime. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 7.36, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly. The filler shall be graded within the limits indicated in Table 7.37

Table 7.37: Grading Requirements for Mineral Filler for Asphalt Concrete

IS sieve(mm)	Cumulative Per cent Passing by Weight of Total Aggregate
0.6	100
0.3	98-100
0.075	85.-100

e) Aggregate Grading and Binder Content

The combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in Table 7.38. The grading shall be as specified in the Contract.

Table 7.38: Composition Quantity of Asphalt Concrete Pavement Layers

Grading	1	2
Nominal aggregate size	19 mm	13.2 mm
Layer thickness	50 mm	30-40 mm
IS Sieve(mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix	Min 5.2	Min 5.4

2. Mix Design

The bitumen content required shall be determined following the Marshall Mix design procedure contained in Asphalt Institute Manual MS-2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2. The mixture shall meet the requirements set out in Table 7.39

Table 7.39: Requirements of Mix for Asphalt Concrete

Properties	Viscosity Grade Paving Bitumen
Properties	75 blows on each face of the specimen
Minimum stability (KN at 60 ^{o}C)	9.0
Marshall flow(mm)	2-4
Marshall Quotient (Stability/ flow)	2-5
% air voids	3-5
%Voids Filled with Bitumen (VFB)	65-75
Coating of aggregate particle	95% Minimum
Tensile Strength Ratio	80% Minimum
% Voids in Mineral Aggregate(VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 7.40

The binder content shall be optimized to achieve the requirements of the mix set out in Table 7.40. 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

Table 7.40: Minimum Percent Voids In Mineral Aggregate (VMA) in Mix Design

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

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

3. Job Mix Formula

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details:

I. Source and location of all materials;
II. Proportions of all materials expressed as follows:
    - Binder type, and percentage by weight of total mix;
    - Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

III. A single definite percentage passing each sieve for the mixed aggregate;
IV. The individual grading of the individual aggregate fraction, and the proportion of each in the combined grading;
V. The results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;
VI. Where the mixer is a batch mixer; the individual weights of each type of aggregate, and binder per batch;
VII. Test results of physical characteristics of aggregates to be used;
VIII. Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications. Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

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

4. Plant Trials

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 7.41

Table 7.41: Permissible Variations in Plant Mix from the Job Mix Formula for Asphalt Concrete

Description	Permissible Variation
Aggregate passing 19 mm sieve or large or more	±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	$\pm 10^0$C

5. Site 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 specification.

The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100 sq.m of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method. The compacted layers of Bituminous Concrete (BC) shall have a minimum field density equal to or more than 92% of the 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.

7.10.1. Methodology

I. Prepare the base on which Asphalt Concrete is to be laid to the specified lines, grade and cross-section and Intensive cleaning of underlying layers by labors with the help of mechanical brushes and or hand brush and get approval from engineer before applying prime coat.
II. Apply a prime coat over the prepared base as per Sub- Chapter 7.2
III. The tack shall be applied over primed surface as per Sub- Chapter 7.3 prior to laying of the carpet.
IV. Hot mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The plant shall have coordinated set of essential units capable of producing uniform mix as per job mix formula. The plant must be installed nearby site so that the required temperature of mix is maintained at all stages from mixing to laying and compaction.
V. Mixing of binder, aggregate and filler shall be thorough to ensure that a homogenous mixture is obtained. The temperature of bitumen at the time of mixing should be in Celsius as the Table 7.42 below.

Table 7.42: Mixing, Laying and Rolling Temperature for Bituminous mix

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	Rolling Temperature
VG-40	160-170	160-175	160-170	150 Min	100 Min
VG-30	150-165	150-170	150-165	140 Min	90 Min
VG-20	145-165	145-170	145-165	135 Min	85 Min
VG-10	140-160	140-165	140-160	130 Min	80 Min

Note: The difference between the temperature of aggregate and the binder should not exceed 14^0C.

VI. The mix shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and covered for maintaining temperature and preservation from contamination.

VII. The mix shall be spread by means of a self-propelled mechanical paver with suitable screeds capable of screening, tamping and finishing the mix to specified, grade lines and cross-sections. However, in restricted location and in narrow width where the available plant cannot be operated, manual laying of mix may be permitted. The mix should be spread in such a manner that after compaction, the required thickness of wearing course is uniformly obtained.

VIII. During the laying of asphalt concrete mix, a good coordination between labor and equipments is very important and shall be maintained.

IX. Check the loose thickness manually.

X. Follow up level corrections by skilled labors.

XI. After spreading by paver, the mix shall be thoroughly compacted by rolling with a set of rollers moving at a speed not more than 5 km per hour, immediately close to the paver. Each pass should have an overlap of at least one-half of the track made in the preceding pass.

XII. Typical roller position used in compaction are:

Breakdown roller: The first roller behind the screed. It generally effects the most density gain of any roller in the sequence. Breakdown rollers can be of vibratory steel wheel or smoot wheel roller but most often used are vibratory steel wheel.

Intermediate Roller: Used behind the breakdown roller and provides additional compaction. Pneumatic tire rollers are used as intermediate rollers because they provide a different type of compaction (kneading action) than a breakdown steel wheel vibratory roller, which can help further compact the mat or at the very least, rearrange the aggregate within the mat to make it receptive to further compaction.

Finish Roller: The last roller in the sequence. It is used to provide a smooth mat surface. Although the finish roller does apply compactive effort, by the time it comes in contact with the mat, the mat may have cooled below cessation temperature. Static steel wheel rollers are almost always used as finishing rollers because they can produce the smoothest surface of any roller type. Continue rolling operations till a smooth uniform surface is achieved and all roller marks are eliminated

XIII. Commence rolling beginning from the edge and progressing towards the longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to line of pavement).

XIV. To prevent adhesion of the mixture to the rollers, the wheels shall be kept lightly moistened with water

XV. In areas too small for the roller, a vibrating rate plate compactor or a hand tamper shall be used to achieve the specified compaction

XVI. Correct any high spots or depressions noticed after the roller has passed over the whole area once by removing or adding bituminous mix and re-compact.

XVII. Cut the edge of previously laid mix with edge cutter for laying mix on next lane. The edge cut should be perfectly vertical.

XVIII. Core sample of the previously laid mix is taken out with the help of core cutter for further necessary laboratory tests.

7.10.2. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 7.36

(b) Binder

The binder shall be a viscosity grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract. Binder shall confirm the requirements indicated in Table 7.4.

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25 mm the cross profile.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.43

Table 7.43: Quality Control Tests Prior to Construction of Asphalt Concrete

Type of Test		Frequency
1	Quality of Binder (Viscosity Graded Bitumen)	As per Table 7.4.
2	Los Angeles Abrasion Value/ Aggregate Impact Value Test	For each new source and in every 500 cum or part of it
3	Combined Flakiness and Elongation Index Test	- do as above -
4	Water Absorption	- do as above -
5.	Soundness Sodium Sulphate	- do as above -
6	Gradation	- do as above -
7	Bitumen Stripping of Aggregate Test	One set of 3 specimen for each source of supply

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.44

Table 7.44: Quality Control Tests During Construction of Asphalt Concrete

Type of Test	Frequency
1. Grading of Aggregates (IS:2386 Part 1)	For each new source and in every 500 cum or part of it
2. Flakiness of Aggregate	- do as above -
3. LAA or AIV,	- do as above -
4. Quality of Binder	One set of test for each 50000 liters supply and part of it
5. Binder Content	At least two tests per day
6. Temperature of Binder	Regular close intervals
7. Thickness of layer	Regularly at close intervals
8. Density of compacted layer	One test per 700 square metre area

7.11 DENSE BITUMINOUS MACADAM (DBM)

The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

1. Material

a) Bitumen

The bitumen shall be Viscosity Grade (VG) paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with IS: 15462 or as otherwise specified in the Contract

b) Coarse Aggregates

Coarse aggregates shall satisfy the physical requirements of Table 7.36 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.

(c) Fine Aggregates

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

(d) Filler

The requirement of filler in bituminous concrete shall normally material passing 75 –micron sieve. Filler shall consist of finely divided mineral matter such as rock or stone dust, hydrated lime or cement approved by the Engineer. The filler shall be free from organic impurities and have a plasticity Index not greater than 4. The Plasticity index requirement shall not apply if filler is cement or lime. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 7.36, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly. The filler shall be graded within the limits indicated in Table 7.37.

e) Aggregate Grading and Binder Content

The combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in Table 7.45. The grading shall be as specified in the Contract.

Table 7.45: Aggregate Grading and Binder Content for DBM

Grading	1	2
Nominal aggregate size*	**35.5 mm**	**26.5 mm**
Layer thickness	**75-100 mm**	**50-75 mm**
IS Sieve(mm)	**Cumulative % by weight of total aggregate passing**	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0**	Min 4.5**

* The nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained.

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

2. Mix Design

The bitumen content required shall be determined following the Marshall Mix design procedure contained in Asphalt Institute Manual MS-2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2. The mixture shall meet the requirements set out in Table 7.39

The binder content shall be optimized to achieve the requirements of the mix set out in Table 7.40. 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

3. Job Mix Formula

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the details as mentioned in sub-chapter 7.10 (4).

4. Plant Trials

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 7.46.

Table 7.46: Permissible Variations in Plant Mix from the Job Mix Formula for DBM

Description	Permissible Variation
Aggregate passing 19 mm sieve or large or more	±8%
Aggregate passing 13.2 mm, 9.5 mm	±7%
Aggregate passing 4.75 mm	±6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%
Aggregate passing 0.3 mm, 0.15 mm	±4%
Aggregate passing 0.075 mm	±2%
Binder content	±0.3%
Mixing temperature	$\pm 10^0$C

5. Site 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 sub-chapter 7.10 (5) and 7.10.1.

The compacted layers of DBM shall have a minimum field density equal to or more than 92% of the 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.

7.11.1. Methodology

I. Prepare the base on which DBM is to be laid to the specified lines, grade and cross-section and Intensive cleaning of underlying layers by labors with the help of mechanical brushes and or hand brush and get approval from engineer before applying prime coat.
II. Apply a prime coat over the prepared base as per Sub- Chapter 7.2
III. The tack shall be applied over primed surface as per Sub- Chapter 7.3 prior to laying of the carpet.
IV. Follow Steps as mentioned in Chapter 7.10.1.

7.11.2. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 7.36.

(b) Binder

The binder shall be a viscosity grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract. Binder shall confirm the requirements indicated in Table 7.4.

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25 mm the cross profile.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 7.43

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 7.44

Chapter 8. CEMENT CONCRETE PAVEMENT

8.1 INTRODUCTION

Cement Concrete Pavements (Rigid pavements) have sufficient flexural strength to transmit the wheel load stresses to a wider area by slab action. Compared to flexible pavement, rigid pavements are placed either directly on the prepared sub-grade or on a single layer of granular or stabilized material. Since there is only one layer of material between the concrete and the sub-grade, this layer can be called as base or sub-base course. In rigid pavement, load is distributed by the slab action, and the pavement behaves like an elastic plate resting on a viscous medium.

Rigid pavements can be classified into three types:

1. Jointed Plain Concrete Pavement (JPCP) or Plain Concrete Pavement (PCC)
2. Jointed Reinforced Concrete Pavement (JRCP) or Reinforced Concrete Pavement (RCC)
3. Continuous reinforced concrete pavement (CRCP)
4. Precast Panel Concrete Pavement (PPCP)

1. Jointed Plain Cement Concrete Pavement (JPCP)

Jointed Plain Cement Concrete Pavement (JPCP) is the most common type of rigid pavement. JPCP is constructed with longitudinal and transverse joints to control cracking that occurs in the slabs. JPCP contain enough joints to control the location all of the expected natural cracks. All necessary cracking occurs at joints and not elsewhere in the slabs. JPCP do not contain any steel reinforcement. Tie bars and dowel bars are provided for the transfer of wheel load from one to the neighboring concrete slabs. Dowel bars are placed along the longitudinal direction and across the transverse joints. Similarly, tie bars are placed along the transverse direction and across the longitudinal joints. The mostly used rigid pavement around the world (i.e more than 90% of concrete pavement road) is JPCP.

2. Jointed Reinforced Concrete Pavement (JRCP)

These pavements are provided with longitudinal and transverse reinforcement, which is discontinued at joints. Although reinforcements do not improve the structural capacity significantly, they can drastically increase the joint spacing. JRCP has transverse joints spaced about 13 to 17 m apart and contains steel reinforcement in the slab. The steel reinforcement is designed to hold tightly together any transverse cracks that develop in the slab. Dowel bars and tie bars are also used at all transverse and longitudinal joints, respectively. Reinforcement help to keep the slab together even after cracks. They are used for high traffic roads.

3. Continuous Reinforced Concrete Pavement (CRCP)

These are special type of reinforce concrete pavement in which steel reinforcement is not discontinued at the contraction joints but painted with a bond-braking layer of specified distance on either side of the joint, which is termed as elastic joint. CRCP has no regularly transverse joints

i.e. saw cutting of transverse joints is not required for CRCP and contains more steel reinforcement than JRCP. The high steel content influences the development of transverse cracks within an acceptable spacing and serves to hold these transverse cracks tightly together. Hence, complete elimination of joints are achieved by reinforcement.

Conventional CRCP requires relatively high percentage of steel ranging from 0.7 to 1.0 percent of concrete cross-section. CRCP construction generally cost more than JPCP or JRCP due to increased quantities of steel. The technique of CRCP construction with elastic joints (CRCP-EJ) facilitates significant reduction in quantity of steel required (0.4 - 0.5 percent) and also eliminates the random cracks which occur in conventional continuously reinforced concrete pavements.. However, CRCP is typically more cost-effective over the life of the pavement on high volume routes due to improved long-term performance and reduced maintenance. In CRCP, there are no transverse joints (expansion and contraction joint), properly built CRCP should have better ride quality and less it has less maintenance than JPCP. The expansion joints are provided only at the ends of the CRCP-EJ sections and there is no need of providing these in-between.

4. Precast Panel Concrete Pavement (PPCP)

PPCPs use panels that are precast off-site instead of cast-in-place. The precast panels can be linked together with dowel bars and tie bars or can be post-tensioned after placement. PPCP offers the advantages of:

- Improved concrete mixing and curing in a precast yard
- Reduced pavement thicknesses, which is beneficial when there are profile grade restrictions such as vertical clearances and
- Shorter lane closure times, which is beneficial when there are short construction duration.

8.2 JOINTS IN RIGID PAVEMENT

The location and types of joints shall be as per design and drawing. There are three general types of joints. These are:

A. Transverse Joints

These joints can be expansion, contraction or construction joints and shall be placed across the traffic direction.

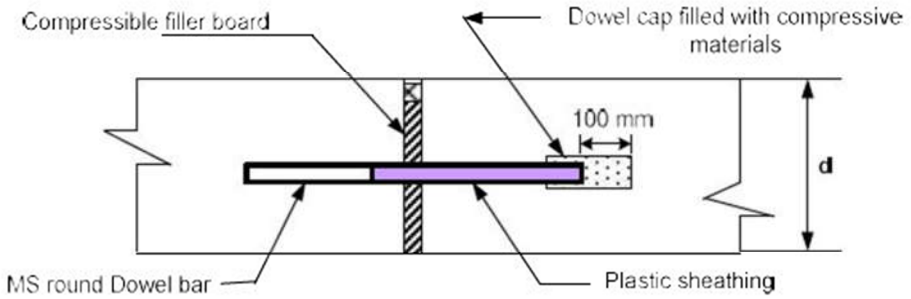
I. Expansion Joint

- Such a joint provides the space into which pavement can expand thus relieving compressive stresses due to expansion and inhibiting tendency towards buckling of concrete slabs.
- Expansion joints are 20-25 mm wide and these shall extend over the entire width of the pavement. They shall be provided only at bridge, under pass and culvert abutments. From the experiences around the world, in construction of rigid pavement has shown that there is no need to provide expansion joints at regular intervals but they are essential where cement concrete pavement is designed to adjoin with structures like bridges. Expansion

joints against culvert should normally be avoided by taking pavement over the deck of culverts.

- The dowel bar, plastic sheath or bitumen, filler board, compressible material, end caps and joint sealants are required for of construction of expansion joints.
- The grooves are constructed and shall have a depth equal to 25mm and shall be 20 to 25 mm wide. The pre-moulded synthetic expansion joint filler board of thickness 20-25 mm shall be used such that the height of filler board shall be such that its top is 25 mm below the surface of pavement and the compressible material shall be used to fill the gap/ grooves between adjacent slabs at expansion joint. The grooved can be formed by placing wooden strips of 20-25mm * 25 mm sections above the filler board. This can be pulled out when concrete sufficiently hardens. For easy removal of the wooden strip without damaging the edges, the sides of the strips may be shaped suitably.

Figure 8-1 Expansion Joint with Dowel Bar



Dowel Bar

- Dowel bars shall be mild steels round confirming to NS: 84:2042 and in accordance with details/ dimensions as indicated in the drawing and free from oil, dirt, loose rust or scale.
- The dowel bar shall be straight and free from irregularities.
- The dowel bar shall be supported on cradles/ dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs.
- The recommended dimensions of dowel bars in concrete pavement shall be as follows:

Table 8.1: Recommended Dimension of Dowel Bar

Slab thickness, mm	Dowel Bar Details		
	Diameter, mm	Length, mm	Spacing, mm
200	25	450	300
250	32	450	300
300	38	500	300
350	38	500	300

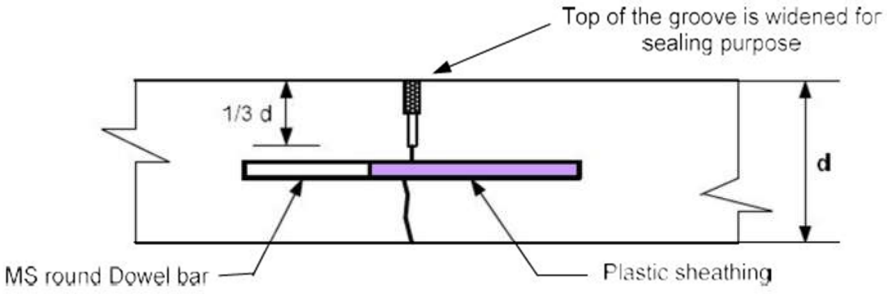
- Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of +- 20 mm, and ed equally about intended line of the joint within a tolerance of +- 20 mm
- The bond must be break bond between dowel bar and concrete. Generally two methods are used. One of the method is covering dowel bars with thin plastic sheath for at least 60 percent of the length from one end of dowel bars in contraction joint or half the length plus 50mm for expansion joint. The sheath shall be tough, durable and of average thickness not greater than 0.5 mm and shall have one closed and for expansion joint.

  The other method is that one half of the dowel bar is painted with a bond-breaking (un-bonded) layer of bitumen.
- This un-bonded portion of dowel is provide with expansion cap at the end. Cotton waste, sponge or other compressible material shall be inserted but not tightly packed before fitting the cap over the painted end of the dowel bar so that there is sufficient gap between the bar end and the inside of the cap. The caps are 100 mm long with closed end consisting of GI pipe of 3 mm thickness shall be placed over the end of each dowel bar. An expansion space at least equal in length to the thickness of joint filler board shall be formed between the end of the cap and end of the dowel bar using compressible sponge. To block the entry of cement slurry between dowel and cap it may be taped all around.
- Dowel bars are not required for low traffic volume roads i.e CVPD less than 150 and pavement thickness less than 200 mm.

II. Contraction Joint

- Such a joint releases tensile stress in the concrete and prevents formation of irregular cracks due to restrain in free contraction of concrete.
- Contraction joints also relieve stresses due to warping. These shall have a depth equal to 1/3 to 1/4 of pavement thickness and shall be 8 to 10 mm wide. The dummy groove type joint may be formed by driving or vibrating into the fresh concrete a flat metal bar or the web of a T-bar, held on its edges by guides. The metal bar shall be withdrawn as soon as the concrete has set sufficiently so as not to flow back in to the groove.
- Alternatively, the slot may be formed by sawing the concrete with joint cutting machine when the concrete has sufficiently hardened, that is, between 12 and 18 hours of laying of concrete under moderate climatic condition. Under extreme cold conditions this period may be suitably increased on the basis of experience.
- The procedure for construction is similar to expansion joint with dowel bars except that the pre-moulded joint filler is not provided and no expansion caps are necessary in case of dowel bars.

Figure 8-2 Contraction Joint with Dowel Bar



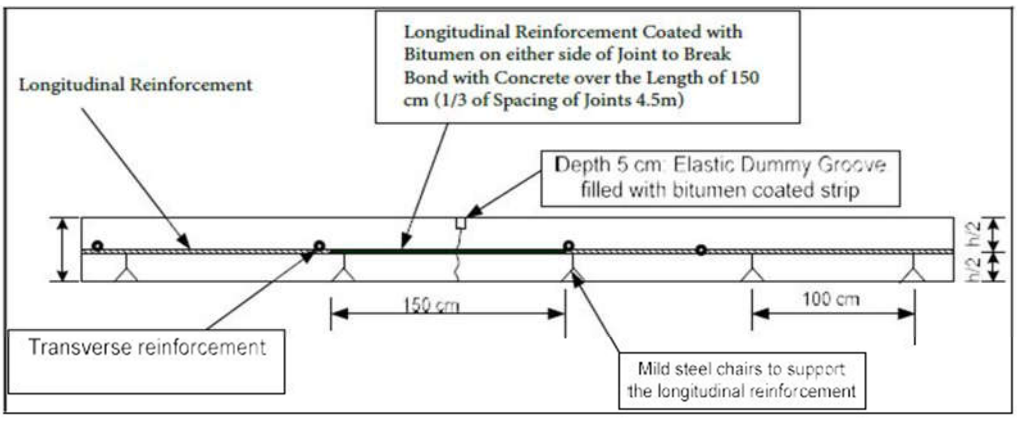
III. Construction Joint

- In addition, construction joints are provided whenever day's construction operation start and stops. Such joints are provided when concrete laying is suspended for more than 30 minutes. These are full depth joints.
- Construction should be so planned that day's construction activity may end at the location of contraction join except for the emergency stops. The procedure for construction is similar to contraction joint

IV. Elastic Joints

- These joints are provided in continuously reinforced concrete pavements, through which the steel reinforcement is not discontinued, but is painted with a bond-breaking agent on either side for length of 1/3- 1/4 of joint spacing in order to break the bond of steel with concrete and to provide greater length for elongation due to joint opening for reducing stress in the reinforcing steel.
- The dummy grooves are shall be made as in case of PCC or JRCC. As due to elastic or spring action of steel, the movement at these joints is much smaller than that for the dummy joints in PCC or JRCC pavement. The joint groove shall be formed and seal by the sealing compound. Alternatively, bitumen coated plywood strips of 5 cm width and 3 mm thickness maybe inserted therein.
- In CRC-EJ, the elastic joints shall be provided at the same spacing as joints for PCC pavements.

Figure 8-3 Details of Elastic Joint



❖ **Spacing of Transverse Joints**

The recommended spacing for expansion and contraction Joints are as given below in Table 8.2:

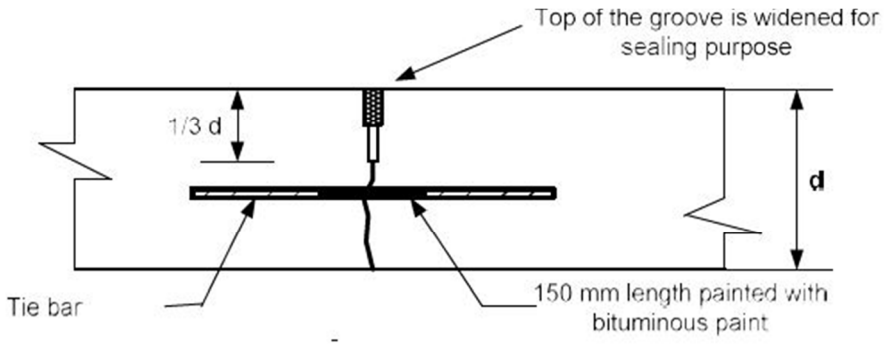
Table 8.2: Spacing for Expansion and Contraction Joints

S. No.	Types of Slab	Slab Thickness (m)	Spacing of Expansion Joint (m)	Spacing of Contraction Joint (m)
1	Reinforce Concrete	0.25 or above	51	17
		0.20	45	14
		0.15	36	13
2	Unreinforced Concrete Slabs	0.20 and above	36	4.5
		0.15	27	4.5
3	Continuously Reinforced Concrete Pavement with elastic joints		At the ends of CRC-EJ section or junctions with structures only	Elastic Joints at 4.5 Intervals

B. Longitudinal Joint

- Such a joint relives stresses due to warping. These are commonly used for longitudinal joints dividing the pavement into lane when width of the slab becomes more than 4.5 m. Longitudinal joints should be provided with tie bars to prevent progressive opening of the joints due to lateral movement of slabs.

Figure 8-4 Longitudinal Joint with Tie Bar



Tie Bars

- Tie bars in longitudinal joints shall be plain mild steel bars or deformed steel bars complying with NS standards.
- Tie bar are used across the joints of concrete pavements wherever it is necessary or desirable to ensure firm contact between slab faces or to prevent abutting slab from separating.
- Tie bars are not required for structural reasons but their only function being to prevent separation of the slabs, especially at fills of curves.
- Tie bars are not designed to act as load transfer devices. Tie bars are designed to with stand tensile stresses only.

- Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm in each side of the joint by a protective coating of bituminous paint with approval of Engineer. The coating shall be dry when the tie bars are used.
- Tie bars when provided shall be well supported so as not to be displaced during construction operations. These shall be bonded in the slabs across the joins and holes should be provided in the side shuttering to accommodate the tie bars.
- The diameter of tie bars should not be greater than 20 mm so as to facilitate angular warping movement at the joints and their spacing, not more than 750 mm and 800 mm for plain and deformed bar so as to avoid concentration of tensile forces.
- Joint grooves shall have a depth equal to 1/3 to ¼ of pavement thickness and shall be 6 to 8 mm wide. The dummy groove type joint may be formed by driving or vibrating into the fresh concrete a flat metal bar or the web of a T-bar, held on its edges by guides. The metal bar shall be withdrawn as soon as the concrete has set sufficiently so as not to flow back in to the groove.
- Alternatively, the slot may be formed by sawing the concrete with joint cutting machine when the concrete has sufficiently hardened, that is, between 12 and 18 hours of laying of concrete under moderate climatic condition. Under extreme cold conditions this period may be suitably increased on the basis of experience.

Spacing of Tie Bar

The spacing for Tie bar is as shown in Table 8.3

Table 8.3 : Spacing for Tie Bars

Slab Thickness	Tie Bar Details				
	Diameter (d) (mm)	Max. Spacing (mm)		Minimum Length (mm)	
		Plain Bars	Deformed Bars	Plain Bars	Deformed Bars
150	8	330	530	440	480
	10	520	830	510	560
200	10	390	620	510	560
	12	560	900	580	640
250	12	450	720	580	640
300	12	370	600	580	640
	16	660	1060	720	800
350	12	320	510	580	640
	16	570	910	720	800

8.3 CONSTRUCTION METHODOLOGY

8.3.1 Jointed Plain Cement Concrete (JPCC) or Plain Cement Concrete (PCC)

1. Approval of materials, plant, equipment and construction method: All the mentioned below must be followed;

i. Relevant test data of materials and construction methodology listing all steps, details of personnel and plant, equipment, batching and mixing of materials handling, curing texturing should be furnished by the Contract or before constructing the concrete pavement.
ii. Before construction of concrete pavement, ensure that the sources with test results of all materials to be used in the concrete work are approved by the Engineer well in advance, (at least 30 days before their use),
iii. The mix design based on laboratory trial mixes using approved materials is submitted for approval of the Engineer at least 30 days prior to the paving work.
iv. The mix design shall be based on the compressive strength of concrete as specified in the contract.
v. Mixing of materials shall be carried out in batching plant. All batching of materials shall be by weight. Volume batching may be allowed for small jobs with the approval of the Engineer. Minimum M 35 grade concrete is recommended. Water cement ratio should not be more than 0.45. Admixtures may be used to achieve the desired workability and strength after approval of engineer.
vi. Semi-mechanized and labor oriented construction techniques will be permitted. Plant, equipment and tools required for preparation and laying of concrete shall be as specified in the contract, Specifications.
vii. The minimum thickness of rigid pavement shall be 20 cm, however the pavement thickness shall be designed as per IRC standards.

2. Prepare the Sub-grade to the specified grade, cross-sections and cambers and compact to the design strength specified in the Contract. A day before placing the sub-base, clean the surface and apply a light spray of water on the sub-grade and roll with one or two passes of suitable 80-100 KN roller to stabilize any loose material.
3. Lay and compact granular or WBM sub base of the specified type and thickness. Near the bridge or culvert, an additional layer of 200 mm thick non-plastic GSB over the subgrade, should be provided in full panel length and full carriageway width.
4. Provide a separation membrane of 125 micron thick transparent or white in color, impermeable plastic sheet/geo-textile between sub-base/base and concrete slab. It should be laid without creases. Before placing the separation, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same at least 300 mm and any damaged sheathing shall be replaced at the contractor's cost. The separation membrane shall be nailed to the lower layer with the concrete nails.
5. Mark location and type of the joints on either side of the surface of the sub-base/base, with red paint for Contraction joints, construction, expansion and longitudinal joint. Provide joints as stated in Sub-chapter 8.2.
6. All side forms shall be of mild steel channels or fabricated plates with adjustable jacks at the back and of depth equal to the thickness of pavement. Plant, equipment and tools required for preparation and laying of pavement concrete are listed as specified in the contract.

7. Pavement concrete shall be produced near the site, using approved concrete mixers of at least 0.2 cum capacity. Ready mix concrete conforming to the specified properties of strength and workability may also be used.
8. Check the slump of concrete. It should be in the range of 30 mm ±10 m.
9. Concrete mixed in central mixing plant/batching plant shall be transported to site without delay and the concrete which has been mixed too long before laying will be rejected and shall be removed from the site. The total time taken from the addition of water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25^0C and 100 minutes when the concrete temperature is between 25^0C to 30^0C.
10. No concreting shall be done when the concrete temperature is above 30^0C. As placing of concrete in air ambient temperature s above 35^0C, is associated with defects like loss of workability through accelerated setting, formation of plastic shrinkage, cracks etc. It is recommended that unless adequate precautions are taken, no concreting shall be done in conditions more severe than above.
11. As the temperature of concrete mix is not to exceed 30^0C, it is desirable to use chilled water or ice flakes so that the temperature of the mix can be controlled in hot weather.
12. Under no circumstances shall the concreting operations continue when the temperature is less than 5^0C. In case of temperature below 5^0C, concrete heating capable of producing concrete that will have temperature of at least 15^0C and not exceeding 30^0C at the time of placing it between the forms shall be provided. The aggregates shall be heated prior to being loaded into the concrete mixture. The equipment used hall mix the mass uniformly and shall preclude the possible occurrence of overheated zone which might affect the concrete properties. Water used for mixing shall not be heated beyond 66^0C.
13. Concreting during monsoon is not recommended. However, under unavoidable situation, when concrete is being placed during monsoon months or during the period when it may be expected to rain, sufficient supply of tarpaulins or other waterproof cloth shall be provided along the line of work in addition to the portable tents. Any time when it rains, all freshly laid concrete which has not been covered for curing purposes shall be adequately protected by means of tarpaulins or waterproof cloth. Any concrete damaged by rain shall be removed and replaced. Any damage caused to the surface or texture shall be corrected as decided by the Engineer. All other precautions recommended before concreting in hot or cold weather shall be adhered to as far as possible.
14. Concrete shall be placed between the side forms and shall be leveled with rakes and shovels.
15. Around man-holes or other openings in pavement, place 12 mm thick pre-moulded board as specified or as shown in drawing and bar mats before concreting.
16. Compact concrete by a vibrator. In case of the work on gradient, the progress of all operations of placing, compacting and finishing of concrete should proceed from the lower to higher reaches. Slump of concrete mix in such situations should be adjust from field trails.

17. As soon as practicable after compaction of concrete, smoothening and finishing the surface with a longitudinal float operated from both side slab manually. The slab edge shall be straight in position parallel to the road line in contact with the surface.
18. After final floating and finishing of slab and Just before the concrete becomes non-plastic, it shall be textured with a long handled steel rectangular tines or wire brush. Tines grooves shall be 3 mm wide and 3 to 4 mm deep. Before commencing texturing, the bleeding water, if any, shall be removed and texturing shall be done on a firm surface. Normally, transverse lining will be preferred.
19. After completion of texturing , before the concrete has taken its initial set, the edges of the slab shall be carefully finished so as to leave the pavement edges smooth and true to line.
20. Provide joint saw cut. Joints shall be cut when the pavement is neither too soft nor too hard and is able to bear the weight of the machine and crew. Normally it may vary from 8 to 12 hours depending on weather conditions.
21. Forms shall not be removed from freshly placed concrete until it has set, or at least 12 hours whichever is later. They shall be removed in such a manner that no damage is done to edges of the pavement. After the forms have been removed, the slab edges shall be cleaned and any limited honey-combed areas pointed with 1:2 cement: sand mortar, after which the sides of the slab shall be covered with hessian fir curing.
22. Slabs with excessive honey-combing as a result of inadequate compaction shall be removed between nearest transverse joints and re-laid.
23. After completion of the finalizing operations, the surface of the pavement shall be covered with wet Hessian cloth, or jute mats. The coverings used shall be of such length or width that when laid will extend at least 500 mm beyond the edges of the slab and over entire surface. They shall be maintained fully wetted and in position for 24 hours.
24. Upon the removal of the wet covering out the end of 24 hours, the slab shall be thoroughly wetted and then cured by pounding or sprinklers of water. The water used for curing shall also be free from all injurious chemical like chlorides and sulphates.
25. The slab shall be covered with sufficient sandy soil so as to produce a blanket of earth not less than 40 mm thick after wetting. The earth covering shall be thoroughly wetted while it is being placed in the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days. The sand shall not be removed and shall thereafter remain in place till 28 days from date of casting so that the concrete has attained the required strength. Construction traffic may be allowed only after 14 days of paving with written permission of the Engineer. However, it is preferable to open traffic after 28 days of curing.
26. Suitable barricades and sign boards shall be erected and maintained and watchmen employed to exclude traffic from the newly constructed pavement for the period wherein prescribed and these barriers shall be so arranged as not in any way to interfere with or impede traffic on any lane intended to be kept open and necessary sign and lights shall be maintained clearly indicating open to the traffic.
27. After minimum of 28 days after casting the concrete pavement (i.e curing period is over) and before the pavement is opened to traffic, the intruded materials in all the joints shall be

removed completely and joint groove filled in with the sealing compound. The joint opening shall be thoroughly cleared of all foreign matter before the sealing material is placed. The contact face of the joint shall be cleared with wire brush to remove loose material and shall be surface dry when the sealing compound is used.

28. The contact faces of joint shall be primed with a thin bituminous paint which shall be allowed to dry before the sealing compound is applied. The primer shall be applied with a brush. Bituminous emulsion shall not be used as primers.
29. Sealing compound shall be poured into the joint opening in such a manner that the material will not get spilled on the exposed surface of the concrete. Any excess filler on the surface shall be removed immediately and the pavement surface cleaned.
30. After completion of sealing works, the traffic are opened.

8.3.2 Jointed Reinforced Concrete Pavement (JRCP)

- The construction procedure for JRCP is same as stated above procedure for PCC and in addition laying of longitudinal of longitudinal and transverse reinforcement as per design and specification before concreting. In case of high gradient or where fill up areas/very weak subgrade or high traffic road, reinforcement in single layer or in two layers in the PCC may be provided.
- The reinforcement in the concrete slabs is not intended to contribute towards its flexural strength so, its position within the slab is not important except that it should be adequately protected from corrosion. The cracks starting from the top surface are more critical because of ingress of water when they open up, therefore the general preference is for the placing of reinforcement about 50 to 60 mm below the top surface.
- Reinforcement is often continued across longitudinal joints to serve the same purpose as tie bars, but it is kept at least 50 mm away from the face of the transverse joints and edge.
- In special cases, the steel reinforcement shall be provided in acute curve portions, under passes, steep gradients and slabs having man-hole covers and slabs having length to breadth ratio more than 1.5 and at acute angled corners. Due care shall be taken to ensure that the reinforcement is not displaced during concreting operations.

8.3.3 Continuously Reinforced Concrete Pavements with Elastic Joints (CRCP-EJ)

- The construction procedure for JRCP is same as stated above procedure for PCC and in addition, the steel mats, assembled at site, are placed over suitable chairs at mid depth of the slab before concreting is done. The bars should be continuous across elastic joints and any construction joints.
- Where overlap of bars is required, a minimum overlap of 30 diameters should be provided. Such overlaps should be staggered. It should also be ensured that no overlap of steel bars is provided at the location of elastic joints.
- Elastic Joints and longitudinal joints are provided as stated in Sub Chapter 8.2.

- The expansion joints are provided only at the ends of the CRCP-EJ sections and at junctions with structures, there is no need of providing these in-between. Expansion joints are provided as stated in Sub Chapter 8.2. No need of contraction joints.

8.4 QUALITY CONTROL REQUIREMENTS

1. Material

(i) Cement

Cement of any of the following types Ordinary Portland Cement (OPC), High Strength Portland cement (HSPC), Portland Slag Cement (PSC) Portland Pozzolana Cement (PPC) shall be used meeting the physical requirements as per the NS:123/IS:4031. The Physical Characteristics requirement of the cement is given in Table 8.4.

Table 8.4: Requirement on the Physical Characteristics of Cement

S.No	Physical Characteristics	OPC/PSC	PPC	HSPC	Test Procedure
1	Fineness (m^2/kg)	225	320	225	IS-4031 Part2; PPC- IS 1489 Part 2
2	Initial setting Time (Minutes) minimum	45	30	45	IS-4031 Part5
3	Final setting Time (Minutes) maximum	600	600	600	IS-4031 Part5
4	Soundness (mm)	10	10	10	IS-4031 Part2
5	Compressive Strength: Minimum Average Compressive Strength of 3 mortar cubes (N/mm^2) 3 days 7 days 28 days	 16 22 33	 16 22 33	 27 37 53	IS-4031 Part6

(ii) Admixture

Chemical admixture conforming to IS: 6925 and IS: 9103 may be used to improve workability and strength of concrete.

(iii) Aggregate

(a) Aggregate for pavement concrete shall be as per Table 13.6 of Chapter 13 of this Manual with a Los Angeles Abrasion test value not more than 35% or Aggregate Crushing Value not exceeding 30%.

(b) Coarse aggregate shall be clean, hard, strong, dense, non-porous and durable crushed stone or crushed gravel.

The maximum size of coarse aggregate shall not exceed 20 mm complying gradation as per Table 13.5 of Chapter 13. It shall not have a flakiness index more than 15% and water absorption exceeding 2%.

(c) Fine aggregate shall be clean natural sand or crushed stone sand or a mixture of both complying with Table 13.7 of Chapter 13.

(iv) Water

Water used for mixing and curing concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter.

(v) Dowel Bars

These steel bars of NS standard shall be free from oil, dirt, loose rust, scale, and irregularities and burring. Dowel bars shall be positioned at mid depth of the slab within a tolerance of (±) 20mm. All bars in a joint shall be within (±) 5 mm in length of bar. Normally 500 mm long and spaced 300 mm c/c or as specified. They shall be parallel to the longitudinal axis of the pavement.

(vi) Pre-moulded Joint Filler

Bitumen impregnated filler board/pre-moulded synthetic joint filler board for expansion joints shall be 20mm thick within a tolerance of (+) 1.5 mm and of a firm compressible material in conformity with the requirements of IS:1838.

(vii) Joint Sealing Compound

Joint sealing compound shall be hot poured sealing compound type having flexibility, resistance to age hardening and durability and shall conform to IS:1834-1984.

3. Horizontal Alignment

The tolerance in horizontal alignment level of cement concrete pavement shall be

± 20 mm	Plain & Rolling Terrain
± 30 mm	Hilly Terrain

3. Surface Level

The tolerance in surface level of cement concrete pavement shall be (+) 5 mm or (-) 6 mm which may exceed up to (–) 8 mm at 0-300 mm from the edges.

4. Surface Regularity

The maximum allowable difference between the pavement surface and a 3 m straight edge/profile plate shall not exceed 6 mm for the longitudinal profile/cross profile.

5. Acceptance Criteria for cracked concrete slabs (one panel):

(i) Slabs with cracks penetrating to more than half the depth of slab shall not be accepted.

(ii) For cracks with depth less than half the depth of slab, no single crack shall exceed 750 mm length; cumulative length of such cracks in each slab shall not exceed 1250 mm.

6 Quality Control Tests

6.1 Tests Prior to Construction

The Quality Control Tests to be carried out prior to construction are indicated in Table 8.5

Table 8.5: Quality Control Tests Prior to Construction of Rigid Pavement

S. No.	Test	Frequency
1	Cement	As in Table 8.4
2	Fine Aggregates	As in Table 13.7
3	Coarse Aggregates	As in Table 13.6
4	Water	As in Table 13.8
5	Admixture - Chemical (For workability) (IS:6925 & IS:9103) - Mineral (Fly ash) (IS:3812)	Manufacturer's certificate before procurement - do -
6	Dowel bars (Plain steel) IS:432 (Part I)	Tests on 3 samples to determine yield strength
7	Pre-moulded Joint Filler (IS:1838) or Joint Sealing Compound(IS:1834)	Manufacturer's Certificate -do-
8	Plant, equipment and tools	As per contract
9	Concrete mix design.	To be approved by Project Manager
10	Granular Sub base/base	Table 6.2

6.2 Tests During Construction

The tests required to be carried out during construction are indicated in Table 8.6

Table 8.6: Quality Control Tests During Construction of Rigid Pavement

S. No.	Tests / Check	Frequency
1	Subgrade &Subbase	As in Tables 5.4 and 6.2
2	Gradation and moisture content of aggregate for CC pavement	As in Table 13.5 and 13.6

S. No.	Tests / Check	Frequency
3	Concrete workability	One test per 3 cum of concrete at paving site.
4	Strength of Concrete (IS:516)	Minimum 6 cubes (3 each for 7 day & 28 day strength) as per Table 13.10
5	Straightness of side forms (steel)(For paralleling and possible settlement and securing position before concreting)	To be checked daily
6	Size, spacing, paralleling of Dowel bars and location of different joints	To be checked prior to casting of concrete at the location.
7	Batching and Mixing of materials	Check for measurements and proper mixing
9	Compaction equipment (Needle, Screed and Plate vibrators)	For continuous working and stand by arrangement
10	Levels and Alignment i) Level tolerance (ii) Surface Regularity (Transverse and Longitudinal including camber/cross slope) (iii) Width of pavement and position of paving edges work Regularly at grid points (iv) Pavement thickness (v) Alignment of joints (vi) Depth of Dowel Bars	 to be checked for each day's work Regularly to be checked for each day's To be checked for each day's work -do- -do-

Chapter 9. BRICKWORK FOR STRUCTURE

9.1 CONSTRUCTION METHODOLOGY

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer. The following methodology shall be adopted for the construction of brickworks:

I. Excavate the foundation to required depth following the methodology provided in Sub-Chapter 5.4 and according to the design.
II. If the foundation is adequate, check the cross slope & check the foundation level and get approval from engineer before brick work is carried out.
III. After the completion of foundation work, construct the retaining structure following the steps given below:
IV. Soak all bricks for a minimum period of one hour before use and remove from water sufficiently in advance so that they are skin dry before actual laying.
V. Before laying the bricks in foundation, hack the top surface of the foundation block, clean, wet and spread a layer of mortar of 12 mm (minimum) thickness, to prepare the surface. In case of masonry works resting on rock base, lay a leveling course of 150 mm (average) thickness in concrete of M10 grade if required.
VI. Lay all brickwork in English bond, even and true to line, plumb or specified batter and level. All joints are staggered in successive courses and lay joints accurately. The bricks used on the face must be complete one with uniform size and true rectangular face.
VII. Lay all bricks with frogs up, if any on a full bed of mortar. Slightly press the bricks so that the mortar gets into all hollow space of bricks to ensure proper adhesion. Flush all joints and pack with mortar, to fill all hollow spaces.
VIII. To avoid unequal settlement and improper jointing, construct the brickwork in uniform layers so that no part of brickwork shall rise more than one meter above the general construction level in a day.
IX. Remove all loose bricks and mortar while joining partially set or fully set brick masonry with new one by roughening the surface and apply cement slurry on it to achieve proper bond. In case of vertical and inclined joints, achieve proper bond by inter locking the bricks.
X. Finish all joints on exposed faces to give a concave shape, the thickness of joint not exceeding 10mm.
XI. Masonry work in cement mortar is kept constantly moist on all faces for a minimum period of seven days. The top of masonry work is left flooded with water at the close of the day. During hot weather cover all finished or partly completed work by wet hessian jute or make it wet by watering to prevent rapid drying of brickwork. Continue watering and curing at the close of day's work or for other period of end of works. Curing is done at least for 7 days.

XII. Erect single scaffolding for plastering, pointing and any finishing in which one end of the putlogs/pole shall rest in the hole provided in the header course of brick masonry. Provide double scaffolding having two independent supports clear of the work when brick work is exposed and not to be finished.

XIII. Provide weep holes to masonry structures higher than 2 m to drain water from back filling. Use 100 mm dia HDPE pipes and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 2 m in horizontal or 1 m in vertical direction, with the lowest one at about 150 mm above the low water level or bed level whichever is higher.

XIV. Provide concrete coping of 150 mm thickness over the masonry where specified. While using precast or cast in site concrete coping, provide vertical construction joints at spacing of not more than 1.5 m

Pointing and Plastering

- For a surface which is subsequently plastered or pointed, make out the joints to a depth of 15 mm while mortar is green
- Carry out pointing using mortar of proportion shown on drawings but not leaner than 1:3 by volume of cement and sand. Fill and press mortar into the raked out joints before giving the required finish.
- Execute plastering using mortar of proportion where shown on the drawings but not leaner than1:4 by volume of cement and sand to the specified thickness which will not be higher than average thickness by 3 mm.
- Commence curing as soon as the mortar or pointing/plastering has hardened sufficiently. Keep the surface wet for a period of at least 7 days.

9.2 QUALITY CONTROL REQUIREMENTS

1. Materials

i. Bricks

First class burnt clay bricks conforming to the requirements of NS-1/2035 shall be used for the brick work with the physical requirements as given in Table 9.1.

Table 9.1: Physical Requirements of Bricks

Item	Requirements
Burnt Clay bricks	NS-1/2035 or IS:1077
Minimum Compressive Strength	Not less than 8N/mm^2 for individual bricks and 10 N/mm^2 for average 5 specimen.
Water absorption	Upto 20% by weight (IS:3495 Part 2)
Efflorescence	'Moderate' upto 50% of exposed area of brick covered with a thin deposit of salt but unaccompanied by powdering or flaking of Surface (IS:3495 Part 3)
Preferred size	According to the local practice or 230 x 110 x 50 mm

ii. Cement

The cement shall meet the physical characteristics given in Table 9.2.

Table 9.2: Requirements on Physical Characteristics of Cement for Brick work

S.No	Physical Characteristics	OPC/PSC	PPC	HSPC	Test Procedure
1	Fineness (m^2/kg)	225	320	225	IS-4031 Part2; PPC- IS 1489 Part 2
2	Initial setting Time (Minutes) minimum	45	30	45	IS-4031 Part5
3	Final setting Time (Minutes) maximum	600	600	600	IS-4031 Part5
4	Soundness (mm)	10	10	10	IS-4031 Part2
5	Compressive Strength: Minimum Average Compressive Strength of 3 mortar cubes (N/mm^2)				IS-4031 Part6
	3 days	16	16	27	
	7 days	22	22	37	
	28 days	33	33	53	

iii. Sand

Sand shall consist of hard, durable and clean particles, free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified of natural sand, crushed gravel, suitable combinations thereof and shall conform to the requirements as per IS2116 (1980) and given in Table 9.3 and the gradation of the sand shall be comply as per the Table 9.4.

Table 9.3: Requirement of Nature /Crushed Gravel / Crushed Stone Sand

S.No	Particulars	Requirements	Test Procedure
1	Deleterious material	Not more than 5% by mass	IS:2386 part 2
2	Stone/Marble Dust	Color of liquid shall be lighter than that indicated by standard solution specified in IS 2386 part 2	IS:2386 part 2

Table 9.4: Grading of Sand for the use of Masonry Mortar

IS Sieve	Percentage Passing by Mass	Test Procedure
4.75 mm	100	IS 2386 Part I
2.36 mm	90 – 100	
1.18 mm	70 – 100	
600 µ	40 – 70	

IS Sieve	Percentage Passing by Mass	Test Procedure
300 µ	5 – 70	
150 µ	0 – 15	

iv. Cement Sand Mortar

Cement Sand Mortar is a homogeneous mixture, produced by intimately mixing cement, water and inert materials, such as sand, to the required consistency for use in building together with masonry units. Cement Sand mortar shall in general conform to IS:2250 and its consistency shall be determined as per the code. The mortar used should have the strength not less than 5N/mm^2 or 7.5 N/mm^2 at 28 days as specified.

2. Workmanship and Tolerances

Permissible values of workmanship and tolerances for bricks and brick masonry are given in Table 9.5

Table 9.5: Workmanship and Tolerances for Brick Masonry

Item	Permissible Value
Dimensions of Bricks	±5 per cent in size
Thickness of joints for general brick work Plaster furnish	Not more than 10 mm Surface thickness, not less than specified thickness by more than 3 mm.

3. Quality Control Tests for Brick Masonry

3.1 Tests Prior to Construction

The tests / checks to be carried out prior to construction are indicated in Table 9.6.

Table 9.6: Quality Control Tests Prior to Construction of Brick Masonry

S.No.	Material	Test / Check	Frequency
1	Bricks	a) Color and Dimensional check b) Water absorption (IS:3495 Part 2) procurement c) Efflorescence (IS:3495 Part 3) samples at random, at source d) Compressive strength (IS:3495 Part 1)	3 samples at random at source In case of doubt, 5 samples at random at source
2	Cement	a) Setting time of cement (IS:4031 part 5) b) Fineness (IS: 4031 Part 1)	One samples of same type and grade of cement
3	Sand (Natural and crushed stone)	a) Gradation (IS: 2115) b) Deleterious material and organic impurities(IS: 2386 Part 2)	3 samples for each source of supply If in doubt, one test per source

S.No.	Material	Test / Check	Frequency
4	Water	Normally potable water is good enough. If impurities are present test as per IS:3025 (parts 17, 24, 32)	Samples taken at each source tested at an approved test house if doubt

3.2. Tests During Construction

The tests to be carried out during construction are indicated in Table 9.7

Table 9.7: Quality Control Tests During Construction of Brick Masonry

S.No.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	English bond, verticality by Plumb bob	For each course
2	Laying in Mortar	Laying in full bed of mortar with proper lapping	- do -
3	Individual Course	Height of course and Joint thickness (IS:2212)	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength (IS:2250)	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

Chapter 10. STONE MASONARY CONSTRUCTION

10.1 CONSTRUCTION METHODOLOGY

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer.

A. General Stone Masonry Work (Random Rubble masonry)

1. Excavate the foundation to required depth following the methodology provided in Sub-Sub- Chapter 5.4 and according to the design drawing.
2. If the foundation is adequate, check the cross slope & check the foundation level.
3. If foundation work is complete construct the retaining structure following the steps given below and get approval from the engineer before commencement of structural works.
4. Dress the stones of required size (least dimension not less than 150 mm) and quantity, immerse in water for sufficient time before use.
5. Before laying the stone in foundation, hack the top surface of the foundation block, clean, wet and spread a layer of mortar of 12 mm (minimum) thickness, to prepare the surface. In case of rock base, place concrete leveling course (M 10 grade) of average thickness of 150 mm.
6. Lay masonry work to lines, levels and dimensions as shown on the drawings. The stones shall be laid on their natural beds in horizontal courses. Keep height of each course same, fine tooled on all bed, joints and faces, full and true.
7. Lay outer layers of masonry first, fix the location of headers and bond stones and lay them. Lay stones in the heading on their broadest face to ensure filling the spaces between stones.
8. When there is to be variation in the height of the courses, place larger courses at lower levels with heights of courses decreasing gradually towards the top of the wall.
9. In tapered walls, the beds of the stones and planes of courses shall be kept right angle to the batter. In case of piers with batter on both sides, keep the course horizontal.
10. Lay all stones, full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet, immediately on placement and solidly embedded in mortar before it has set. Placing loosed mortar on the course and pouring water upon it to fill the gaps is not allowed.
11. Clean and wet chips and spalls can be used whenever necessary to avoid thick joints or bed of mortar. Ensured that no hollow space are left anywhere in masonry. Chips and spalls shall be used in the interstices between the adjacent stones in hearting only and shall not be more than 20% of the quantity of masonry.
12. In case any stone already set in mortar, is disturbed or the joint broken, take it out without disturbing the adjacent stones and joint. Reset the stone in fresh mortar after removing dry mortar and thoroughly cleaning the stones and joints.

13. Provide sufficient transverse bonds by the use of bond stones or set of bond stones extending from the front to the back of the wall from outside to the interior and vice versa, overlapping each other by 150 mm (minimum).
14. Make vertical joints truly vertical and staggered as far as possible. Keep the distance between vertical joints of upper and lower layer, more than half the height of the course.
15. Provide weep holes to masonry structures higher than 2 m of size not less than 80 x 150 mm to drain water from back filling. Use 100 mm dia. HDPE pipes and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 1 m in either direction or as shown in the drawing, with the lowest one at about 150 mm above the low water level or bed level whichever is higher or as directed by engineer.
16. Provide concrete coping of 150 mm thickness over the masonry where specified. While using precast or cast in site concrete coping, provide vertical construction joints at spacing of not more than 1.5 m
17. Commence curing as soon as the mortar or pointing/plastering has hardened sufficiently. Keep the surface wet for a period of at least 7 days.

10.2 QUALITY CONTROL REQUIREMENTS OF STONE MASONARY CONSTRUCTION

1. Materials

(a) Stone

Use stone which is hard, sound, and free from cracks, decay, and weathering, defects like cavities, flaws, sand holes and patches of loose or soft materials. Do not use stones with round surface. The specifications and requirements of stones shall satisfy those given in Table 10.1

Table 10.1: Physical Requirements of Stones

Item		Requirements
1	Least Dimension (IS:1597 Part 1) Length of stone Height of stone (IS: 1597 Part 1)	150 mm 3 times its least dimension or width of wall whichever is less 300 mm (Max)
2	Water Absorption in stone (IS:1124)	5 percent of its weight
3	Specific Gravity (IS: 1124)	2.5

Bond Stone

Each bond stone or a set of bond stones shall be provided for every 0-5 m^2 of the wall surface and shall be provided at 1.5 m to 1.8 m apart clear in every course.

Quoin-Stone

Quoin stone shall not be less than 0.03 m^3 in volume.

Hearting-Stone

The hearting or interior filling of wall face consist of rubble stone not less than 150 mm in any direction.

(b) Stone Masonry

The specifications and requirements of Stone Masonry shall satisfy those given in Table 10.2

Table 10.2: Requirements of Stone Masonry

Item		**Requirements**
1	Dressing of Stone	IS:1129 and IS:1597
2	Minimum height of individual course	150 mm
3	Thickness of joint	10 - 20 mm

2. Quality Control Tests For Stone Masonry

2.1 Tests Prior to Construction

The tests / checks to be carried out prior to construction are indicated in Table 10.3

Table 10.3: Quality Control Tests Prior To Construction of Stone Masonry

S. No.	**Material / Work**	**Test / Check**	**Frequency**
1	Stones	a) Shape and Dimension (IS:1597 part 1) b) Water absorption/Sp .gr (IS:1124) c) Dressing of Stones via Hearting, Bond, Quoin, Face stones, Headers, etc. (IS:1129)	3 samples on receipt at site 3 samples on receipt at site Once for each stock after selection for individual work
2	Cement	Setting time of cement (IS:4031 part 5)	1 samples of same type and grade of cement
3	Sand	a) Gradation (IS:2116) b) Deleterious materials and organic impurities (IS:2386 part 2)	3 samples for each source of supply, If in doubt, one test per source
4	Water	If impurities are present test as per IS:3025 (parts 17,24, 32)	If doubt Samples taken at each source tested at an approved test house
5	Mortar for Joints (Mix Design)	a) Mix proportions for different works b) Compressive Strength (IS:2250)	As required 6 samples of cubes for each type of cement & source of sand

2.2 Tests During Construction

The tests to be carried out during construction are indicated in Table 10.4

Table 10.4: Quality Control Tests During Construction of Stone Masonry

S. No.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	For stability and appearance with plumb	For each course
2	Laying in Mortar	Horizontality of courses verticality and staggering of joint	- do -
3	Individual Course	Height of course and Joint thickness and laying (IS 1597 part 1&2, IS:2212)	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength (IS:2250)	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

B. Dry Stone Masonry

Dry stone masonry shall be constructed generally to the requirement of random rubble masonry but with the omission of mortar. All the stones shall be carefully shaped to obtain as close as fit as possible at all bed and joints, any interstices between the stone being filled with selected stone spalls. The stone in course shall be laid perpendicular to the batter face.

Hands Feel Tests for Stones

The chief requirements of a building stone are strength, density and durability. All stones other than those of sedimentary origin are suitable for stone masonry work. Some of the requirements and simple tests are indicated below:

i. The stones should be hard, tough, compact grained and of uniform texture and color.
ii. They should be free from cracks, decay, weathering defects like cavities, flaws, veins, sand holes and patches of loose/soft material.
iii. Break a stone with a hammer. The surface of a freshly broken stone should be bright, clean and sharp and should show uniformity of texture without loose grains and be free from any dull chalky or earthy appearance.
iv. If a drop of dilute hydrochloric acid or sulphuric acid on a piece of stone causes effervescence, the stone contains weathering materials.
v. A sample of stone when struck with a 1 kg hammer should emit a ringing sound and should not break with one blow. A pen-knife when scratched on surface should not make an impressions on hard stone.

Chapter 11. FORMWORK AND SURFACE FINISH FOR STRUCTURES

11.1 CONSTRUCTION METHODOLOGY

11.1.1 Construction Operation of Formwork

1. Examine all materials and components used for formwork, for damage or excessive deterioration before use and reuse only if found suitable after repairs.
2. For timber formwork, inspect for physical damages, besides signs of attack by decay, rot or insect attack or development of splits.
3. Use familiar materials like timber, steel, plywood, concrete and masonry for false work. For metal forms, the thickness should be adequate to keep them true to shape. Use counter sunk bolts and permit use of approved internal steel ties or steel or plastic spacers. Bamboos supports shall not be provided.
4. Ensure false work (formwork + temporary support system) is designed to meet the requirements of permanent structure including ease of erection and dismantling and is approved by the Engineer.
5. Provide proper and safe access to all parts of formwork for inspection.
6. Make the formwork robust and use ballies of 100 mm dia of heights not more than 4 m. provide cross and diagonal bracings of 75 mm dia (ballies) in both directions. For metal forms, the diagonal bracings shall be of the same size of angles used for columns.
7. Check for design deficiencies such as shoring or re-shoring, insufficient allowance for unsymmetrical or eccentric loading due to placement sequence of concrete.
8. Pay attention to detailing which otherwise may cause instability, local failure or progressive collapse. Lay emphasis on attention to details.
9. In case of false work erected on normal ground, ensure distribution of loading to the ground, through timber or base plates to avoid differential settlement.
10. Control the alignment of the distribution members, so that shores of the false work system are centrally placed on the member.
11. Make the forms tight and sufficiently rigid by using ties and bracings to prevent any displacement or sagging between the supports.

11.1.2 Preparation before Concreting

1. Apply a coat of oil or grease as release agent, inside the surfaces of forms to prevent adhesion of concrete to formwork.
2. Make the formwork leak proof to prevent escape of cement slurry during compaction with vibrators. Clean the forms thoroughly just before concreting.
3. Line formwork with a proven material to provide smooth finish of uniform texture and appearance, without leaving stain on concrete.
4. Take special measure to ensure that the formwork doesn't hinder the shrinkage of concrete due to which cracking occur before the framework is removed.

11.1.3 Removal of Formwork

1. Plan removal of formwork (de-shuttering and de-ing) in advance. Give due consideration to the local conditions viz. character of structure, weather and other conditions that influence the setting of concrete and materials used in mix.
2. Lower ing gradually and uniformly so as to permit the concrete to take self-weight, uniformly and gradually to avoid shock or vibration. At reentrant angles of concrete sections, remove formwork soon after setting of concrete to prevent shrinkage cracking.
3. When internal metal ties are permitted, remove them or their parts without damaging concrete.
4. Fill the holes left out with cement mortar (1:3)
5. The time of removal of formwork when OPC is used without any admixtures is given in Table 11.1. Otherwise it may be taken as 14 days for Superstructure.

Table 11.1: Time for Removal of Formwork

Member	No. of days
Walls, piers, abutments, columns and vertical faces of structural members	1 to 2
Soffit of slab (with prop left under)	3
Props (left under slabs)	14
Soffit of girders (with props left under)	7
Props (left under girders)	21

11.1.4 Reuse of Formwork

i. After dismantling examine individual components for damage and remove damaged pieces for rectification.

ii. Straighten all bent steel props before reuse, the maximum deviation from straightness being 1/600th of its length. Maximum permissible axle loads on used props shall be suitably reduced depending on their condition.

11.2 QUALITY CONTROL REQUIREMENTS

1. Tolerances in Formwork

(a) Deviations from the specified dimensions of cross Section of columns, beams	+ 12 mm - 6 mm
(b) Deviations dimensions of footing/open foundation	
(i) Dimensions in plan	+ 50 mm
(ii) Eccentricity in plan 0.02 times the width	- 12 mm of the footings in the direction of deviation but not more than 50 mm
(iii) Thickness	± 0.05 times the specified thickness

2. Quality Control Tests

2.1 Tests Prior to Construction

The Quality Control tests to be carried out prior to construction are indicated in Table 11.2

Table 11.2: Quality Control Tests Prior to Construction of Form Work

S. No.	Test	Frequency
1	Thickness of Steel tubes	Before use / Procurement
2	Dia of 'ballies'	- do -
3	Size of panels (steel sheets / timber planks)	- do -
4	Formwork if in reuse (Clause 909 of MORD Specifications)	To be approved by Engineer
5	Design of formwork	To be approved by Engineer

2.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 11.3

Table 11.3: Quality Control Tests During Construction of Formwork

S. No.	Test	Frequency
1	Clamps for strength and stability of Form work	Regular
2	Camber and Surface smoothness	At the end of erection work
3	Mortar tightness	Before concreting
4	Supporting system on ground (To prevent settlement and distribution of load)	Check before/during concreting
5	Safe access onto and about the formwork	Regularly during concreting
6	Height of panels for supporting structures and return walls	Check before concreting

Note:

- Do not use form panels of height less than 1.0 m for abutments, piers and return walls.
- Do not keep and shutter on soft or filled up earth.
- Use large size panels to keep the number of joints to a minimum.
- Avoid sharp corners by providing fillets of 25 x 25 mm (minimum) size at all angles of formwork.
- Do not allow stagnation of water near the base plate supporting the staging.
- Use clamps of adequate strength to hold the forms together.

Chapter 12. STEEL REINFORCEMENT

12.1 CONSTRUCTION METHODOLOGY

12.1.1 Bending and Placing

1. Use reinforcement bars of the same type and grade as specified in drawing for construction.
2. Straighten the bars which get bent during transportation or handling. All reinforcement which has become corroded or rutted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from site or may be tested for compliance with appropriate IS standard.
3. Reinforcement shall be cut, bend and fix as per bending schedule provided in drawing. Bars shall be bent mechanically using appropriate benders. Bars shall be bent cold by the application of slow steady pressure.
4. Provide a U type hook at the end of each bar unless otherwise specified. The total length of hook is the sum of radius of bend (twice the diameter of the bar) and the length of the straight part of the bar beyond the end of curve (at least 4 times the diameter of the bar).
5. Place reinforcement bars accurately in position as shown on drawings. Make the skeleton of Reinforcement rigid by tying all bars crossing one another at every intersections using annealed binding wire not less than 1 mm diameter.
6. Position the bars on industrially produced polymer cover blocks or concrete cover blocks of required thickness, to provide cover to reinforcement.
7. Position the vertical projected reinforcement from sub-structure or foundation, by means of timber templates with slots cut in them accurately or with cover blocks tied to the reinforcement.
8. Separate layers of reinforcement by spacer bars at a maximum length of 1m, keeping the minimum diameter of spacer bar as next higher size of main reinforcement.
9. At construction joints, bend aside reinforcing bars and bend back to the original position, by ensuring that concrete around the bar is not damaged beyond the bend.

12.1.2 Splicing, Welding and Substitution of bar sizes

1. Stagger the lapped splices and place at points along the span where stresses are low.
2. Keep a minimum spacing between overlapped bars of 25 mm or 1¼ times the maximum size of coarse aggregate whichever is greater.
3. Bars are cleaned of all loose scale, rust, grease etc, before carrying out welding by metal arc welding process.
4. Butt weld all bars except bars of dia less than 20 mm, which are to be lap, welded.

5. Locate welded joints well away from the bends and not less than twice the bar diameter from a bend.
6. The bars are laid by staggering the weld joints such that at any section less than 20% of the bars are welded.
7. Substitute bars where necessary with the same type and grade after ensuring the minimum area provided is equivalent to the original at each cross section.

12.2 QUALITY CONTROL REQUIREMENTS

1. Material

i. The Steel reinforcement used and works executed shall conform to the requirements given in Table 12.1

Table 12.1 Requirements of Reinforcement

Grade Designation	Bar type conforming to governing IS Specification	Characteristic strength (fy) MPa	Elastic Modulus GPa
Fe 240	NS:84/IS:432 Part I Mild Steel	240	200
Fe 415 of Fe 415 D	NS:191/IS:1786 High Strength Deformed Bars (HYSD) or Thermo technically Treated (TMT) bars	415	200
Fe 500 or Fe 500 D	IS:1786 High Strength Deformed Bars (HYSD) or Thermo technically Treated (TMT) bars	500	200
Fe 550 or Fe 550D	IS:1786 High Strength Deformed Bars (HYSD) or Thermo technically Treated (TMT) bars	550	200

ii. The workmanship for welding of steel reinforcements shall conform to the specifications given in Table 12.2

Table 12.2: Workmanship for Welding

Welding of Mild Steel	IS:432
Welding Method	IS:2751 and IS:9417
MS Electrodes for welding	IS: 814
Inspection of Welds	IS: 8222

2. Tolerances

The Reinforcement shall be placed within tolerances given in Table 12.3

Table 12.3: Tolerances for Cover for Reinforcement Work

Member/Cover	Tolerance
Members with effective depth less than 200 mm	± 10 mm
Members with effective depth more than 200 mm	± 15 mm
Cover	+ 10 mm (No minus tolerance permitted for cover)

3. Quality Control Tests

3.1 Tests Prior to Construction

The Quality Control tests to be carried out prior to construction are indicated in Table 12.4

Table 12.4: Quality Control Tests Prior to Construction of Reinforcement

S. No.	Test	Frequency
1	Grade, percentage elongation and ultimate tensile strength (For culverts and small bridges) (IS:432 part 1 and IS:1786)	3 samples from each supplier (certificate from an approved test house)
2	Pitch of the Ribs and Nominal Diameter	Random checking
4	Substitution of bar sizes	Approval before execution of work
5	Detailing of reinforcement cages	Approval before execution of work

3.2 Tests During Construction

The Quality Control tests to be carried out during construction are indicated in Table 12.5

Table 12.5: Quality Control Tests During Construction of Reinforcement

S. No.	Test	Frequency
1	Bending and placing of reinforcement (IS:2502)	Daily/Regularly
2	Splicing and welding	As and when such work is taken up
3	Tolerances (Spacing and cover)	Before concreting

Note

- *Protect reinforcement steel from rusting or chloride contamination, by thorough cleaning using suitable method before use.*
- *Follow the working drawings and bar bending schedules and match detailing and construction.*
- *Do not weld reinforcement at site welding unless adequate facilities, equipment etc to maintain quality is attainable.*

Chapter 13. PLAIN AND REINFORCED CEMENT CONCRETE FOR STRUCTURES

13.1 CONSTRUCTION METHODOLOGY

I. PRODUCTION OF CONCRETE

1. Designate concrete in grades viz M10, M15, M20, M25, M30, M40, M45 where the characteristic strength of concrete is defined as the strength of concrete below which not more than 5 percent of the results are expected to fall.
2. Choose Design Mix of grades higher than M20 for large works. For culverts and small bridges involving small quantity of concrete, nominal mix of grades M20 and M25 may be used with adequate supervision and quality control measures.
3. The suggested grades of concrete together with cement content, for different exposure conditions indicated in Table 13.1. Letter M in class designations stands for Mix, Letter SM stands for Special Mix.

Table 13.1 : Cement Content and Maximum Water Cement Ratio

Classes of concrete	Minimum Cement Content in Kg/ m^3 of Compacted Concrete		
	Moderate Exposure	Intermediate Exposure	Severe exposure
M 10/75, M 10/40	125	150	175
M 15/40, M 15/20	150	200	225
M 20/40, M 20/20	250	300	325
M 25/20, M 25/40	300	325	350
M 30/40, M 30/20, M 30/12	325	350	375
M 35/40, M 35/20			
M 40/20, M 45/20, M 50/20	375	400	425
SM 30/20, SM 30/40	400	400	425
SM 40/20, SM 45/20	425	425	450

Note: *The minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required. The categories applicable to the works are based on the factors listed hereunder:*

Moderate Exposure: Concrete surface sheltered from severe rain or freezing whilst wet concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non aggressive soil/ground water.

Intermediate Exposure: Concrete exposed to severe rain, alternate wetting and drying or occasional freezing whilst or severe condensation.

Severe Exposure: Surface exposed to water having a PH of 4.5 or less, ground water containing sulphates.

4. The cement content shall not be more than 450 Kg/m^3 unless special consideration has been given in design to cover the risk of cracking due to drying and shrinkage in thin section or to early thermal cracking and to the increased risk of damage due to alkali silica reaction.
5. For "Smaller Contracts Works", the following compositions shown in Table 13.2 are suggested as a starting basis for the Laboratory trials for one m^3 of concrete.

Table 13.2: Quantity of Materials Required for Different Grade of Concrete

Class of Concrete	Characteristic Strength (N/mm^2)	Cement (Kg)	Total Aggregate (Kg)	Fine Agg./ Total Agg. (%)	Maximum Water (Ltr)	Workability
M 15/40	15	250	1900	35 - 45	160	Stiff-Plastic
M15/20						
M20/20	20	300	1875	35 - 45	160 – 170	Stiff
M30/40	30	350	1825	35 - 45	170	Stiff
M30/20	30	350	1825	35 - 45	175	Plastic
M35/20	35	350	1825	35 - 45	175	Plastic

Consistency of mix assessed through the slump test where the slump is measured in mm is designated as below:

S : Stiff consistency, for slump ≤ 40

P : Plastic consistency, for slump › 40 and ≤ 90

VP: Very Plastic consistency, for slump › 90 and ≤ 150

F : Flowing consistency, for slump › 150

5. Use Mechanical mixer (min. one bag capacity) fitted with water measuring device for culverts and small bridges with length less than 60 m and individual span less than 15 m. However for control mix of M 25 for superstructure, use mechanical mixer of minimum 200 liter capacity having integral weigh batching facility, automatic water measuring and dispensing device.

6. Avoid hand mixing of concrete for use in structural concrete except for isolated culverts (upto 2 m) in remote areas or for certain other reasons. Add 10% extra cement in such situations.

7. Use Admixtures where necessary or instructed by engineer to meet specific requirements of concrete.

II. TRANSPORTATION, PLACING AND COMPACTION OF CONCRETE

1. After mixing, transport concrete to the formwork as quickly as possible in wheel borrows to site.
2. Transport and place concrete such that no contamination, segregation or loss of its constituent materials or ingress of foreign material or water takes place.

3. During hot or cold weather, concrete shall be transported in deep containers or other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.
4. Proceed with concreting continuously, over the areas between construction joints. Deposit concrete in horizontal layers to a compacted depth of not more than 450 mm, when internal vibrators are used and not more than 300 mm in other cases.
5. Choose appropriate methods of placing concrete so as to avoid segregation.
6. Care should be taken to avoid displacement of reinforcement or movement of formwork. As a general guidance, the maximum permissible free fall of concrete may be taken as 1.5 m.
7. Compact concrete using internal (needle/poker) vibrators of suitable size or form vibrators, during placing and worked around the reinforcements, to produce dense, homogeneous and void free mass.
8. Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators should receive special consideration to ensure efficient compaction and to avoid surface blemishes.
9. Compact before the initial setting but not later than 30 minutes of its discharge from the mixer

III. CONCRETING UNDER WATER AND IN EXTREME WEATHER

1. When it is necessary to deposit concrete under water, add 10 percent more cement than required and place the mix dry. Proportion the materials so as to produce a slump between 100-180 mm.
2. Make cofferdams or forms in water, sufficiently tight to prevent loss of mortar through the joints in the walls. Avoid pumping of water, while concrete is being placed or until 24 hours thereafter.
3. Concrete cast under water should not fall freely through the water. Otherwise it may be leached and become segregated. Concrete shall be deposited, continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided.
4. Where concrete is to be deposited at or near freezing temperatures, heat the mixing water to temperature below 65^0C and if necessary heat the aggregates as well, before mixing. In general the temperature of water and aggregate shall not be more than 65^0C
5. When concrete is to be deposited in hot weather, ensure that the temperature of green concrete does not exceed 30^0C before placement. Ensure this by mixing water with ice and keeping the aggregates under shade before use and cool the outside of formwork by water sprinkling.

IV. CURING PROTECTION AND FINISHING

1. Commence curing and protection immediately after the compaction of concrete, to prevent premature drying, leaching out by rain etc.
2. After initial set (about two hours) of concreting, cover the work with moist gunny bags, canvas, hessian or similar material.

3. After 24 hours, keep all exposed surfaces of concrete in damp or wet condition by pouring or by wet covering with a layer of sacks, canvas, and hessian for a period of not less than fourteen days from the date of placement.
4. Use curing compounds only in special circumstances. Avoid use of curing compound at locations where concrete surfaces are required to be bonded together.
5. Examine concrete immediately on removal of formwork and any defects are be made good. Cut all exposed bars or bolts passing through RCC member and used for shuttering or any other purpose, to a depth of 25 mm below the surface of the concrete and close the holes with cement mortar.

V. CONSTRUCTION JOINTS

1. Do not place fresh concrete against concrete which has hardened in position for more than 30 minutes or initial set unless proper construction joint is formed.
2. Before concreting fix a stopping board at predetermined position, for vertical construction joint, which has adequate lateral rigidity to withstand lateral displacement or bulging during concreting.
3. Continue concreting up to the board. Remove the board before expiry of 24 hours.
4. Before resuming work on a partially hardened surface, remove all laitance by scrubbing the wet surface with wire or bristle brush. Coat the prepared surface, thoroughly wetted, with cement grout. Keep thickness of first layer of fresh concrete upto 150 mm and well ram against old work.
5. Before resuming work on a fully hardened surface, hack the surface without dislodging coarse aggregate, clean loose material, wet it and cover with a layer of cement grout.
6. Ram the first batch of concrete against old work, to avoid formation of any pockets, by paying attention to corners and close spots.
7. Carefully tool all construction and expansion joints in the completed work, free from any mortar and concrete. Leave expansion joint filler exposed for its full length with clean and true edges.

13.2 QUALITY CONTROL REQUIREMENTS

1. Materials

(i) Cement

Use any of the following types of cement given in Table 13.3 for Structural Concrete

Table 13.3: Types of Cement

Type	IS Code
Ordinary Portland Cement (OPC)	IS:269; IS:8112
High Strength Portland Cement (HSPC)	IS:8112
Portland Pozzolana Cement(PPC)	IS:1489 (Part 1)
Portland Blast Furnace Slag Cement (PSC)	IS:455

Obtain samples of cement once for each source of supply and occasionally when called for determine various properties given in Table 13.4

Table 13.4: Requirements of Physical Characteristic of Cement

S.No	Physical Characteristics	OPC/PSC	PPC	HSPC	Test Procedure
1	Fineness (m^2/kg)	225	320	225	IS-4031 Part2; PPC-IS 1489 Part 2
2	Initial setting Time (Minutes) minimum	45	30	45	IS-4031 Part5
3	Final setting Time (Minutes) maximum	600	600	600	IS-4031 Part5
4	Soundness (mm)	10	10	10	IS-4031 Part2
5	Compressive Strength: Minimum Average Compressive Strength of 3 mortar cubes (N/mm^2) 3 days 7 days 28 days	 16 22 33	 16 22 33	 27 37 53	IS-4031 Part6

(ii) Coarse aggregates

The gradation of coarse aggregate shall satisfy the requirements given in Table 13.5

Table 13.5: Gradation of Coarse Aggregate

	Percent by weight passing the sieve			
IS Sieve Size	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
63 mm	100	-	-	-
40 mm	95-100	100	-	-
20 mm	30-70	95-100	100	-
16 mm	-	-	90 - 100	100
12.5 mm	-	-	-	90-100
10.0 mm	10-35	25-55	30 - 70	40-85
4.75	0-5	0-10	0 - 10	0-10

Table 13.6: Other Physical Requirements for Coarse Aggregate

S.No	Type of Tests	Requirements
1	Flakiness Index (IS: 2386 Part 1)	Maximum 25 for ordinary concrete Maximum 15 for high quality concrete
2	Water absorption (IS:2386 Part 3)	Maximum 2%
3	Los Angeles Abrasion (IS:2386 Part4)	Maximum 45% for ordinary concrete Maximum 35% for high quality concrete
4	Aggregate Crushing Value (IS:2386 Part4)	Maximum 30% for pavement structures Maximum 45% for other structure

(iii) Fine Aggregates

The gradation of fine aggregates shall satisfy the requirements given in Table 13.7

Table 13.7 : Gradation of Fine Aggregates

IS Sieve Size	Percent by weight passing the sieve			
	Zone I	Zone II	Zone III	Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 Micron	15-34	35-59	60-79	80-100
300 Micron	5-20	8-30	12-40	15-50
150 Micron	0-10	0-10	0-10	0-15

(iv) Water

Samples of water used in making mortar and concrete are tested once for approval of source of supply and subsequently only in case of doubt. The permissible limits for solids in water shall be as per Table 13.8

Table 13.8: Limits for Solids in Water

Types of Solid	Maximum permissible limit
Organic	200 mg/litre
Inorganic	3000 mg/litre
Sulphates (as SO4)	400 mg/litre
Chlorides (as Cl)	2000 mg/litre (For Plain Concrete) 500 mg/litre (For Reinforced Concrete
Suspended matter	2000 mg/litre

(v) Concrete

The grades of concrete and their equivalent nominal mix are given in Table 13.9 as reference only.

Table 13.9 : Nominal Mixes of Concrete

Grade of Concrete	Nominal Mix by volume
M 10	1:3:6
M 15	1:2.4
M 20	1:1.5:3
M 25	1:1:2

Add approved quality of plasticizer @ 300 ml per 50 kg of cement to M 25 grade concrete or as per Manufacturers specifications

(vi) Frequency of Sampling

The minimum frequency of sampling of concrete of each grade is given in Table 13.10

Table 13.10: Frequency of Sampling of Concrete

Quantity of concrete in work (m^3)	No. of samples
1-5	1
6-15	2
16-30	3
31-50	4
51- and more quantity of work	4 plus one additional for each 50 m^3 or part of it.

2. Quality Control Tests / Checks

2.1 Tests Prior to Construction

The tests and checks to be carried out prior to construction are indicated in Table 13.11

Table 13.11: Quality Control Tests Prior to Construction of PCC/RCC

Material / Work	Test / Check	Frequency
Cement	a)Setting Time (IS:4031 Part 5)	One test for 200 tonnes of cement (same brand & grade)
	b) Soundness (IS:4031 Part 3)	- do –
	c) Compressive strength of mortar cube (IS:4031 Part 6)	one set for 200 tonnes of cement (same brand and grade)
Coarse Aggregates	a) Gradation for PCC or RCC works	One set of test for each quarry source
	b) Flakiness index (IS:2386 part 1)	-do -
	c) Deleterious constituents (IS:2386 part 2)	If in doubt Once for each source of supply
	d) Water absorption / content (IS:2386 part 3)	One test per source of supply
	e) Aggregate Crushing value (IS:2386 part 4)	- do –
	f) Soundness (IS:2386 part 5) [if water absorption exceeds 2%]	
	g) LAA (IS 2386 -4)	-do-
Fine Aggregates	a) Gradation (IS:2720 part 4)	One test for each source of supply
	b) Deleterious Constituents (IS:2386 part 2)	If in doubt, one test per source
Water	Normally potable water is good enough	

Material / Work	Test / Check	Frequency
	for making concrete. Determination of Impurities - Suspended matterIS:3025 (Part 17) - Organic IS:3025 (Part 16) - Inorganic IS:3025 (Part 19) - Sulphates (as SO3) IS:3025 (Part 24) - Chlorides (as Cl) IS:3025(Part 32)	For large works If the quality is in doubt Samples taken from each source and tested at an approved test house
Reinforcement	As per Table 12.1 and 12.4	As per Table 12.1 and 12.4
Concrete	Mix Design (for each work)	Well before the commencement of work and approved by Engineer

2.2 Tests / Checks During Construction

The tests required to be carried out during construction are indicated in Table 13.12

Table 13.12: Quality Control Tests During Construction of PCC/RCC

S.No.	Material / Work	Test / Check	Frequency
1	Fine and coarse aggregate	Gradation (IS2720 Part4) Water Absorption (IS:2386 part3) Flakiness index (IS:2386 part 1) Aggregate Crushing value (IS:2386 part 4) LAA (IS 2386 -4)	Each delivery and every 100 t or part of it for fine aggregate and 250 t or part of it for coarse aggregate
2	Cement	a) Setting Time (IS:4031 Part 5) b) Compressive strength of mortar cube (IS:4031 Part 6)	Each supply and not less than 200 t or part of it -do-
3	Reinforcement	As per Table 12.5	As per Table 12.5
4	Concrete	a) Workability .– Slump cone test (IS:1199) b) Cube Strength (IS:516)	2 tests/ day As per Table 13.10
5	Construction Joints	Fixing location before concreting and resumption of work	As and when work demands
6	Formwork	For stability, leakage of slurry, bulging etc.	Throughout concreting

S.No.	Material / Work	Test / Check	Frequency
7	Concreting	a) Transporting / placing segregation of concrete b) Precautions for hot weather or cold weather concreting c) Compaction with vibrators	Random check in each member Once check before commencement of work Regularly
8	Curing of concrete	Regular (till 28 days after casting) inspection	Daily

13.3 PLUM CONCRETE

- The use of aggregate as an inert filler can be extended to the inclusion of large stone up to 300 mm size in a normal concrete; thus the apparent yield of concrete for a given amount of cement is increased. The resulting concrete is called "Plum Concrete" or "Cyclopean Concrete".
- These large stones are called 'plums" and used in a large concrete mass. Composition of the plum concrete shall be 60 to 70 % M 15 concrete and 40 to 30 % of stones by volume. This is achieved by placing a layer of normal concrete, then spreading the plums, followed by another layer of concrete and so on. The grade of concrete used for plum concrete shall be minimum of M 15.
- The plums must have no adhering coating. Otherwise, discontinuities between the plums and the concrete may induce cracking and adversely affect permeability.
- The proportion of plums should not exceed 40 per cent of total volume of plum concrete /plum masonry. The stone size to be used for plum shall be between 200 to 300 mm. The stone shall be basalt, trap or any other approved locally available stone from quarries approved by Engineering.
- The stone shall be hard durable and tough free from mud and other deleterious materials. The length of stone shall not exceed 3 time its height. The coarse aggregate shall be 25 mm down. The water cement ratio shall be adjusted at site to maintain the flow ability of concrete to fill all the interstices properly. The plums are laid in layers using the cement concrete as mortar.
- Double scaffolding shall be provided for construction and piercing of walls for scaffolding shall not be permitted.
- Form work shall be of ply wood or steel.

13.3.1 CONSTRUCTION METHODOLOGY

a. Where the plum concrete is used for retaining structures the preparation of foundation for the wall shall be as per Chapter 10 of this Manual. Similarly the concrete used shall be prepared as per preparation of Plain Cement Concrete
b. Form work shall be placed in position and approved before the placing plum concrete. The form work shall be according to Chapter 11 of this Manual

Placing Plum in concrete

c. The place to be filled up with the plum concrete shall be cleaned and chipped for adhesion with the concrete.
d. Following completion of form work a layer of concrete minimum 100 mm thick shall be laid upon which clean and moist stones shall be placed at a distance of min 100 mm measured from face to face in any direction.
e. The distance between the outer edge of the concrete mass and the nearest face of the stone to the edge shall not be less than 100 mm.
f. Lay the plum on the laid concrete approximately covering 30 to 40 % of the volume of concrete used for each layer.
g. Then another layer of concrete having thickness not less than 100 mm measured from the top of the stone to the top surface of the layer or half-height of the plum shall be laid and compacted. Compaction is carried out in each layer of concrete with the help of vibrator.
h. The concrete shall be deposited as nearly 'as practicable in final position and shall not be piled up in large masses at any point and then pushed, shovelled, or vibrated into space for large distances
i. Place another layer of plum in scatter position and fill the concrete to the half-height of the newly laid plum.
j. Repeat the step (d) to (i)
k. The plum shall be raised uniformly, and no part, at any time shall be raised more than 450 mm above adjoining work.
l. The stones shall not be dropped in place, but each stone shall be laid and carefully embedded so as to avoid any injury to the forms or adjacent masonry and in such a manner that no planes of weakness of unnecessary seams occur in the structure.
m. Care must be taken to ensure that no air is trapped underneath the stones.
n. Concrete shall be systematically deposited in shallow layers and at such rate as to maintain, until the completion of the unit, a plastic surface approximately horizontal throughout.
o. Each layer shall be thoroughly compacted before placing the succeeding layer.
p. Weep holes shall be provided by HDPE pipes buried in plum masonry. The end of the weep holes, on the filled up side, shall be covered by geo-membrane and filled by gravels of sizes 40 mm.
q. All plum concrete/ plum masonry shall be thoroughly wet for at least 7 days and maintained for 28 days.

13.3.2 QUALITY CONTROL REQUIREMENTS

1. Materials

Requirements of Cement Sand and Aggregate: As per Table 13.4, 13.7 and 13.5.

Stone (Plum): Size	:	200 - 300 mm
Water absorption	:	5% maximum
Specific Gravity	:	2.5 minimum

2. Quality Control Tests / Checks

2.1. Tests Prior to Construction

The tests and checks to be carried out prior to construction for concrete shall be as per Table 13.11 and for stone shall be as per Table 10.3.

2.2. Tests / Checks During Construction

The tests required to be carried out during construction for concrete shall be as per Table 13.12 and for stone shall be as per Table 10.4.

Chapter 14. PIPE CULVERTS

14.1 CONSTRUCTION METHODOLOGY

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer

14.1.1 Excavation of Foundation for Pipes

1. Lay the pipes in shallow excavation of natural ground or in open trenches cut in existing embankments taken down to required level as shown on drawing.
2. For embankments of height of fill more than 3 m, or three times the external dia of pipe above bed level, construct the embankment to the level above the top of the pipe (equal to external dia of pipe) and width not less than five times the dia of pipe. Lay the pipe in trench after the construction of embankments.
3. While trench cutting is involved, the width of pipe bed is cut minimum of 150mm on either side of pipe not exceeding one-third the diameter of pipe and the cut should be as vertical as possible.
4. If spongy, soft or other unstable material is met with at the location of pipe culvert, remove the material to the required depth, width and length, and back fill with approved granular material properly shaped and compacted to the required level as directed by the engineer.
5. Where rock or boulder strata is met with, take down excavation to at least 200 mm below the bottom level of pipe, remove all loose material and fill the space with sand moorum or approved granular material, passing 4.75 mm sieve
6. The minimum bed slope for pipe bed shall be 1:20.

14.1.2 Loading and Unloading of Pipes

1. Make arrangements for lifting, loading and unloading of pipes from factory/yard to site, such that no undue strain or damage occurs due to fall or impact.
2. For manual unloading from trucks, roll down pipes on a pair of skids hooked onto the trucks and control movement with a rope passing round the pipes.

14.1.3 Bedding for Pipe

1. Provide a cradle constructed of plain concrete not leaner than M 15 as the bedding for pipes of internal dia 900 mm or more and when height of fill is more than 4 m above the pipe.
2. When height of filling is less than 4 m above the pipe. Make a continuous layer of well compacted sand, moorum or approved granular material, passing 4.75 mm sieve and shaped concentrically, to fit the lower part of the pipe exterior for a minimum 10 per cent of its overall height. The compacted thickness of the granular bedding layer shall not be less than 75 mm.

3. For expansive soils, provide a layer of sand/moorum on non-expansive material of minimum 450 mm thickness under the bedding

14.1.4 Laying of Pipes

1. Preload the areas to induce major portion of settlement before the pipe is installed.
2. Lower the pipes in bed either by tripod pulley arrangement or by manual labour using chain pulley blocks in a manner to place them in proper position without damage.
3. When two or more pipes are laid adjacent to each other, place them separated by a distance equal to half the dia of the pipe subject to a minimum space of 500 mm.
4. When pipes are laid in two layers, keep the s of pipes such that when joined shall form equilateral triangles.
5. Lay the pipes on the prepared foundation, commencing from outlet and proceed towards the inlet.

14.1.5 Jointing

1. Join the pipes either by collar joint or by flush joint. Place the collar such that it coincides with the joints and even annular space is left between the collar and the pipe.
2. Choose either internal flush joint or external flush joint. Fill the jointing space with1:2 cement mortar, which remains in position when forced with a trowel or rammer.
3. Fill the recess at the end of the pipe with jute braiding dipped in hot bitumen or suitable approved compound, while jointing pipe lines.
4. Keep the width of collars 150-200 mm and caulking space between 13 mm and 20 mm according to dia of pipes.
5. All the joints are made with care so that their interior surface is smooth and consistent with the interior surface of the pipe. After finishing the joints cover the joint with wet jute to make the joint damp at least for four days.

14.1.6 Back Filling

1. Back fill trenches after the pipes have been laid and after jointing material has hardened. On top of pipe up to 300 mm, thoroughly ram, tamp or vibrate the soil in two layers. Thoroughly consolidate the materials under the ‘haunches’ of pipes using light mechanical tamping equipment.
2. Carryout filling of the trench simultaneously on both sides of the pipe, such that unequal pressures do not occur.
3. Provide minimum cushion of 600 mm or the diameter of pipe whichever is greater by filling the suitable material on the pipe after its laying. When minimum specified cushion cannot be provided over the pipe, enclose the pipe in M 10 concrete of specified thickness not less than 200 mm in thickness.

14.1.7 Head Walls and Other Ancillary Works

1. Headwalls, wing walls, aprons and other ancillary works are constructed in accordance with the details shown on the drawings or as directed by the Engineer.
2. Masonry works for the walls are constructed conforming to the requirements given in Chapters 9, 10 and 13 as applicable.
3. While constructing the headwall first construct the wall up to the top level of pipe, place the pipe in position and, fill the pipe with suitable material up to the road level compact the material as required and construct the remaining part of wall.
4. The construction of apron and other protection works are carried as per Chapter 15.

14.2 QUALITY CONTROL REQUIREMENTS

1. Materials

i. Use NP-3 type reinforced concrete pipes, conforming to NS – 80/2042 or IS 458:2003. The internal diameter shall not be less than 600 mm except in exceptional situations.
ii. Conform brick masonry work for pipe culverts to Chapter 9.
iii. Conform stone masonry work for pipe culverts to Chapter 10
iv. Conform reinforcement for concrete work for pipe culverts to Chapter 12
v. Conform concrete work for pipe culverts to Chapter 13.

2. Back filling

The back fill material shall be clean from boulders, large roots, clay lumps and pass from 75 mm sieve.

3. Tolerances

The following tolerances are permitted for concrete pipes as per IS 458

i. Overall length ±1 percent of standard length
ii. Internal dia ±10 mm
iii. Barrel thickness
  a) 60-90 mm + 5 mm , -2.5 mm
  b) Over 90 mm +7 mm, -3.5 mm

4. QUALITY CONTROL TESTS

4.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 14.1.

Table 14.1 : Quality Control Tests Prior to Construction of Pipe Culvert

S.No.	Material / Work	Test / Check	Frequency
1	Bricks	As in Chapter 9	As in Table 9.6
2	Stones	As in Chapter 10	As in Table 10.3
3	Concrete Pipe	- Dimensions	At factory before

S.No.	Material / Work	Test / Check	Frequency
		- Manufacturing defects - Tolerances (IS:458) - Three edge bearing test (IS:3597)	delivery Manufacturer's certificate

4.2. Tests / Checks During Construction

The Quality Control Tests / checks to be carried out during construction are indicated in Table 14.2

Table 14.2: Quality Control Tests During Construction of Pipe Culvert

S.No.	Material / Work	Test / Check	Frequency
1	Bedding	- Materials (As per specification) - Length, width and thickness - Pre formation of cradle to lay pipes in bedding - Top and bottom levels	While laying
2	Laying and Jointing of pipe	- Invert level - Longitudinal gradient - Spacing when 2 or more pipes are laid in a row or staggered columns. - Jointing of pipes - damage to pipe during laying	Before laying pipe Before back filling
3	Backfill	- Filling of trench on both sides (simultaneously) - Tamping around pipe	During filling earth / granular material around pipe after laying
4	Cushion over pipes	Thickness	While filling
5	Brick/Stone Masonry for head walls	Set of tests as per Chapter 9 and 10	As per Table 9.7 and 10.4
6	Side slopes on Head walls	- Slope - Stone pitching	Before construction of guard stones

Chapter 15. PROTECTION AND DRAINAGE WORKS

In this Chapter, the construction and quality control aspects of aprons, pitching on slopes, masonry flooring over cement concrete bedding, curtain wall besides chute, roadside and hill drains have been dealt with.

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer.

15.1 CONSTRUCTION METHODOLOGY

15.1.1 Apron

This work consists laying of boulders directly or in gabion crates on the bed of rivers for protection against scour.

Methodology

1. Keep the length of apron not less than twice the depth of curtain wall or as shown in drawing.
2. Level the surface on which the apron is to be laid and prepare for the length and width as shown on drawings. In case the surface is below low water level, raise the ground level by dumping earth, moorum, brick bats, stones, etc., so that apron can be laid thereon.
3. For regular and orderly disposition of stone in apron, build template cross walls in dry masonry of about 1 m thickness and full height specified thickness of apron at 30 m intervals all along the length and width of apron. Hand pack stone within these walls.
4. Use wire crates of galvanized steel wire as specified with mesh not more than 150 mm.
5. Use in situ built wire-crates of size not larger than 3 m x 1 m x 1 m and not smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1.5 m to prevent bulging.
6. Place the crates in position before filling in boulders.

15.1.2 Pitching on Slopes

1. Use quarry stone of minimum 225 mm thickness or 40 kg as pitching or as specified, and spalls of minimum 25 mm size to fill the voids. Alternatively PCC blocks of 190 x 190 x 225 mm size (minimum) in M15 Concrete can be used for pitching.
2. Provide one or two layers of graded materials (filter medium) of 150 mm thick or as specified under the pitching to drain off the seepage water and prevent erosion of base material.
3. Trim the sides of banks to the required slope before laying the pitching and fill the depressions and thoroughly compact.
4. Start the lowest course of pitching from the toe wall and build courses upwards. Use either dry rubble or brick masonry for toe wall.

5. Use dry masonry, when two or more layers of stones are to be laid to obtain design thickness of pitching and bond the stones well. Template cross walls in dry masonry can be built, as done for aprons.
6. When bricks are to be laid in more than one layer, ensure proper bonding with the adjacent layers by means of sufficient number of pin headers extending from one layer to the other.

15.1.3 Toe Protection

The toe wall shall be in dry Random Rubble matting conforming to the drawings. Toe protection shall be done by constructing a toe wall, retaining/breast wall or close bamboo walling at the junction of embankment slope and general ground level, to protect the embankment from damages.

15.1.4 Rubble Stone/Brick Flooring

1. Where specified provide rigid flooring under culverts and extend for a minimum distance of 1.5 m on upstream side and 3m on downstream side or as shown in drawings.
2. Excavate trench for laying foundation of bed protection and lay 150 mm thick cement concrete of minimum M 10 grade, so as to commence paving work.
3. Where rubble stone is specified as flooring, carryout the work with flat stones 150 mm thick, which are bedded on a 25 mm thick layer of 1:5 cement mortar. Fill the joints with 1:3 cement sand mortar of 20 mm thick.
4. Where bricks are to be used, carryout the work on 150 mm thick brick on edge, with each layer of brick bedded on 25 mm thick 1:5 cement mortar. Fill in the joints with 1:3 cement mortar of thickness 10 mm.
5. Keep the top of flooring 300 mm below the lowest bed level and extend the flooring. Extend the line connecting the end of splayed wing walls on either side of the culvert/bridge.
6. Adopt dry rubble stone/brick flooring at Cross Drain works where the velocity of flow is less than 1.5 m/sec by keeping the top of flooring 300 mm below the low bed level.
7. Lay the rubble stones closely, breaking joints and fill all joints with spalls of proper size and wedged in with rammers to ensure tight packing.
8. When dry brick is to be used, follow the procedure as above on a prepared base and lay in one or more layers. Ensure proper bond.

15.1.5 Curtain Wall

Enclose flooring by curtain walls in cement concrete (M 10) or stone/brick masonry in cement mortar 1:4 and take to a depth of at least 1.5 m on u/s side and 2 m on d/s side below the floor level.

15.1.6 Chute Drain, Roadside Drain, Hillside Drain, Catch Water Drain

1. Provide rectangular or trapezoidal chute drains of specified dimensions in sections of road embankment, of height more than 8 m at minimum 10 m intervals. Provide them in

embankment slopes in approaches of bridges and on horizontal curves connected at the tow of the embankment with parallel open drains discharging into a nearby kholsi or Cross Drain work.

2. Locate the open drain at the toe of embankment far away from imaginary slope of 4 (horizontal): 1 (vertical).
3. Build catch water /intercepting drains on hill slopes to intercept water flooring from upper reaches and guide such flow into culverts. Adopt trapezoidal shape and line them.
4. Refer to IRC: SP: 42 'Guidelines on Road Drainage' for more details and design of section.

Protection of Vented Causeways

Damages to submerged structures occur due to out flanking at one or both banks, heavy erosion on downstream side, collapse of headwalls and washing of paved surface. The design of such structures is inter woven taking protection aspects into consideration.

i. For vented causeways, prepare the stream bed crossing by stabilizing with crushed stone, riprap or rubble after removal of silt and compact the base and core to reduce future settlement.
ii. Provide side drains on either side along the side slopes which are rubble pitched. Take the side drains at least 10 m away from the edge of main causeway junction, to meet the stream proper.
iii. Provide face walls to protect the edges of the structure and to prevent erosion of core material.
iv. Build face walls of the approaches strong enough to avoid damage during floods. Seal the joints in concrete face walls to prevent ingress of water to the core.
v. Make the approaches of causeways in Cement Concrete pavement laid over WBM or in Stone Set pavement, to prevent their damage due to frequent over topping.
vi. In case of submersible bridges, provide bed protection for the whole bed-width of water course plus 3 m on both sides.
vii. Provide a minimum foundation depth of 1.5 m on u/s side and 2.5 m on downstream side for cut off wall.
viii. Provide RCC guard stones at 1.2 m c/c for both vented and non-vented causeways.

15.2 QUALITY CONTROL REQUIREMENTS

1. Stones for Apron

The size and weight of stones for laying boulder on apron shall conform to the requirement given in Table 15.1

Table 15.1: Requirements of Stones for Apron

Mean Design Velocity m/sec	Minimum size and weight of stone	
	Diameter (mm)	Weight (kg)
Upto 2.0	220	25
2.5	300	40
3.0	380	76
3.5	510	185
4.0	670	417

2. Stones for pitching on slopes

The size and weight of stones for pitching on slopes shall conform to the requirements given in Table 15.2

Table 15.2 : Requirements of Stones for Pitching

Mean Design Velocity m/sec	Minimum size and weight of stone			
	Slope 2:1		Slope 3:1	
	Diameter (mm)	Weight (kg)	Diameter (mm)	Weight (kg)
Up to 2.0	220	25	220	25
2.5	300	40	300	40
3.0	300	40	300	40
3.5	350	59	300	40
4.0	450	126	350	59

Where the required size stone are not available for use in wire crates, Cement Concrete blocks in M15 grade weighing not less than 25 kg may be used.

3. Quality Control Tests

3.1 Tests Prior to Construction

The Quality Control tests to be carried out prior to construction are indicated in Table 15.3

Table 15.3: Quality Control Tests Prior to Construction of Protection Work

S. No.	Test / Check	Frequency
1	Size and weight of stones in apron / slope / flooring etc. (Table 17.1 and 17.2)	At quarry site before procurement
2	Wire crates (Size and mesh size)	Before procurement
3	Cement concrete blocks (Weight and Size)	Before procurement

3.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 15.4

Table 15.4: Quality Control Tests During Construction of Protection Work

S. No.	Test / Check	Frequency
1	Laying of Filter granular material	Daily check for workmanship
2	Laying boulders for - Apron - Pitching on Slopes - Toe protection - Wire crates	Daily check for uniformity in workmanship
3	Mortar for Joints a) Mix proportions, (control on quality of cement/ lime by weight b) Compressive strength(IS:2250)	Each batch 6 samples of cubes for 10 m^3 of work
4	Laying of brick stones in flooring	Daily check for workmanship
5	Curtain wall	Daily check for workmanship
6	Drain (Chute, Road side, Hill side and Catch water)	Daily check for workmanship

Chapter 16. GABION MASONRY STRUCTURES

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer.

16.1 CONSTRUCTION METHODOLOGY

1 Excavate the foundation to required depth following the methodology provided in Sub-Chapter 5.4 and according to the design drawing
2 If the foundation is adequate, check the cross slope &check the foundation level and get approved from the engineer.
3 If foundation work is complete construct the retaining structure following the steps given below.
4 Assemble the gabion boxes as described in Section 2401 and 2402 of Standard Specification for Road and Bridge Works -2073 , Department of Roads
5 After assemble of gabion boxes, fix its shape and size by stretching it's all sides and fix the diaphragms as per Table 16.2
6 Place in positioned by lay the gabion boxes as required in header bond by tying to adjacent gabion boxes by looping the wire through each mesh of both adjacent boxes around both salvage with three rounds as described in Section 2401 and 2402 of Standard Specification for Road and Bridge Works -2073 , Department of Roads
7 Lay the Geo-textile at the back of the gabion boxes to cover the length and height including footing of the wall.
8 Fill the gabion boxes with stones with proper bonding in three equal layers for 1 m deep gabions and in two layers for 0.50 m deep gabions. The filling is carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded. All stones are carefully set with a bond stone provided at the rate of at least one to every 0.9 m^2 of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face; and not less than 450 mm in length or the full thickness of the wall, whichever is the less.
9 No loose stones are allowed to tip into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaid stones shall not be permitted.
10 Horizontal bracing wires made with the same binding wire as used for tying is fixed directly above each layer of the stone in the compartments at 330 mm spacing inwards from edge of box in both direction as specified in the Clause 2400 of Standard Specification for Road and Bridge Works -2073 , Department of Roads
11 After completing stone filling cover the upper faces (Lid) of gabion boxes and tie by gabion wires by looping the wires on the selvedge wires of adjacent panels as per Clause 2400 of Standard Specification for Road and Bridge Works -2073, Department of Roads. Measure the dimensions of the filled boxes.

12 Repeat the Steps given in para 4, 5, 6, 8 and 9 for upper successive layers. Both upper and lower boxes shall have vertical tie wires. Construct the vertical joints in staggered position.
13 Take the level of the top of the wall.
14 Cover the entire wall by the Geo-textile already provided covering the footing left in each layer.
15 The back of the wall is filled with suitable materials. Compact the backfilling in layers not exceeding 150 mm of compacted thickness to achieve 95% MDD from the bottom of the wall to full height.

16.2 QUALITY CONTROL REQUIREMENTS

1. Materials

(i) Stone

Use stone which is hard, sound, and free from cracks, decay, and weathering, defects like cavities, flaws, sand holes and patches of loose or soft materials. Do not use stones with round surface. The Specifications and requirements of stones shall satisfy those given in Table 16.1

Table 16.1: Requirements of Stones for Gabion Masonry

S.No	Item	Requirements
1	Least Dimension (IS:1597 Part 1)	150 mm
2	Water Absorption in stone (IS:1124)	5 percent of its weight
3	Specific Gravity (IS: 1124)	2.5

(ii) Gabion

The gabion wire consists of steel wire mesh crate conforming to NS-169-2045 and shall satisfy as per the Clause 2400 of Standard Specification for Road and Bridge Works -2073, Department of Roads

The number and size of diaphragms to be provided with each crate shall be as in Table 16.2. All crates shall be supplied with binding and connecting wire of the gauges shown in Table 16.3 of sufficient quantity to bind all diaphragms and closing edges.

Table 16.2: Standard Size of Wire Mesh Gabions

Dimensions in Meters (Prior to fill)	Number of diaphragms	Dimension of diaphragms in meters	Volume of crate in cubic meters
1 x 1 x 1	-	-	1
1.5 x 1 x 1		1 x 1	1.5
2 x 1 x 1	1	1 x 1	2
3 x 1 x 1	2	1 x 1	3

Dimensions in Meters (Prior to fill)	Number of diaphragms	Dimension of diaphragms in meters	Volume of crate in cubic meters
1 x 1 x 0.75	-	-	0.75
2 x 1 x 0.75	1	1 x 0.75	1.5
3 x 1 x 0.75	2	1 x 0.75	2.25
1 x 1 x 0.5	-	-	0.5
2 x 1 x 0.5	1	1 x 0.5	1
3 x 1 x 0.5	2	1 x 0.5	1.5
1 x 1 x 0.3	-	-	0.3
2 x 1 x 0.3	1	1 x 0.3	0.6
3 x 1 x 0.3	2	1 x 0.3	0.9

Table 16.3: Standard Size of Mesh and Wire in Gabions

Mesh opening mm	Mesh type	Thickness of mesh wire	Thickness of binding and connecting wire	Thickness of selvedge wire
(DxH)		S.W.G.	S.W.G.	S.W.G.
64 x 83	60 x 80*	11, 12	13, 14	8, 9
83 x 114	80 x 100	9, 10, 11	11, 12, 13	6, 7, 8
104 x 128	100 x 120	10, 9	12, 11	7, 6

* To be used in special cases subject to approval by the Engineer where stone of larger size are not available.

Note: Equivalent diameter in mm as per NS 163-2045

Table 16.4: Equivalent Diameter in mm as per NS 163-2045 – Gabion Wire

SWG	6	7	8	9	10	11	12	13	14
mm	4.88	4.75	4.06	3.66	3.25	2.95	2.64	2.34	2.03

2. Quality Control Tests

2.1 Tests Prior to Construction

The tests / checks to be carried out prior to construction are indicated in Table 16.4.

Table 16.4: Quality Control Tests Prior to Construction of Gabion Masonry

S.No.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension (IS:1597 part 1) b) Water absorption (IS:1124)	3 samples on receipt at site; Once for each stock after selection for individual work
2	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity and adhesion of Zinc coating	As per Table 24.4 (A) to 24.4 (C) of Standard specification for Road and Bridge Works - DOR
2	Gabion crates	Size and mesh size	Before Procurement/after fabrication

2.2 Tests / Checks During Construction

The tests / checks to be carried out during construction are indicated in Table 16.5.

Table 16.5: Quality Control Tests During Construction of Gabion Masonry

S.No.	Material / Work	Test / Check	Frequency/ Stage
1	Assembling of Gabion Crate	Size of Crate, Lacing as per specification,	During laying
2	Filling of crate with stone	For stability and appearance with plumb bob and bracing as per specification	While laying each course
3	Securing Lids of gabion crate	Lacing and binding the of panels, filling of stone	While closing the led after completion of stone filling
4	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity and adhesion of Zinc coating	Each lot of gabion received at site. As per Table 24.5, 24.6 and 24.7 of Standard specification for Road and Bridge Works -DOR

Note: It is suggested to construct 2x1x1 gabion wall at the side of the road surface as a Demonstration Wall, constructed according to the above methodology.

Chapter 17. CEMENT CONCRETE CAUSEWAYS

Under this Chapter quality aspects of different submersible structures viz., Flush Causeway, and Vented Causeway for rural roads are dealt with:

17.1 CONSTRUCTION METHODOLOGY

1. FLUSH CAUSEWAY

I. Choose flush causeway (Paved dip) to cross a shallow water course.
II. Keep top level of floor of causeway same as that of bed of water-course.
III. Build cut-off walls in brick masonry or stone masonry or plain cement concrete with suitable formwork as per provisions given in Chapters 9, 10, 11 and 13 respectively of this Manual
IV. Excavate for laying of foundation of u/s and d/s cut-off walls. Keep it sufficiently deep to avoid exposure due to scouring. Provide a PCC footing of 150 mm thickness in M15 grade, laid on a layer of 100 mm thick lean concrete (minimum M10 grade) or as per design.
V. Adopt a plain cement concrete slab of minimum thickness 200 mm in a minimum grade of M25 as paved dip. Provide construction joints 4-6 m apart and seal them with poly-suphide or as per design.
VI. Provide u/s and d/s protection works, apron, pitching as per requirement.
VII. Provide guide posts/stones at required spacing.

2. VENTED PIPE CAUSEWAYS

I. Choose vented pipe causeway to cater to low flows through circular vents which overtop during monsoon. Usually RCC pipes NP3 are used for providing circular vents.
II. Follow the same methodology as detailed in Chapter 14 of this Manual for laying of RCC Pipes.
III. For headwalls or other ancillary works, adopt the requirements given in Chapter 9, 10 & 15.
IV. Take foundation and head walls sufficiently deep to avoid exposure to scouring in erosive strata.
V. Batter the d/s side headwall on the outside and round the corners.
VI. Adopt rectangular or arch type vents instead of circular pipe as per local practice.
VII. Raise end portion of face walls and protect entire top of causeway by well desirable non-erodible wearing coat

3. ANCILLARY ITEMS (WEARING COAT, RAILING, KERBS, WARNING SIGNS, FLOOD GAUGES)

I. Provide 75 mm thick Cement Concrete wearing coat in M25 grade with a cross slope of 2.5 per cent towards d/s side of deck slab in submersible bridge. For vented causeways adopt 200 mm thick RCC Slab or as per design.
II. Discontinue wearing coat at expansion joint locations. Extend joint fillers up to the top of wearing coat.

III. For Cement Concrete wearing coat, provide 8 mm diameter bars @ 200 mm c/c reducing to 100 mm c/c in both directions over a strip length of 300 mm near expansion joint or as per design.
IV. Use open type or filler joint with appropriate nose protection.
V. Use discontinuous kerbs 300 mm wide at 1.8 m c/c on both sides, the continuous length of each piece being 1.5 m.
VI. Locate advance warning/cautionary signs at about 200 m from the beginning of submerged causeways and submersible bridges, to indicate speed limit, depth of submergence etc.
VII. Install flood gauges as required or as shown in drawing.

17.2 QUALITY CONTROL REQUIREMENTS

Various components of flush and vented causeways shall conform to relevant provisions provided in this manual as listed below:

1. Material and Work

Refer the respective chapters for required quality of Bricks, Stones Cement, Sand, Coarse Aggregate, Water and Reinforcement. Similarly refer the quality control requirement for components / works i.e Earthwork, RCC pipe, Cement concrete pavement and drainage spout to the respective chapters of this manual.

2. Quality Control Tests

The quality control tests/checks listed here in cover causeways and submersible bridges where in materials such as brick or stone masonry, plain or reinforced concrete are used. The openings in causeways could be of concrete pipes or rectangular / arch semicircular vents in RCC.

2.1. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 17.1

Table 17.1 Quality Control Tests Prior to Construction of Cement Concrete Causeways

S.No.	Material	Test / Check	Frequency
1	Bricks	As in Table 9.1	Table 9.6
2	Stones	As in Table 10.1	Table 10.3
3	Concrete Materials	As in Chapter 13	Table 13.11
4	Steel reinforcement	As in Table 12.1	Table 12.4
5	Cement pipes (If used)	As in NS 80 -2042	Table 14.1
7	Pavement Materials	a) Sub-base b) WBM c) Cement concrete	Table 6.3 Table 6.9 Table 13.11

2.2. Tests During Construction

The Quality Control Tests /checks to be carried out during construction are indicated in Table 17.2

Table 17.2: Quality Control Tests During Construction of CC Causeways

S.No	Material / Work	Test / Check	Frequency
1	All concrete works	a) Workability (IS:1199) b) Cube strength (IS:516) c) Curing	As per Table 13.12
3	Formwork	Design, Erection, Camber, etc.	As per Table 11.3
7	Jointing of pipes & bedding	During construction	As per Table 14.2
8	Cement Concrete Pavement	As per Table 8.2	Table 8.2
9	Equipment for handling pipes (prior to lowering)	- Adequacy of chain pulley block - Stability of Tripod arrangement etc.	Check by Engineer

Chapter 18. PERMANENT TRAFFIC SIGNS, PROJECT INFORMATION BOARD, ROAD MARKER STONES AND DELINEATORS

The three main functions of traffic signs are to regulate, warn and inform. There is different group of signs for each function, and the signs in each group have a uniform shape to help drivers recognize them quickly. The three groups are:

Regulatory Signs: These signs give orders. They tell drivers what they must not do (prohibitory), or what they must do (mandatory). Most of them take the form of circular disc, although two signs, the Stop sign and the Give Way sign, have distinctive individual shapes.

Warning Signs: These warn drivers of some danger or difficulty on the road ahead. Most of them take the form of an equilateral triangle with its apex uppermost.

Information Signs: Most of these signs give drivers information to enable them to find their way to their destination. It is a varied group of signs, but they are all either square or rectangular in shape.

Another important group of signs are **Road Markings**. These can regulate, warn and inform, and some help clarify or emphasis the message given by other signs.

18.1 CONSTRUCTION METHODOLOGY

1. **TRAFFIC SIGNS**

I. The color, configuration, size, location and dimensions of different road signs shall be incompliance with the Traffic Signs Manual Volume I & II prepared by Government of Nepal, Ministry of Physical Planning and Works, Department of Roads. The language of inscription and font for informatory signs shall also be in conformity with the same manual. Signs shall be semi-reflective, fixed over mild steel sheeting duly stove enameled in white color in front and grey color on the back, red engineering grade tape on borders and required message in non-reflective black sheeting of the Engineering grade tape.

II. Road signs, in particular, the Cautionary/ Warning and Mandatory/ Regulatory signs in the approaches to level crossings or narrow bridges may be reflectorized using luminous paints or other similar reflective material.

III. It is desirable that Cautionary/ Warning and Mandatory signs are fabricated through the process of screen-printing. In other cases, signs may have inscription/message having cut letters of non-reflective black sheeting which shall be bonded well with the base sheeting.

IV. Concrete for footings shall be of minimum M15 grade. Reinforcing steel shall conform to the requirements of IS:1786. High strength bolts, nuts and washers shall conform to

IS:1367, Plates and support sections shall be either 50 mm internal diameter steel tube or 78 mm x 38 mm C channel conforming to IS:2062.

V. Sign posts, their foundations and sign mountings should be so constructed as to hold them in proper position against normal wind loads or displacement by vandalism.

VI. Normally signs with an area up to 0.90 sqm can be mounted on a single post and for greater area two or more supports shall be provided.

VII. Sign supports may be of mild steel (MS), reinforced concrete (RC) or galvanized iron (GI). The post ends should be firmly fixed to the ground.

VIII. The signs and supports, except the reflectorized portion and GI posts, shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. The portion of mild steel post below ground should be painted with three coats of red lead paint.

IX. The signs should be fixed to the MS posts by welding and to the RC or GI posts by bolts and washers. After the nuts have been tightened, the tails of the bolts should be furred over with a hammer to prevent removal.

X. The extreme edge of the Road Sign adjacent to the highway should be at a distance of at least 2.0 m from the edge of the carriageway. In no case any part of the Road Sign shall come in the way of vehicular traffic.

XI. The lowest edge of Road Sign shall not be less than 2.0 m above the crown of pavement.

2. ROAD MARKINGS

I. The road markings shall be in conformity with the Traffic Signs Manual Volume I & II prepared by Government of Nepal, Ministry of Physical Planning and Works, department of Roads.

II. Painting may be done by machine or by hand, preferably by machine.

III. The finished road markings shall be free from ruggedness on sides and ends and these should be parallel to the general alignment of the carriageway. The upper surface of the lines shall be free from streaks.

3. ROAD MARKER STONES

The work covers the supply, painting, lettering and fixing of road markers. The Road Markers Stones includes:

- Standard Marker Stones (Kilometer Posts)
- 5^{Th} kilometer Marker Posts
- Node Point Marker Stones

I. The marker stones shall be constructed of reinforced cement concrete of grade M15/20 as per Chapter 13 and the non-reflectorized paint shall be used conforming to NS 112-2042.

II. The location of the marker stones shall be as shown on the Drawing. The marker stones shall be placed at right angles to the line of the carriageway.

III. On embankments they are installed on the edge of the roadway at least 0.5 m outside the road shoulder. Where there is no shoulder the marker is located at least 1.5 m outside the road edge, if necessary on specially erected platforms. In cut sections they shall be fixed clear of the shoulders as well as the side drains.

IV. Marker stones shall be placed on the left hand side of the road as one proceeds from East to West and from South to North. On divided roads with a median the marker stones shall be placed on the left hand side of the road in each direction of travel. In hilly areas, where the road has a valley on one side and a hill slope on other, the marker stones shall be placed on the valley side of the road.

V. Marker stones posts shall be bedded into the ground with concrete foundation of grade M 10/40 as shown in the Drawing.

VI. Marker stones shall be applied with a coat of primer and two coats of enamel paint.

4. DELINEATORS

I. The work covers supplying and fixing of delineator posts. The design and painting of the posts shall be in accordance with the drawing B48 of Traffic Sign Manual Vol I – Department of Roads.

II. The delineator posts shall be constructed of reinforced concrete of grade and M 20/20 in accordance with Chapter 13 or as shown in the Drawing. These shall be painted by non-reflectorized painting after primer in accordance with NS 112-2042 and NS 190/2045 respectively.

III. The posts shall be constructed/manufactured as per the drawing with true shape and smooth surface without honeycombing.

IV. Posts shall be erected after the completion of pavement surface and located at 600 mm from the edge of the road.

V. Two coat of synthetic enamel paint shall be done after cement priming. The paint shall be applied in 200 mm wide alternate strips of white and black starting from top.

VI. Provide grove for reflectorized painting as shown in the drawing and paint accordingly.

18.2 QUALITY CONTROL REQUIREMENTS

1. Traffic Signs

The materials should conform to the following requirements.

i. **Concrete:** Concrete for footing shall be of the grade shown on the Contract drawings or of minimum M15 grade conforming to Chapter 11 of this Manual

ii. **Reinforcing steel**: Reinforcing steel shall conform to the requirements of IS:1786 unless otherwise shown on the drawing.

iii. **Bolts, nuts, washers**: High strength bolts shall conform to IS: 1367

iv. **M.S. Sheets, Plates and supports**: Plates and support sections for the sign posts shall conform o IS: 2062 or any other relevant IS Specifications.

v. **Reflectorized paint:** Reflectorized paint shall conform to IS 5 or the manufacturer's specifications in case of proprietary product and as approved by the Engineer.

vi. **Non reflectorized paint**: Non-reflectorized paint shall conform to NS 408/2045, IS:164 and as approved by the Engineer.

vii. **Engineering grade sheeting**: This sheeting shall be enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. The retro reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM Standard) as indicated in Table 18.1.When totally wet, the sheeting shall not show less than 90 per cent of the values, of retro reflection indicated in Table 18.1. At the end of 5 years, the sheeting shall retain at least 50 per cent of its original retro-reflectance.

Table 18.1 : Acceptable Minimum Coefficient of Retro-reflection for Engineering Grade Sheeting (Candel as Per Lux Per Square Metre)

Observation angle in degree	Entrance angle in degree	White	Yellow	Orange	Green	Red	Blue
0.2	-4	70	50	25	9	14.5	4
0.2	+30	30	22	7	5.5	6	1.7
0.5	-4	30	25	13.5	4.5	7.5	2
0.5	+30	15	13	4	2.2	3	0.8

viii. Signs with a maximum side dimension not exceeding 600 mm shall not be less than 2.0 mmthick. The thickness of the sheet shall be related to the size of the sign board and its support and shall be such that it does not bend or deform under the prevailing wind and other loads.

ix. In respect of sign sizes not covered by Traffic Signs Manual Volume I & II prepared by Government of Nepal, Ministry of Physical Planning and Works, Department of Roads, the structural details (thickness, etc.) shall be as per the approved drawings.

2. Road Markings

Ordinary paints shall be used for road markings, conforming to NS 408/2045 or BS 6044 or IS:164. These shall have a wear resistance of at least 4 hours under accelerated laboratory test. Yellow color conforming to NS 408/2045 or BS 6044 IS:164, white and black colors are the standard colors used for markings.

If specified the paint may be reflectorized paint, in which case paint shall be reflectorized by addition of reflecting beads (Ballotini). Ballotini shall comply with BS 6088.

3. Marker Stones

The material shall be tested in accordance with the relevant standard specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

4. Delineators

The material shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

Chapter 19. KERBS AND FOOTPATHS

19.1 METHODOLOGY FOR CONCRETE KERBS

- The kerbs confirm the barrier between the shoulder and islands or footpaths. The height of road kerb above the pavement edge varies from 100 mm to 200 mm as per requirement.
- The kerbs shall be laid on either concrete or compacted sand-gravel as indicated in the Drawing.
- The foundation shall be prepared and levelled as indicated in the drawing and compact well using hand rammer or vibrator. The foundation shall have a projection of 50 mm beyond the kerb in plan.
- Before laying of lean concrete of grade M 10, the foundation base shall be leveled and slightly watered to make it damp.
- In the case of a sand gravel it shall consist of a material approved by the Engineer having a property complying with granular sub-base as mentioned in Chapter 6.1.
- The kerb shall then be laid out and bedded on 12 mm thick cement sand mortar of 1:3 ratios.
- The joint of the kerb stone shall be spaced for at least 10 mm and the same will be filled with mortar so that there will be no lack of bond between adjoining kerb.
- The line, alignment and level of kerb stone are to be checked periodically throughout the installation to ensure that it complies with the drawing and site requirements.

19.2 QUALITY CONTROL REQUIREMENTS

1. Materials

The kerbs shall be provided in cement concrete of grade M 20/20 in accordance with Chapter 13. These shall be either precast concrete blocks or cast-in-situ concrete.

Cement sand mortar used for bedding and joint shall be in 1:3 ratios and shall comply with the Sub-chapter 9.2.

2. Quality Control Tests

Concrete shall be tested in accordance with mentioned in Chapter 13 and shall meet the specified criteria. All kerbs shall be laid true to the lines and levels shown on the Drawing or as instructed by the Engineer.

19.3 METHODOLOGY FOR CONCRETE/STONE FOOTPATHS

The base shall be prepared and finished to the lines, levels and dimensions as indicated on the Drawing. Generally, material for base shall be:

(a) 150 mm thick compacted granular Sub-base as per Chapter 6.1 or
(b) 30 mm thick concrete base of grade M 15 or
(c) Flat brick flat soling base.

19.4 QUALITY CONTROL REQUIREMENTS

1. Materials

Pre-cast cement concrete blocks of grade M20 as per as mentioned in Chapter 6.1. Unless otherwise specified or ordered by the Engineer they shall be 50 mm thick of a uniform width of 600 mm and not less than 450 mm nor more than 900 mm in length.

2. Quality Control Tests

Concrete shall be tested in accordance with Chapter 13 and shall meet the specified criteria. Granular subbase shall be tested in accordance with Chapter 6.1 and shall meet the specified criteria.

Chapter 20. REFERENCES

I. Standard Specifications for roads and Bridge works: 2073 Department of Roads, Ministry of Physical Planning and works, Government of Nepal

II. Quality Control Handbook for Rural Road Construction and Maintenance, Volume – I Quality Control Requirement, March, 2016

III. Quality Control Hand Book for Rural Roads; Quality management System and Quality Control Requirements: Ministry of Rural Development, Government of India, May, 2007

IV. Overseas Road Note 3, A Guide to Surface Dressing in Tropical and sub-tropical Countries; TRL, DFID UK.

V. Overseas Road Note 31, A Guide to Bituminous Pavement, TRL, DFID UK.

VI. International Road Maintenance Hand Book, Volume-I Maintenance of Unpaved Roads and Volume II, Maintenance of Paved Roads, Published by TRL, UK

VII. IS: 2116 Sand for Masonry Mortar, Published by Bureau of Indian Standards

VIII. IS: 1489 Part -2; Portland-Pozzolana Cement Specification, Published by Bureau of Indian Standards

IX. IS: 2250. Code Practice for Preparation and Use of Masonry Mortar, Published by Bureau of Indian Standards

X. IS: 1597, Part 1; Construction of Stone Masonry, Code of Practice, Published by Bureau of Indian Standards

XI. IS: 456 Plain and Reinforced Concrete, Code of Practice, Published by Bureau of Indian Standards

XII. IS:786, Code of Practice for Laying of Concrete Pipes, Published by Bureau of Indian Standards

XIII. IRC SP 20-2002; Rural Road Manual, Published by Indian Road Congress , Special Publication 20

XIV. Specification for Roads and Bridges, 2013 (Fifth Version); Published by Indian Road Congress: Government of India, Ministry of Road, Transport and Highway.

Chapter 21. ANNEXES

ANNEX 1: CONTENTS OF QUALITY ASSURANCE PLAN

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- Project Information

Quality Assurance Plan
- Quality
- Quality Assurance System
- Objectives of QA Plan
- Scope and Application of QA Plan
- Quality Assurance Flow Chart
- Construction Planning and Schedule

Organization and Management
- Parties to the Contract
- Organization Structure for Quality Assurance
- Key Personnel
- Job Description of Key Personnel

Quality Control of Construction Work
- Quality Control System
- Material Quality Control Flow Chart
- Quality Control of Structural / Cutting Work – Chart
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- Quality Control of Concrete Construction– Flow Diagram
- Quality Control Tests, Frequencies, Technical Specification and Test Methods
- Monitoring of Quality Control

Construction Method Statement
- Order and Sequence of Execution of Work
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Environment Management Action Plan

Traffic Management Plan

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CV of Key Personnel Assigned to QA

Available Laboratory Equipment

Laboratory Formats for Testing and Controlling

ANNEX 2: WORK REQUEST FORM

Transport Infrastructure Directorate
Bagmati Province
Hetauda, Makwanpur

WORK REQUEST FORM

Name of Project :-
Contract No :-
From Contractor :- **To Engineer:**
Requested Work Schedule to Start on
(Contractor must submit request in minimum of 48 hours in advance of schedule start) **Date:** **Time:**

Description of Work Requested	Equipment to be Used	Estimated Quantity to be Accomplished	Location/Chainage

Submitted by Contractor :- Date: Time:
Received By Site Supervision Engineer :- Date: Time:

Inspected by:	Observed Parameters / Comments	Status (Satisfactory/ Unsatisfactory)
Site Supervision Engineer *Signature:* *Date:*	Equipments:	
	Materials:	
	Labors (Skilled and Unskilled):	
	Safety Measures:	
	Site-in-Charge:	
	Other Comments if any:	

	Approved ☐ Disapproved ☐ Project Manager Signature: Date:	Accepted by Contractor: Signature: Date: Time:

Note: Working drawing and suitability test reports of material should be submitted with Work Request Form.

ANNEX 3: SITE INSTRUCTION FORMAT

Transport Infrastructure Directorate
Bagmati Province
Hetauda, Makawanpur

Name of the Project:

Contract no:

SITE INSTRUCTION

From:	Date/Time:
To:	Location/ Chainage:

□ Dismantle	□ Redo
□ Expedite the work	□ Rectify the defects
□ Improve the quality of work	□ Addition of equipment
□ Delay of work	□ Addition of manpower
□ Prioritize the work	□ Change material
□ specification	
□ For discussion	
□ Any Other	

Detail Notes:

Site instruction issued by:

Signature:

Copy to:

□ Project Manager

ANNEX 4: DAILY SITE DIARY

Transport Infrastructure Directorate
Bagmati Province
Hetauda, Makwanpur

Daily Site Diary

Name of the Project:	Contract No:
	Date :
Contractor:	Weather : @ 9:00 Weather : @ 14:00

Daily Diary For Construction Works

A. Construction Activity

Activity	Unit	From	To	Tentative Quantity	Remarks R/L

B. Equipment at Site

Name of Equipment	No.	Condition	Remarks

C. Material at site

Material	Previous stock	Purchase/ Production	Consume	Balance	Remarks

C. Staff at site

Contract Manager	Site In-charge	Lab Technician	Skill Labor	Un-skill labor	Other

D. Visitor:

E. Other (if any)

Submitted By: Contractor	Received By: Client/Consultant

Note: Add extra sheet if required

ANNEX 5: CHECKLIST FOR ACCOMMODATION OF TRAFFIC

Name of Project:

Contract No:

Contractor:

104 ACCOMMODATION OF TRAFFIC

Spec Clause no	Description	Yes/No
104 (3)	Temporary traffic diversion works have been approved by the Engineer.	
104 (3) f	The Contractor maintains diversion roads to a standard that will ensure proper passage for traffic in all reasonable weather conditions.	
104 (2)	Any road closure has been authorized by the Engineer.	
104 (5)	Temporary traffic control techniques and signage are operating effectively.	
104(5)	Road furniture removed as a result of temporary works has been reinstated, if required, at project completion.	

Spec Clause no. refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073.

Name of Site Engineer:

Signature:

Date:

ANNEX 6: CHECKLIST FOR SETTING OUT OF THE WORKS

Name of Project:

Contract No:

Contractor:

106 SETTING OUT OF THE WORKS

Spec Clause no	Description	Yes/No
106(5)	Setting out pegs for the works have been installed prior to commencement of construction work upon the Contractor's request.	
106 (8)	The Contractor has maintained all set out pegs in their correct position.	

Spec Clause no	Description	Yes/No
	Temporary structures have not overstressed or are in any way detrimental to permanent works.	
	Temporary and permanent works are stable.	
	Construction traffic abides by any enforced load limits on roads and structures.	
	The Engineer has been advised of any conflict with Public or Private Utilities.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073.

Name of Site Engineer:

Signature:

Date :

ANNEX 7: CHECKLIST FOR CLEARING, GRUBBING, STRIPPING AND DISPOSAL OF MATERIAL

Name of Project:

Contract No:

Contractor:

201 CLEARING AND GRUBBING

Spec Clause no	Description	Yes/No
201 (2) (a)	Trees to be removed have been identified.	
201 (2) a	Top soil is removed to a depth of 150mm and stockpiled or disposed of as directed by the Engineer.	
201 (2) c	The area to be cleared and grubbed has been adequately identified.	
201 (3) a	The area has been adequately grubbed by removing fallen trees, stumps, logs, upturned roots, rotten wood and all other vegetable growth.	
202 (3) c	Holes, such as those left from stumps and anthills, in areas of embankments have been backfilled and compacted.	

201. (b) GRUBBING AND STRIPPING OF TOP SOIL

Spec Clause no	Description	Yes/No
201 (2) (b)	In a Roadway, All tree trunks in excess of 300 mm girth shall be cleaned off to a depth not less than 900 mm below the finished road level and a minimum 500 mm below the original ground level whichever is lower	
	After grubbing and stripping, the topsoil surface has been graded to facilitate accurate survey.	

201(3) (d) DISPOSAL OF MATERIAL

Spec Clause no	Description	Yes/No
	All material from the clearing operation has been burned unless otherwise directed.	
	The Contractor has adequate measures in place to prevent the spreading of fires.	
	Un-burnable material if buried on site is done outside the structural backfill area.	
	Clearing is performed at least 300m ahead of any earthworks.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:
Signature:

Date :

ANNEX 8: CHECKLIST FOR EARTHWORK

Name of Project:

Contract No:

Contractor:

900 EARTHWORKS

Spec Clause no	Description	Yes/No
902 (1)	Dimensions of excavations and embankments are in accordance with Drawings.	
902 (1)	Slopes of excavations and embankments have been neatly trimmed.	
	Joints between new and existing pavement are stepped 150 mm (vertical) x 300mm (horizontal)	
903	Identification of different material boundaries have been identified and the Engineer notified by the Contractor.	
	Pavement sub-grade is compacted in 150 mm layers to 95% MDD (Characteristic Value) unless otherwise directed by the Engineer.	
902 (3)	Excavated material unsuitable for construction has been disposed of at designated areas, providing a stable, well drained and neat appearance.	
902 (3)	Unsuitable sub-grade material under embankments or below pavement layers has been removed and replaced.	
	Rock cuts have been excavated to at least sub-grade level to a firm and reasonably uniform surface.	
	Excavated rock suitable for stone pitching, gabions etc has been reserved if required.	

907 EXCAVATION FOR STRUCTURAL FOUNDATIONS

Spec Clause no	Description	Yes/No
	The Contractor has repaired any damage to adjacent buildings, roads and footpaths etc. caused by his construction activities.	
	Founding levels have not been affected by water inflow and are suitable for pouring blinding concrete.	

909 EARTH EMBANKMENTS

Spec Clause no	Description	Yes/No
909 (3)	Earth embankments have been constructed in horizontal layers not exceeding 150 mm loose.	
909 (5)	Each layer has been compacted to 95% of MDD	
	When filling upon existing embankments or hillsides, slopes of the original ground have been terraced.	
909 (1)	The 300mm layer below the sub-base, or other thickness, as directed by the Engineer has been formed with material < 75mm nominal size. This material has been compacted in 150mm layers loose, to 95% MDD (Characteristic Value).	
	The Contractor has provided prior notice of "Upper Layer" placement and has submitted material samples for approval prior to placement.	
	Trimming of embankments provide a neat finish of sub-grade surface. Waterways have been cleared of debris resulting from the trimming operation.	
	Topsoil has been spread in the areas and to the depths required. Stones, roots or other material with least dimension greater than the depth of spread has been removed.	

908 FILL TO STRUCTURAL FOUNDATIONS

Spec Clause no	Description	Yes/No
	Fill to structural foundations has not commenced without approval of the Engineer. The Contractor's construction procedure has also been approved by the Engineer.	
	Fill below structural foundations above natural surface has been in 300mm layers compacted to 95% MDD (Standard Compaction).	
	Excavation of unsuitable material below permanent foundations has been backfilled using either lean mix concrete or sub-base material.	

916 CONSTRUCTION COMPLIANCE TESTING

916 (1)	The maximum dry density (MDD) and Optimum moisture content (OMC) test shall be conducted in accordance with IS 2720 Part 8 as specified in Table 5.2.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:

Signature:

Date...

ANNEX 9: CHECKLIST FOR CRUSHER RUN MACADAM FOR BASE AND SUBBASE

Name of Project:

Contract No:

Contractor:

1204 CRUSHER RUN MACADAM FOR BASE AND SUBBASE

Spec Clause no	Description	Yes/No
1204 (2)	The Contractor has provided a material source assessment before material deliveries commence, to stockpile or pavement.	
1204 (2)	Base materials meet all requirements of Section 1204 (2) Tables 12.8 and 12.9 of the Specification such as grading, PI, LL AIV LAA and CBR.	
	Imported material has not been added to the source material without the Engineer's approval.	
	Construction material for use in base layers has been approved by the Engineer.	
	The method of selecting and processing Construction material has been approved by the Engineer.	
	The final unbound pavement layer has a uniform surface free from loose Segregated and contaminated areas and with course particles slightly exposed.	
	The base course after level; compaction and surface finish had been approved by the Engineer.	
	Geometric tolerances, except for surface evenness, have been checked by a method of random stratified sampling.	
	The compaction standard for each lot has been represented by the Characteristic Value of the Relative Dry Density.	
	In-situ compaction has been determined in accordance with Sand Replacement Method and Rapid Moisture Meter.	
	The location of in-situ dry density testing has been chosen by a method of random stratified sampling.	
	The surface of the pavement in every layer displays no visible vertical movement under compaction equipment.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:
Signature:
Date.

ANNEX 10: CHECKLIST FOR PRIME COAT AND TACK COAT

Name of Project:

Contract No:

Contractor:

1302 PRIME COAT

Spec Clause no	Description	Yes/No
1302.2	Cutback bitumen conforms to the requirements of Section 600 of the Specification.	
	The Contractor has tested the cutback bitumen for conformance with 618 Tables 6.12.	
1302 (5)	Blotter material is clean, dry sand or stone screening.	
	The Contractor has measured and recorded the road temperature at regular intervals.	
1302 (3)	Before spraying, the surface of the base course has been swept free of loose stones, dirt and foreign material.	
1302 (3)	Spraying does not commence until the prepared surface has been approved by the Engineer.	
	Application of prime coat is by means of a mechanical distributor approved by the Engineer.	
	The mechanical distributor has the following properties: -pneumatic tyre load < 120kg/cm of tyre width -application width up to 5m -application rates between 0.6 to 1.2 litres/m^2 ± 0.1litre/m^2 -speedometer accurate at low speeds -bitumen flow rate device -tank temperature gauge -spray bar pressure gauge -spare maximum recording thermometer and strainer -accurately calibrated dipsticks in tank -separate power unit for pump and full circulation spray bars	
	The spray bar operator has all nozzles in full view.	
	The spray bar and all measuring equipment on the distributor has been recently calibrated and a record supplied to the Engineer.	
	Performance testing of the distributor has been made, if requested by the Engineer.	

	The use of hand spraying has been approved by the Engineer.	
	The spray length has been measured and marked on the ground.	
	Application commences and finishes on a protective strip of paper.	
	At time of spraying, the surface is clean and slightly damp.	
1302(2)	Prime coat application is as per Tables 13.8 and 13.9. of DOR Specification	
	The width of primed surface is 150 mm wider on each side than that specified.	
1302(4)	Temperature of the prime coat is between 50°C to 80°C.as per Table 13.12 of DOR Specification	
	Adjacent structures and trees are protected from splattering prior to spraying.	
	Traffic has not been permitted on the prime coat until fully penetrated and dried in.	
	If unable to reroute traffic, and if approved by the Engineer, blotter material has been spread to avoid picking up by traffic.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:

Signature:

Date...

ANNEX 11: CHECKLIST FOR FORMWORK FOR CONCRETE

Name of Project:

Contract No:

Contractor:

1804 FORMWORK FOR CONCRET

Spec Clause no	Description	Yes/No
1804 (1)	There are no gaps in the formwork that will permit loss of material.	
1804 (1)	Formwork is rigid and adequately braced to maintain position and shape.	
1804 (1)	Check width and length of formwork, diagonal for square and plum with spirit level.	
1804 (1)	Formwork is clean and if necessary, coated with an acceptable release agent.	
	Formwork is not warped or buckled and concrete contact surface is free of defects and of the correct class.	
	Check that formwork used for exposed surfaces has the correct surface finish.	
	The design of mild steel formwork has been reviewed by the Engineer before work commences.	
	Check for Mild Steel forms that all bolt and rivet heads are countersunk and welds have been ground back.	
	Forms are designed and constructed such that removal can be made without injury to concrete or forms.	
	Block-outs and embedded items (if any) are in the correct place.	
	There are no wires or bolts extending to the surface of the concrete.	
	Internal tie bolts can be extracted without damage to the concrete.	
	Holes left behind from internal ties are filled with mortar to the Engineers satisfaction.	
	Check formwork re-entrant angles are chamfered and corners filleted.	
	Check that the formwork release agent doesn't contact reinforcement.	
	Different release agents are not used on visible sections of the same structure.	
	Formwork remains in position per the requirements of Clause 1804 and Table 18.1 and in no case is removed before the concrete can support its own weight.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:
Signature:
Date...

ANNEX 12: CHECKLIST FOR REINFORCEMENT WORK

Name of Project:

Contract No:

Contractor:

2014 REINFORCEMENT WORK – CHECKLIST

Spec Clause No	Description	Yes/No
2014	The Contractor has produced a Manufacturer's certificate as evidence that all steel complies with the relevant specification. Along with such certificate steel shall be tested in accordance with NS 191 / IS 1786. The certificates and/or samples have been supplied before fixing reinforcement on site.	
2014(2)	Steel is stacked in racks above ground and is clear of mud.	
2014(2)	Placed steel is free of dirt, detrimental scale, paint, oil or other foreign substances.	
2014(3)	Reinforcement is cold bent around the appropriate pin diameter.	
2014(4)	Check steel is of the correct: a) Shape b) Diameter c) Length d) Number and e) Spacing	
	Steel has been placed in the correct location.	
	Steel has the specified cover.	
	Cover is maintained by precast concrete blocks or other devices acceptable to the Engineer. The block strength should be equivalent to that of the surrounding concrete. Bar chairs are adequately spaced to prevent bars from sagging.	
	Welding of reinforcement is not undertaken without written approval of the Engineer.	
	Reinforcement is inspected and approved before placement of concrete.	
	Bars are spliced and lapped as shown on the Drawing or as approved by the Engineer.	

Spec Clause no refer to the relevant section of the Standard Specification for Road and Bridge Works, DoR 2073

Name of Site Engineer:
Signature:
Date:

ANNEX 13: CHECKLIST FOR CONCRETE WORKS

CHECKLIST FOR CONCRETE WORKS

Name of Project:

Contract No:

Contractor:

SN	Activities	Specifications		Remarks
		Yes	No	
A	**Preconstruction**			
1	Visited, Verified and approved the quarry site. Quarry site is satisfactory.			
B	**Preparation before concreting**			
1	There is sufficient and appropriate stroage place at site.			
2	Lab report is submitted			
3	Cement test is carried out and result is satisfactory.			
4	Coarse aggregate test is carried out and result satisfactory.			
5	Fine aggregate test is carried out and result is satisfactory.			
6	Cement, admixtures and ratio are satisfactory and approved.			
7	Design mix carried and as per requirement			
8	Required material stocks at site			
9	Adequate falsework done at the site and Satisfactory			
10	formwork (line/level/chamfering etc.) is satisfactory and as per drawings			
	Plastics, mobiles are not used during formwork			
	Form oil is used during formwork			
11	Cleaning of formwork is satisfactory.			
12	Reinforcement placement is satisfactory and as per design drawing.			
13	Equipment's (Mixer, Batching box, Vibratory, Generator, Cube box, Slump cone, shovel, trowel, wheel barrow, bucket etc.) are in condition, sufficient for working and spares available for emergency.			
14	Survey equipment theodolite, level, total station etc is available at site.			
15	Planning of construction joint is approved.			
16	Sufficient safety gears/ first aid kit are available.			
17	Curing methods are proper, sufficient, satisfactory and well managed.			

C	**During construction and concreting**			
1	Ambient temperature is noted down.			
2	Solution is made at site if temperature is high (with remarks).			
3	Sufficient workers are available and well managed.			
4	Water cement (W/C) ratio is well managed.			
5	Proper Unloading Platform is provided.			
6	Slump test is carried out at required time interval as per specification.			
7	Concrete pouring system (Chute or others) is well managed; method is OK.			
8	Concrete pouring height is not more than 1.5m			
9	Means of material Transportation (Wheel barrow etc.) are sufficient.			
10	Sufficient Concrete cubes are prepared at site as per specification.			
11	Surface preparation activities before concreting are sufficient and OK.			
12	Concrete is properly and satisfactorily poured and OK.			
13	Sufficient numbers of vibrators are used and concrete is well compacted.			
14	Safety gears are sufficiently used at the site.			
15	Concrete is not bleeding.			
16	Surface is well finished.			
17	Cement slurry is properly disposed off, not direct discharge into river			
18	Water used during concrete work is proper and as per specification			
D	**Post concreting**			
1	Completed concrete is satisfactorily and sufficiently cured at the site.			
2	Formworks are satisfactorily and properly removed.			
3	Falsework are satisfactorily and properly removed.			
4	Concrete quality with respect to finishing is well and good and first class.			
5	Honeycombes, air bubbles and cold joint are observed in concrete surface.			
6	Alignment and Dimension of member is correct?			
7	All temporary supports are removed satisfactorily.			

Name of Site Engineer :

Date:

Signature: