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Ministry of Rural Development
Government of India

Quality Assurance Handbook for Rural Roads

Volume - I

Quality Management System and Quality Control Requirements

May 2007

National Rural Roads Development Agency

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QUALITY ASSURANCE HANDBOOK FOR RURAL ROADS

VOLUME I

CONTENTS

FOREWORD

Focus on quality has been a singular feature of the Pradhan Mantri Gram Sadak Yojana (PMGSY) right from its inception. In fact, the report of the National Rural Roads Development Committee, which formed the conceptual basis of this programme, specifically highlighted the need for inbuilt quality assurance mechanisms, as a first step towards institutionalizing quality assurance system in the programme implementation, a quality control handbook for rural roads was brought out in 2002 by the National Rural Roads Development Agency (NRRDA) covering various tests to be conducted, frequency of these tests and details of the test procedures. However, at that time separate specifications were not available for the low volume rural roads. In 2004 the Ministry of Rural Development brought out Specifications For Rural Roads, which was published by the Indian Roads Congress (IRC). Following this technical experts as well as the programme managers felt that there was a consequential need to revise the Quality Control Handbook. Accordingly, the work of revising the handbook was entrusted to the IRC which constituted a group of experts headed by Shri S. C. Sharma, former Director General (Road Development) and Additional Secretary, Ministry of Road Transport and Highways. The other members of this expert group were Shri D. P. Gupta, Dr. V. M. Sharma, Dr N. B. Lal, Shri M. V. B. Rao, Shri G. S. Khinda and Shri S. P. Singh.

This revised version of the quality Assurance Handbook for rural roads does not restrict itself to quality control only. It has widened the scope by adopting the principles of quality assurance as laid down by the IRC. Volume-I of this handbook deals with the quality management system and quality control requirements and Volume-II covers the equipments and test procedures. Quality monitoring of the projects through independent, third party monitors at the State level as well as at the Central level has also been dealt with in Volume-I. Unlike the earlier practice of seeking quality control only during construction, this handbook recommends exercising quality control at three stages – at the stage prior to construction, during the construction phase and quality checks by the field engineers after completion of each stage of construction, which is termed as "stage passing". A number of carefully thought out "Do's and Don'ts" for each activity and item of work have also been prescribed for the guidance of users.

In its present form, this handbook incorporates valuable suggestions and recommendations which were received during a workshop which was specifically organized to review the draft on April 16-17, 2007 at Central Road Research Institute, New Delhi. I would like to express my sincere appreciation to the IRC, the members of the expert group for their painstaking efforts, to all the members of the peer review group for their meticulous and methodical scrutiny, and to all the participants of the national workshop which was held in April 2007 for their valuable contributions. I do believe that in the implementation of PMGSY in substantial measure.

(J. K. Mohapatra)
Joint Secretary (RC)
Ministry of Rural Development &
Director General
National Rural Roads Development Agency

PREFACE

A good road network has an important bearing on the economic growth of the country. Rural Connectivcity is perceived as one of the major component in increasing the agricultural output and earning capacity of the rural population. There is a marked improvement in quality of life by way of better educational facilities, improved health services, improved attendance by the school teachers as well as students. Accessibility also provides improvement in governance and provision of other facilities like post offices, access to police in case of emergencies and other communication system like telephones. As a measure of poverty reduction, Government of India has launched Pradhan Mantri Gram Sadak Yojana (PMGSY) in December, 2000. The management systems developed for implementation of the programme are centered on quality and the guidelines clearly prescribe to provide good all-weather connectivity to target habitations.

Construction of quality roads requires concerted efforts on many fronts, therefore, a *three tier* quality mechanism has been operationalized under the programme. The *first tier* provides for in-house quality control, wherein, the Programme Implementation Unit (PIU) is required to control the quality of work through performing mandatory tests for the material and workmanship. The *second and third tier* of quality mechanism provides for monitoring of quality by the independent quality monitors at the State Level and at the National Level. The PMGSY Guidelines provides that the NRRDA will issue general guidelines on quality control and prescribe a Quality Control Hand Book to regulate the quality control process at works level. Accordingly, a Quality Control Hand Book was brought out in 2002.

Based on feedback received from States, executing agencies and other organizations, it was felt that handbook may also contain details about the tests involved in construction of cross drainage works, rigid and semi-rigid pavements and protection works etc. The Rural Roads Specifications provide for mandatory testing of material and workmanship and feedback of the field formations regarding the frequency of tests indicated that there is a scope to revisit these frequencies. Therefore, National Rural Roads Development Agency decided to review the Quality Control Hand Book and the work of review was entrusted to Indian Roads Congress (IRC).

The IRC was requested to review the content of Quality Control Hand Book with a view to include details about all the tests required for construction of roads and related cross drainage works etc. It was also requested that the IRC may review the prescription of frequency of tests and examine whether the concept of stage passing may be introduced to ensure clear accountability. The IRC constituted Expert Group headed by Shri S. C. Sharma, Former Director General, Ministry of Road Transport and Highways. The Expert Group prepared the contents of the Handbook and based on the level of work and its utility, the title of the handbook was decided as 'Quality Assurance Hand Book for Rural Roads'. The drafts of Quality Assurance Hand Book were reviewed in a series of meetings and deliberations by a Peer Review Committee, constituted by NRRDA as below:

Prof. C. E. G. Justo, Emeritns Fellow, Bangalore University – Chairman

Shri Prabha Kant Katare, Director (Projects-III), NRRDA – Convener

MEMBERS

Dr. Ashok Kumar, Rural Roads Specialist, World Bank

Dr. Praveen Kumar, Indian Institute of Technology, Roorkee

Shri H. L. Meena, Chief Engineer PWD, Rajasthan

Engineer-in-Chief, PWD (R&B), Nagaland

Shri V. V. Gulati, Former Chief Engineer P.W.D, Uttarakhand.

Shri Vidya Sagar Singh, Former Chief Engineer, U.P.P.W.D.

Shri H. K. Srivastava, Director (Projects-I), NRRDA

Dr. B. P. Chandrasekhar, Director (Technical), NRRDA

Shri S. Baliga, Director (Projects-II), NRRDA

State Quality Coordinator (PMGSY), MPRRDA, Madhya Pradesh

State Quality Coordinator (PMGSY), HPPWD, Himachal Pradesh

The suggestions of members of Peer Review Committee and officers of NRRDA on the draft Hand Book were incorporated and final draft document was prepared. A National Workshop on Quality Assurance Hand Book was organized on 16-17th April, 2007 at CRRI to review of the contents of Draft Handbook. Dr. Subas Pani, Secretary, Ministry of Rural Development inaugurated the Workshop and in addition to his valuable guidance about internalizing the quality consciousness, he mentioned that enormous efforts have been made in preparation of the Hand Book and it should be used extensively by the field officers engaged in implementation of PMGSY. It was suggested by him that the Quality Assurance Hand Book should be made available on the Programme Website, so that the officers, contractors and other construction agencies can have easy access to the provisions of quality assurance. The workshop was attended by representatives of almost all the States and experts. A number of valuable suggestions and comments made at the Workshop were suitably incorporated in the present form of Quality Assurance Hand Book.

Volume I of the Handbook covers quality management system and details about quality control requirements. The revised frequency of tests and requirements about stage passing in form of quality control checks have been elaborated in this Volume. Volume II gives detailed description about equipment and test procedures.

I would like to express my sincere gratitude to members of Expert Group, members of Peer Review Committee and Shri R. S. Sharma, Former Secretary, IRC whose pains taking efforts have brought out this wonderful document. I would also like to express my sincere appreciation to the efforts made by Shri V. K. Sinha, Secretary General IRC, officers and other staff of IRC in bringing out this handbook in the present form. I thankfully acknowledge the contribution made by the participants of the workshop organized at CRRI in April, 2007.

The document of this nature cannot remain static with continuous upgradation of technology. User of this handbook would be the best judge of the deficiencies, if any still left in the document. We would greatly value the feedback and suggestions in this regard to keep this document updated. I am confident that this document would serve its intended purpose.

(Prabha Kant Katare)

New Delhi

May, 2007

Director (Projects) & Chief Quality Coordinator

National Rural Roads Development Agency

ABBREVIATIONS

AE	:	Assistant Engineer
AIV	:	Aggregate Impact Value
BOQ	:	Bill of Quantities
CBR	:	California Bearing Ratio
CD	:	Cross-Drainage
CRMB	:	Crumb Rubber Modified Bitumen
cum	:	Cubic metre
EE	:	Executive Engineer
g	:	Gram
GBFS	:	Granulated Blast Furnace Slag
GSB	:	Granular Sub-Base
GTS	:	Grand Triangulation Survey
h	:	Hour
IS	:	Indian Standard
JE	:	Junior Engineer
kg	:	Kilogram
km	:	Kilometre
kN	:	Kilo Newton
l	:	Litre
m	:	Metre
MB	:	Modified Binder
ml	:	Millilitre
mm	:	Millimetre
MORD	:	Ministry of Rural Development
MORTH	:	Ministry of Road Transport & Highways
MOSRTH	:	Ministry of Shipping, Road Transport & Highways
MPa	:	Mega Pascal

MPM	:	Modified Penetration Macadam
MS	:	Medium Setting
NRRDA	:	National Rural Roads Development Agency
NQM	:	National Quality Monitor
OMC	:	Optimum Moisture Content
PMB	:	Polymer Modified Bitumen
RMB	:	Rubber Modified Bitumen
RS	:	Rapid Setting
SQC	:	State Quality Coordinator
SQM	:	State Quality Monitor
sqm	:	Square metre
SS	:	Slow Setting
UCS	:	Unconfined Compressive Strength
WBM	:	Water Bound Macadam
WMM	:	Wet Mix Macadam

CHAPTER 1
INTRODUCTION

1. BACKGROUND

1.1 A major rural road programme known as Pradhan Mantri Gram Sadak Yojana (PMGSY) is being implemented since December 2000 by the Government of India through the Ministry of Rural Development (MORD). The National Rural Roads Development Agency (NRRDA), working under the aegis of the MORD, provides the overall administrative, technical and programme support to the states in the execution of works. The scheme envisages construction of good quality all-weather roads to provide connectivity to habitations with a population of 500 and above (250 and above in case of hills, deserts and tribal areas). Emphasis is being laid on planning, design, construction and maintenance of rural roads based on sound engineering principles, which conform to specifications, codes of practice and manuals of the Indian Roads Congress. A comprehensive document, IRC:SP:20 entitled Rural Roads Manual has been brought out in 2002 for adoption in case of all rural roads including works being carried out under the PMGSY programme. Subsequently, the NRRDA brought out its own Handbook on Quality Control for Road Works and Operations Manual for PMGSY works. A detailed Book of Specifications for Rural Roads and Standard Data Book for Analysis of Rates have also been prepared and published through the Indian Roads Congress. A strong technical underpinning has been given so that roads taken up under this programme conform to the MoRD specifications.

1.2 The Government of India have recently reviewed the progress of the PMGSY and other schemes relating to rural development and have decided to undertake a bold initiative of building infrastructure in rural areas under an umbrella programme, known as 'Bharat Nirman'. The PMGSY is one of the six components of the Bharat Nirman and the following targets have been set:

(i) Provide all-weather connectivity to habitations of population above 1000 (500 in case of hills, deserts and tribal areas).

(ii) The task would involve connectivity to 66,802 habitations.

(iii) The work involves construction of over 140,000 km of new roads and upgradation of over 190,000 km of existing rural roads at an estimated cost of Rs 48,000 crore.

2. QUALITY ASSURANCE

2.1 A three-tier quality management mechanism has been operationalized under PMGSY for ensuring that the quality of assets created conform to the prescribed standards. The first tier of quality management mechanism is in-house quality control at the level of the executing agencies whereas the second tier provides for quality monitoring through independent State Quality Monitors (SQM). Monitoring by independent National Quality Monitors (NQM) constitutes the third tier of this arrangement. Under this arrangement, it is the responsibility of the State Government to operationalize the first and the second tiers of the quality management structure.

It is proposed to widen the scope of quality control by including the principles of Quality Assurance laid down by the Indian Roads Congress in their guidelines on quality systems for roads (IRC:SP:57-2000) and for bridges (IRC:SP:47-1998). A Total Quality Management approach is envisaged. The concept of Total Quality Management (TQM) as defined by ISO reads as "TQM is a management approach of an Organisation, centered on Quality, based on participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all the members of the Organisation and the Society". In fact the TQM is a management strategy aimed at embedding awareness of Quality in all organisational processes. The TQM concept in the context of Rural Roads suggests that quality has to be seen as the basic policy starting from conception till the operation and management of Rural Road assets. The objective of the PMGSY is to provide "Good All Weather Roads" and the implementation strategies of the programme are therefore, centered on the word 'Quality'.

2.2 Class of Quality Assurance (QA) for Rural Roads: Four classes of Quality Assurance are prescribed as under:

	Quality Assurance	Class
1.	Nominal QA	Q 1
2.	Normal QA	Q 2
3.	High QA	Q 3
4.	Extra High QA	Q 4

For rural roads, Class Q 2 may be adopted. However, for a particular project or even for particular activities, decision regarding upgradation of QA class could be taken by the Project Implementation Unit keeping in view the level of quality and the level of control expected beyond Class Q 2. The quality assurance requirements in respect of materials and workmanship to be achieved during execution are described against each item of road and bridge work in relevant Sections.

2.3 For day-to-day reference of the Engineers in the field and the Contractors engaged in construction of rural roads, this Handbook on Quality Assurance has been prepared drawing heavily on the following sources:

(i) Specifications for Rural Roads, MoRD (2004).

(ii) Rural Roads Manual IRC:SP:20-2002.

(iii) Handbook on Quality Control: Road Works NRRDA (2002).

(iv) Hill Road Manual: IRC:SP:48-1998.

The frequency of tests has been further rationalized and NRRDA will bring out the necessary modifications in MoRD Specifications for Rural Roads. The quality control requirements prescribed in the Book will be mandatory for all PMGSY works. This book would also serve as a useful reference to the State Technical Agencies, State-level Quality Control Units, and National Quality Monitors.

3. QUALITY CONTROL

3.1 The Quality Control on Rural Roads and Cross-Drainage Works shall be exercised as follows:

(i) 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, CBR and any other tests specified by the Engineer shall invariably be carried out in the presence of a representative of the Engineer, who will not be below the rank of Junior 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.

(ii) Quality Control Tests During Construction:

During execution of the work, quality control for workmanship and ensuring conformance to specifications 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 Junior Engineer, when available at site or where association of the Employer's representative in test is prescribed. The Junior 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 Assistant Engineer / Executive Engineer during their site visits shall have a few tests carried out in their presence and sign the Quality Control Register.

(iii) Stage Passing:

Supervisory officers of the level of AE and EE shall exercise quality control checks and certify the work of various stages on the basis of tests and their frequencies indicated under 'Quality Control Checks'. The officer certifying the work at various stages as prescribed shall be responsible for the quality and quantity of the work certified by him.

(iv) Procedure to form part of the Contract:

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

3.2 Random Checks

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 atleast 9 m length.

(iii) Transverse profile viz. camber / crossfall / super elevation shall be tested using camber templates at two or three locations for each 100 m length.

(iv) Temperature measurement shall be done by metallic contact thermometer with digital display.

3.3 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 / handfeel tests can be performed. Normally various simple tests have been used by the experienced practising engineers in the field to make a quick assessment of the quality of the product. However, these procedures have not been standardized and involve human judgement. Therefore, these tests which provide useful guidance for supervisory officers during inspections, should by no means be used as a replacement of the specified quality control tests. Some simple handfeel tests which are useful for quality monitoring are given in Appendix I.

4. COVERAGE OF THE HANDBOOK

The Handbook is divided into two volumes:

Volume I: Quality Management System and Quality Control Requirements

Volume II: Equipment and Test Procedures

The Volume I covers quality management system and describes in detail quality control of works by Field Units and supervisory staff and quality monitoring by National / State Quality monitors for various activities of construction and maintenance of rural roads. The Sections in this Volume correspond to the Sections of the Specifications for Rural Roads of the Ministry of Rural Development, Government of India.

The Volume II covers laboratory set up, equipment and test procedures for various quality control tests.

5. Flow Chart

A typical flow chart for quality assurance checks during the construction of rural roads is given as an illustration in Figure 1.1.

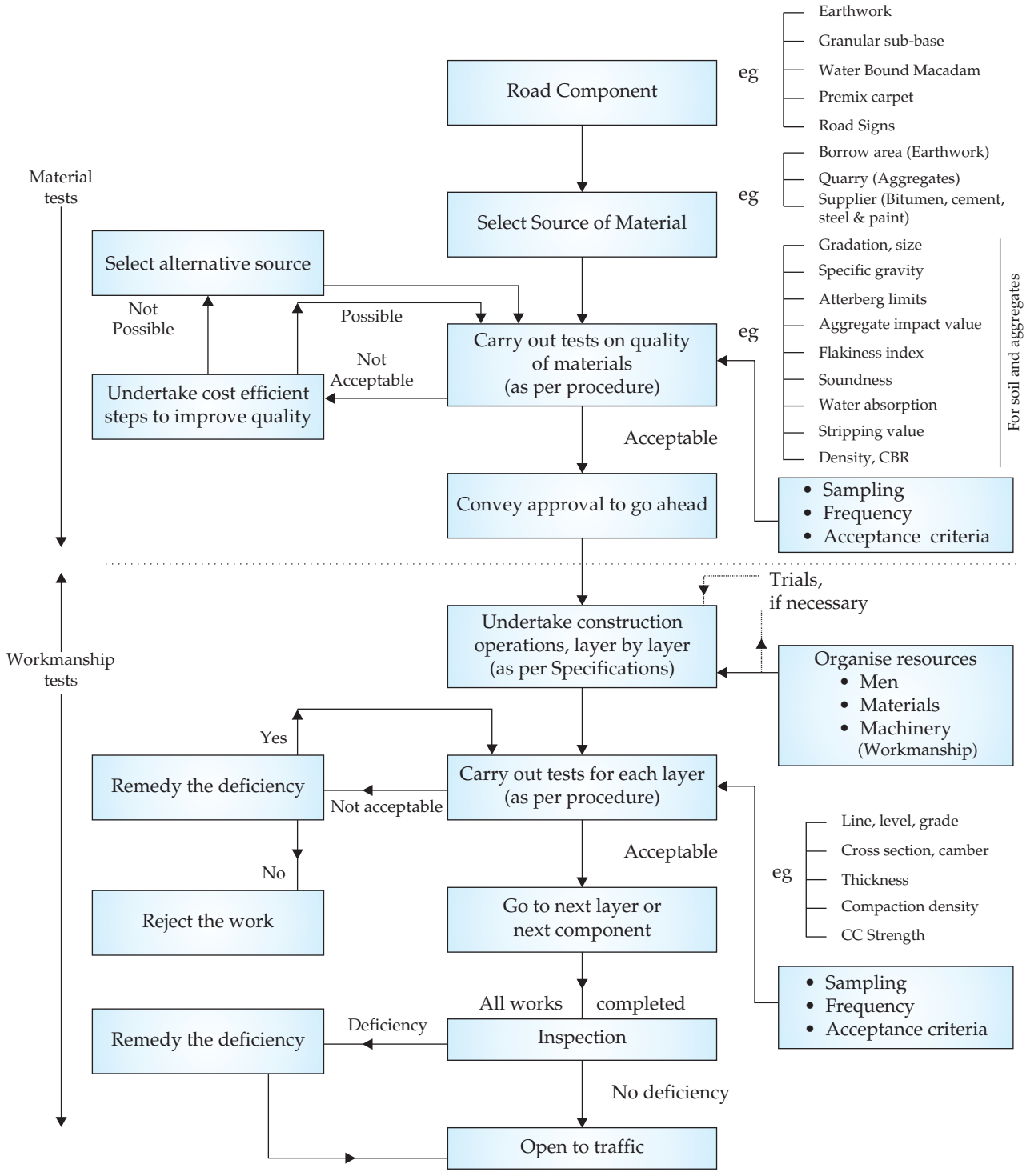


Figure 1.1: Typical Flow Chart for Quality in Road Works

Notes:

1. *Field units shall maintain proper quality control records in the prescribed formats.*
2. *In addition to the quality control exercised by the PIU as described above, additional quality monitoring checks will be carried out by second and third tiers.*

CHAPTER 2

QUALITY MANAGEMENT SYSTEM

1. INTRODUCTION

Rural Road Projects are often very small in size and widely scattered in remote areas with very limited basic facilities like ready availability of electric supply, drinking water and road access to heavy plant/ equipment etc. The material specifications generally incorporate the use of a wide variety of low cost locally available materials. The speed of construction is relatively slow and the available resources as well as skills with small contractors are at a relatively lower level.

It is, therefore, necessary that while developing a suitable Quality Management System for both construction and maintenance work, such constraints are kept in view. The types of quality control tests and their frequency have also to be judiciously selected so as to be achievable under the prevailing conditions.

Keeping the above factors in mind, a three tier quality management system together with a simplified practical approach to Quality Assurance in Rural Road works is prescribed as detailed in subsequent paragraphs.

2. THREE TIER SET UP FOR QUALITY MANAGEMENT SYSTEM

The three tier quality management mechanism comprises:

(a) **First Tier:** In-house quality control by the executing agency

(b) **Second Tier:** Independent quality control set up of the State Rural Roads Development Agency.

(c) **Third Tier:** National Quality Monitoring system as operationalised by NRRDA for PMGSY.

The second and third tier will not be connected with the Project Implementation Unit (PIU).

3. FIRST TIER

3.1 The PIU is envisaged as a first tier of quality management with the primary function of construction supervision and quality control. The quality management functions of the PIU shall include the following:

(i) Preparation of realistic detailed project report (DPR) with adequate attention to investigations and pre-construction activities which are essential for proper design and estimation of the project following MoRD Specifications for Rural Roads, Rural Roads Manual and other relevant IRC specifications.

(ii) Preparation of bid documents and effective selection process for procurement of works, based on proven capacity and ability of the contractors.

(iii) Ensuring that:

(a) Contractors have brought the necessary machinery and equipment to site.

(b) Field laboratory has been established.

(c) Key engineering personnel have been deployed by the Contractor and

(d) The work programme has been approved.

(iv) Supervising Site Quality Control arrangements including materials and workmanship, primarily through testing as per provisions of the Quality Assurance Handbook.

(v) The following frequency of inspection visits to site by PIU staff is recommended while the work is in progress:

(a) Junior Engineer – Daily

(b) Assistant Engineer – Twice a week

(c) Executive Engineer – Once a week

(vi) Taking timely action to ensure replacement of defective material and rectification of defective workmanship.

3.2 To ensure effective Quality Control on materials and workmanship, the procedure described in para 3.1 of Chapter 1 shall be followed:

3.3 A monthly return of the tests shall be submitted in the prescribed proforma by the AE to the EE in the first week of every month. The EE will review this return regularly to see that the Quality Control tests are being performed at the desired frequency and with the desired accuracy. The EE will also verify that the Non Conformance Reports (NCR) are being issued by the AE whenever non-conformance occurs and the Contractor is taking action promptly on the NCR. Payment to the Contractor shall be regulated by the EE as per the returns of the Quality Control tests. Any deviation will be the personal responsibility of the EE.

3.4 The SE in charge of the circle and the Chief Engineer having jurisdiction are responsible for the proper functioning of the PIU as part of their normal administrative duties. Their inspection and quality testing supervision will therefore be counted as part of effective supervision of the first tier of quality management (and not as a second tier of quality management). The SE / CE shall:

(i) During his visits to the work, oversee the operations of the quality control testing procedure and record his observations in the Quality Control Register. The SE / CE will also verify that the Non-Conformance Reports are issued in time and action is being taken by Contractor promptly.

(ii) Prepare Inspection Reports which shall be sent to the PIU for taking remedial action.

The State Govt. / State Rural Roads Development Agency shall prescribe frequency of inspections by various officers and formats for furnishing inspection reports by SE / CE.

4. SECOND TIER

4.1 The first tier of quality management has the primary function of quality control through enforcement of technical standards and quality control requirements through regular testing, close

supervision and inspection. Function of the second tier of independent quality management is to ensure that the Quality Management System at the site is functioning satisfactorily and suggest possible improvements where required. For this, they may be required to carry out and report:

(a) Independent quality tests to verify that the quality management system achieving its intended objectives.

(b) Systemic flaws in the quality control process and action to improve the process.

4.2 The role of second tier in monitoring the quality of the work is of crucial importance during construction stage and therefore the State Quality Monitors are required to carry out inspections at appropriate stages of work under progress.

4.3 The independent Quality Management Division of the executing agency may function as the second tier. The State Rural Roads Development Agency will frame suitable guidelines for proper functioning of second tier.

5. THIRD TIER

The National Rural Roads Development Agency shall prescribe the guidelines for the third tier from time to time.

The objective of this third tier of quality mechanism is to monitor the quality of road works executed by the States with a view to ensuring that the road works under the programme conform to standards and to see whether the quality management mechanism in the State is effective. The role of this tier is to provide guidance to State implementation machinery and the field engineers rather than 'fault finding'. As such, the shortcomings are identified by the third tier and a feedback is provided to the States for improvement.

6. QUALITY CONTROL

The requirement of a quality control organization will vary for different projects depending on departmental set-up and also size of the project. The minimum suggested organization of quality control laboratory set-up at Field, District and Central level shall be as follows:

6.1 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 manned by suitably trained personnel in material testing and quality control works.

6.2 District Laboratory

The tests which are required to be done during the project preparation 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 DPR preparation.

A typical set up of a District Laboratory is given in fig. 2.1.

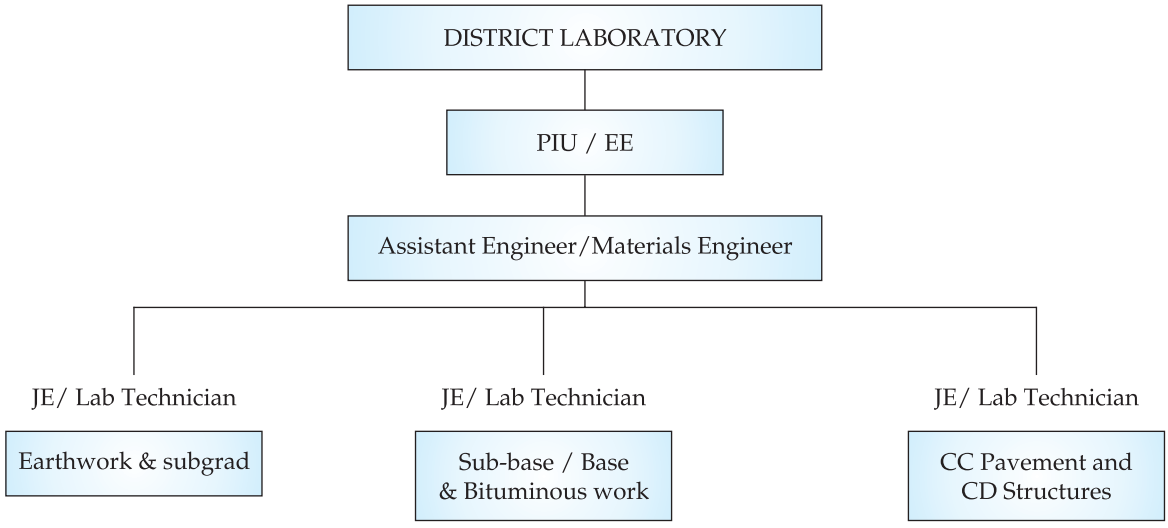


Fig. 2.1 Typical set up of a District Laboratory

6.3 Central Laboratory

Tests requiring high level of skills and sophisticated equipment as also for the other quality tests will be carried out at the Central Laboratory under the control of the Chief Engineer or In-charge Quality Control, State Rural Roads Development Agency preferably at the State Headquarters.

Any special or sophisticated tests, for which the necessary equipment and expertise are not available in the Central Laboratory, shall be outsourced, to approved National Accreditation Board for Laboratories (NABL) accredited Test houses or Higher Technical (academic) Institutes or Research Laboratories.

7. SPECIFICATIONS AND CODES OF PRACTICE

The specifications and codes of practice laid down by Ministry of Rural Development, Indian Roads Congress and Bureau of Indian Standards are required to be followed in construction of rural roads. The list of IRC Publications and List of MORD and MORTH Publications is given at ***Appendix – 3*** and ***4*** respectively in Volume I and list of Indian Standards in Volume II at Appendix-1.

8. LABORATORY AND EQUIPMENT

The equipment requirement for quality control tests for Field, District and Central Laboratories are given in Section100 of Volume II.

CHAPTER 3

QALITY CONTROL OF WORKS

SECTION 100 GENERAL

105. CONSTRUCTION EQUIPMENT

1. For ensuring quality of work, an appropriate technology must be adopted. In the context of rural roads, an appropriate technology implies an optimum blend of manual methods and mechanical equipment of adequate capacity which may also involve use of agricultural implements towed by tractor. Guidelines for choosing appropriate equipment and technology for rural roads are given at Appendix-2.

2. Ensure that the equipment deployed is appropriate to the work and is properly operated and maintained.

3. Arrange a trial run of the equipment before commencement of the work.

4. Ensure that no equipment is deployed at or removed from the site of work without prior approval of the employer.

108. SETTING OUT

A Methodology

1. Establish working bench marks at 250 m intervals and also at or near all drainage structures and bridges on the road. All the bench marks should be tied with the Reference Bench Mark in the area.

2. In hilly areas, reference pillars handed over by the Engineer to the Contractor shall work as bench marks.

3. Establish centre line of the carriageway and have it referenced by marker pegs and chainage boards set near the road land boundary at 50 m intervals for roads in plain and rolling terrains. For roads in hilly areas and on curves in plains, the interval of reference pegs should be 20 m. For sharp curves, the interval should be 10 m and for hair pin bends the interval should be 5 m.

4. 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.

5. 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.

6. Prepare a schedule of reference dimensions and maintain the markers/ reference pillars until the works reach finished formation level and are accepted by the Engineer.

7. Verify the dimensions and levels, shown on the drawings or mentioned in contract documents, on the site and inform the Engineer of any apparent errors or discrepancies.

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

9. The plan dimensions of the foundations for culverts shall be set out at the bottom of foundation trench and checked with reference to original line of reference and axis.

B Quality Control Requirements

1. **Horizontal Alignment**

   Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings.

2. The permitted tolerances are given in Table 108.1

TABLE 108.1: PERMITTED TOLERANCES

Alignment	Plain and Rolling Terrain	Hilly Terrain
Edges of carriageway	± 20 mm	± 30 mm
Edges of roadway and / lower layers of pavement	± 30 mm	± 50 mm

C Do's and Don'ts

Do's	Don'ts
1. Check whether Reference benchmark is indicated on the drawings. 2. Regularly check the working bench marks as work proceeds. 3. Arrange safety of survey bench marks, monuments, beacons etc. and reference pillars in hilly areas 4. Check layout of Curves. 5. Supply a copy of survey file containing the necessary data to the Engineer for his record.	1. Don't commence work until the initial center line is established by marker pegs and cross sections at specified intervals have been approved by the Engineer. 2. Do not remove reference pegs, pillars or markers without approval of the Engineer.

109 & 110. PUBLIC UTILITIES AND ENVIRONMENT

A Methodology

1. Verify at site, public utilities like water pipes, sewers, electric lines, telephone cables etc. included in contract documents.

2. Arrange for regular meetings with various agencies owning utilities at the commencement and throughout the duration of the works.

3. Temporarily support the utilities affected by the works.

4. Assist agencies owning the utilities in carrying out the works with approval of the Engineer.

5. Abide by all laws, rules and regulations in force governing pollution and environment and wild life protection, applicable in the area.

6. Obtain approval of concerned authorities for obtaining materials from quarries and for locating plant and equipment.

B Do's and Don'ts

Do's	Don'ts
1. Protect utility services during construction period. 2. Control soil erosion, sedimentation and reduce levels of noise, vibration, dust and emissions from construction plant and equipment. 3. Keep the roadside and surroundings clean and free from dust, mud or other extraneous material. 4. Cut material should be disposed of at predetermined dumping places.	1. Do not carry out any clearance or alterations to any utility unless especially ordered by the Engineer. 2. Do not cause any damage to public utilities. 3. Do not pollute natural water-courses, pools, tanks and reservoirs. 4. Do not use hazardous materials without providing protective clothing, masks, shoes etc. to the workers.

114. METHODOLOGY AND SEQUENCE OF WORK

A. Methodology

1. Ensure that a detailed construction methodology is submitted by the Contractor prior to start of the construction activities in accordance with the Contract Agreement. The construction methodology will include:-

(i) Mechanical Equipment proposed to be used.

(ii) Sequence of various activities and schedule from start to end of the project.

Programme relating to pavement and shoulder construction shall be an integrated activity to be done simultaneously in a coordinated manner. The methodology and sequence shall be so planned as to provide proper safety, drainage and smooth movement of traffic.

SECTION 200

SITE CLEARANCE

201 & 202. SITE CLEARANCE

A Methodology

1. The road land should be cleared of all materials unsuitable for the work by cutting, trimming, removing and disposing of all materials, such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness and rubbish, etc. This should be carried out well in advance of earthwork operations.
2. The top soil removed during clearing and grubbing of site, if suitable for re-use shall be transported, conserved and stacked for re-use.
3. All trees, stumps, etc. falling within the excavation and embankment lines should be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade. Beyond these limits, they need to be cut down to 500 mm below ground level.
4. Excavations below the ground level arising out of removal of trees, stumps, etc., should be filled in layers with suitable material and compacted to the specified density given by the Engineer.
5. Measurement of trees having girth more than 300 mm should be done as per sizes given in the Bill of Quantities (BOQ).
6. Ant-hills both above and below the ground shall be removed by excavating to a suitable depth as directed by the Engineer. Cavities in the ground after removal of ant-hills shall be filled with appropriate material and properly compacted to the specified density.
7. Existing structures which are within the road land and designated for removal should be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the parts of the structure to be retained and any other adjoining properties and utilities.
8. Holes and depressions caused by dismantling operations or caused by rats etc. shall be backfilled with approved material and compacted to the required density.

B. Do's and Don'ts

Do's	Don'ts
1. Take appropriate measures against soil erosion and water pollution. 2. Obtain prior permission of the competent authority for removing/ disturbing any existing utilities etc. required, if any. 3. Conserve top-soil for re-use where suitable.	1. Do not forget to: (a) backfill the pits resulting from uprooting trees, stumps and removal of anthills etc. with suitable material and compact thoroughly. (b) Immediately remove unsuitable materials obtained from clearing the site. 2. Do not disturb existing poles, fences, signs, monuments, buildings, pipelines, sewers, trees etc. which do not interfere with the work and are to be retained. 3. Do not damage parts of existing structures to be retained while dismantling portions interfering with the work.

SECTION 300

EARTH WORK

301. EMBANKMENT CONSTRUCTION

A Methodology

1 Obtain materials (soil) for embankment from approved sources. Preference should be given to materials that are suitable and become available from nearby road excavation. (Refer Section B for quality control requirements).

2 After clearing the site, mark the limits of embankment by fixing batter pegs and marking toe lines on both sides at regular intervals as guides. The embankment shall be built sufficiently wider (about 300 mm on either side of Roadway) than the specified formation width so that surplus material at the edges may be trimmed to ensure proper compaction of the edges and side slopes.

3 Remove stagnant water, if any, from the foundation of the embankment.

4 Where the available embankment materials (Soil) are not conducive to plant growth, topsoil from areas of cutting and areas to be covered by embankment should be stripped to specified depth not exceeding 150 mm and stored for covering slopes, and other disturbed areas where re-vegetation is required.

5 After removing the top soil / unsuitable material, foundation for embankment construction shall be prepared as follows:

(a) For embankment less than 1.0 m high 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 Para B5.

(b) For embankment less than 0.5 m height 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 Para B5.

(c) 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.

(d) 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.

(e) For embankment over ground not capable of supporting equipment, successive loads of embankment materials should be spread in a uniformly distributed layer of adequate thickness to support the equipment and to construct the lower portion of the embankment.

(f) For embankment construction on existing slope steeper than 1 Vertical: 4 Horizontal, horizontal benches should be cut in the existing slope to a sufficient width to accommodate placement and compaction equipment.

6 The size of the coarse material in the mixture of earth used for embankment construction should ordinarily not exceed 75 mm.

7 The soil should be spread over the entire width of the embankment in layers not exceeding 150 mm compacted thickness. The clods should be broken to less than 75 mm size. Each layer at a moisture content within (±) 2 % of the optimum moisture content, should be thoroughly compacted

by roller, to the specified requirements as per Para B.5 and finished parallel to the final cross-section of the embankment. (Compacted layer thickness can be increased upto 200 mm if heavy vibratory rollers are used).

8 Compaction of soil should 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 should be compacted to at least 97 percent of the Standard Proctor Density. The top 300 mm of the embankment constituting the sub grade should be compacted to 100 percent Standard Proctor Density according to Para B.5.

10 Ensure that longitudinal and cross profiles should be in conformity with the approved drawings.

11 Approval of the Engineer should 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.

B Quality Control Requirements

1. Materials

(a.) 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) Clay having liquid limit exceeding 70 and plasticity index exceeding 45

(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 SO_3) per litre, if deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of permanent works

(ix) Material with a total sulphate content (expressed as SO_3) 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

(b) The size of coarse material shall not ordinarily exceed 75 mm when placed in embankment and 50 mm when placed in sub-grade.

(c) Only the materials satisfying the density requirements given in Table 301.1 should be used for the embankment.

TABLE 301.1: MINIMUM DENSITY REQUIREMENT FOR SUITABILITY OF EMBANKMENT/SUB-GRADE MATERIALS

	Type of Work	Max. laboratory dry unit weight
(a)	Embankment not subject to flooding-	IS:2720, Part 7
	- height upto 3 m	Not less than 14.4 kN / m^3
	- height more than 3 m	Not less than 15.2 kN / m^3
(b)	Embankment subject to flooding	Not less than 15.2 kN / m^3

2. Horizontal Alignment

The alignment shall be reckoned with respect to the centre 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 301.2:

TABLE 301.2: PERMITTED TOLERANCES FOR EDGES OF CARRIAGEWAY AND ROADWAY

Description	Plain and Rolling Terrains	Hilly Terrain
Edges of carriageway	(±) 20mm	(±) 30mm
Edges of roadway and lower layers of pavement	(±) 30mm	(±) 50mm

3. Surface Levels

The permitted tolerance in surface level for sub-grade will be +20 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 15 mm for the cross profile.

5. Degree of Compaction

The embankment shall be compacted to satisfy the density requirements given in Table 301.3.

TABLE 301.3: COMPACTION REQUIREMENTS FOR EMBANKMENT/SUB-GRADE/EXPANSIVE CLAYS

Type of work	Relative Compaction as percentage of maximum laboratory dry density
Embankment	Not less than 97 percent of Standard Proctor Density as per IS:2720 (Part 7)
Sub-grade (Top 300 mm of embankment and shoulders)	Not less than 100 percent of Standard Proctor Density as per IS:2720 (Part 7)
Expansive clays	
i) Sub-grade and 500 mm portion just below the sub-grade.	Not allowed
ii) Remaining portion of Embankment	Not less than 90 percent of Standard Proctor Density as per 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 301.4.

Table 301.4: QUALITY CONTROL TESTS AND THEIR FREQUENCY FOR BORROW MATERIAL, EARTHWORK FOR EMBANKMENT AND FOR SUBGRADE

Type of Test	Frequency
A. Earthwork for Embankment	
1. Soil Classification as per IS:1498 i) Sieve Analysis (Wet Sieve Analysis except for cohesionless soils) ii) LL, PL and PI	One test from each source for one km or part thereof.
2. Standard 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-
(ii) Total soluble sulphate content (IS 2720-Part 27) where suspected on past experience. This can be easily confirmed by a quick test using barium chloride.	-do-

B. Earthwork for Subgrade (Cutting or Filling)	
(i) Tests at 1 to 4, under A above. (In case the soil for embankment meets the prescribed requirements for the Subgrade, the above four tests need not be repeated.)	One test for each km length or part thereof, from each source.(c)
(ii) CBR Test (IS:2720 Part 16) soaked / unsoaked as specified.	One test for each km: this will comprise testing of 3 specimens and the CBR value will be reported as average of the three test values.

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 colour, odour and existence of any organic matter. Where such observations justify need for further testing, simple tests at (i) and (ii) 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.

(c) For hill roads, the frequency of tests may be increased depending upon the variability of the strata met.

6.2 Tests During Construction

The quality control tests to be carried out during construction and their frequency shall be as given in Table 301.5.

TABLE 301.5: FIELD QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Placement Moisture (IS:2720 Part 2) Any of the rapid test methods for determination of moisture content can beused:	At least 3 tests daily (well spread over the day's work)
2.	Insitu Density Measurements (IS:2720 Part 28) (Each layer)	-do- (i) Average of 3 tests results shall not be less than the specified degree of compaction. (ii) Individual test values of the degree of compaction obtained shall not be less than 1% of the specified value of degree of compaction. (For example, for the specified 100% Proctordensity, the individual test value shall not be less than 99% of Proctor density and the average of the three (or more) tests carried out in a day shall not be less than 100% Proctor density).
3.	Thickness of subgrade layer.	At random

6.3 Quality Control Checks by AE/EE

TABLE 301.6 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
A. Top of the Embankment (Before placing Subgrade Layer)	(i) Degree of Compaction (IS:2720 Part 28)	Minimum 3 tests for each km length or part thereof; allowable tolerance in test values as per para 6.2. One of the tests shall be carried out at a depth of 150 mm from the top.	AE
	(ii) Surface Regularity and Transverse Profile	Random Checking	AE
B. Finished Subgrade	(i) Degree of compaction (IS:2720 Part 28)	(a) One test for each 300 m length or part thereof.	AE
		(b) One test for each 1000 m length or part thereof. One of the tests shall be carried out at a depth of 150 mm from the top.	EE
	(ii) Surface Regularity and Transverse Profile / camber / crossfall and superelevation	Random Checking	EE

C. Do's and Don'ts

Do's	Don'ts
1. Discourage borrow pits along the road; where permitted, ridges of minimum 8 m width should be left at intervals not exceeding 300 m. Small drains should be cut through the ridges to facilitate drainage.	1. 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.
2. 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 1.0 m.	2. Do not allow borrow pits within 800 m of towns or villages.
3. Do maintain a camber / cross fall of 4 percent during construction for effective drainage and prevention of ponding of water.	3. Do not use unsuitable material for embankment construction (Refer para B.1).
4. The area of the embankment foundation should be kept dry. Test the material (soil) for its suitability for use in the embankment at least seven days before commencement of earthwork. Tests should include soil. classification test data and data regarding maximum dry density, OMC, and CBR (soaked and unsoaked).	4. Do not allow construction or other vehicular traffic over the prepared surface of embankment / sub-grade.
5. For widening of existing embankment start earth work from toe line.	5. Do not place successive layers of embankment until the previous layer has been thoroughly compacted and duly approved by Engineer.
	6. Do not allow any damage to works, crops or other property while discharging stagnant water found in embankment foundation.
	7. Do not allow dumping of earth from top to widen an existing embankment.

302. EARTHWORK IN CUTTING

A. Methodology

1. After site clearance, the limits of excavation should be set out true to lines, curves, slopes, grades and cross-sections as shown on the drawings by constructing reference pillars, back cutting lines, reference lines (1.5 m away from formation lines on hill and valley sides)

2. If directed, the top soil shall be stripped to specified depths and stockpiled for reuse, as detailed in sub-section 301.

3. Excavation shall be done manually or mechanically using dozers. After excavation, the sides of excavated area should be trimmed and the area contoured to minimise erosion and ponding, allowing natural drainage to take place.

4. Cross drainage works like scuppers or small culverts 1 to 2 m span and side drains, shall be so constructed along the formation cutting work, as to have least interference with the existing drainage.

5. The cut formation, which will serve as sub-grade, should be checked for its field density and if the field dry density of the material in the top 300 mm portion is less than 100 per cent of maximum Proctor density, the formation material shall be loosened to a depth of 500 mm and compacted in layers to 100 per cent Standard Proctor Density (IS:2720-Part 7).

6. In hilly areas, cutting should be done from top to bottom. Special attention should also be paid to side slopes and side drains in cutting.

7. Rock when encountered in road excavation shall be removed upto the formation level. Where unstable shales or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level.

8. In rocky formation, the surface irregularities shall be corrected with granular base material to achieve the specified profile and levels.

9. Where blasting is involved for rock cutting, guidelines given in sub-section 304 shall be followed.

10. Excavation in marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of backfilling to ensure complete removal or displacement of muck.

11. For widening of existing pavement, the existing shoulders shall be removed to their full width and upto sub-grade level to enable proper compaction in the widened portions.

B. Quality Control Requirements

1. Horizontal Alignment

The horizontal alignment should be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the roadway as constructed should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

2. Finishing

No point on the slopes shall vary from the designated 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 in surface level for sub-grade will be (+) 20 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 15 mm for the cross profile.

5. Quality Control Tests

Subgrade material shall be tested as per tests given in Table 301.4 (B). If the material in the subgrade has a density of less than 100% of maximum dry density (IS:2720 Part 7), the same shall be loosened to a depth of 500 mm (depth could be reduced to 300 mm if insitu density is not less than 95% of maximum dry density) and compacted in layers to 100% of maximum dry density. The density of compaction shall be tested as per Table 301.5 and checked as per Table 301.6.

C. Do's and Don'ts

Do's	Don'ts
1. Take precautions against soil erosion, water pollution, etc. and for preservation of existing trees, drains, sewers, pipes, conduits, poles or any other structures.	1. Do not remove the bench marks, reference lines, stakes etc. used for setting out of works without informing the Engineer.
2. Remove water, if met during excavation, from springs, seepage or other causes, by suitable diversions, pumping, or bailing out to keep the excavation dry.	2. Do not let the loose material / debris remain on the slopes of cutting / along the road.
3. Rocks and boulders, which are likely to cause differential settlement should be removed to the extent of 500 mm below the formation level.	3. Do not allow the rock to protrude above the formation level at any point.
4. Take precautions during construction to ensure stability and safety of slopes.	4. Do not stack stone boulders on embankment to ensure free flow of traffic especially on hill roads.
5. Near village settlements, trenches and foundation pits should be securely fenced and provided with caution signs in the interest of public safety.	5. Do not throw the debris on the valley side to avoid damage to property / environment.
6. Ensure that unsuitable and surplus material from cuttings is disposed of as directed by the Engineer.	
7. Ensure that proper longitudinal gradients as per drawings have been achieved.	

303. SUBGRADE CONSTRUCTION

The sub-grade is top 300 mm compacted layer in embankment or cutting just beneath the pavement crust. The subgrade in embankment is compacted to a higher standard than the lower layers of the embankment. In cutting, the cut formation, which serves as the subgrade, is treated similarly to achieve the specified density to provide a suitable foundation for the pavement.

A Methodology

1. Setting out, dewatering, stripping of top-soil etc. for subgrade construction shall be the same as for embankment construction described in sub-section 301.

2. Ensure that the soil for subgrade meets the specified requirements in terms of physical properties and the specified CBR value for pavement design.

3. Compact each layer of the material in the subgrade at OMC (±) 2% to at least 100% of Maximum Dry Density as per IS:2720 (Part 7).

4. If the difference between the subgrade 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 100% relative compaction with respect to IS:2720 (Part-7), loosen the ground upto a level 300 mm below the subgrade level, correct moisture content to OMC (±) 2% and compact in layers to 100% of the maximum dry density as per IS:2720 (Part 7).

5. If the subgrade 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 treatment with additives like lime / cement etc. as described in sub-sections 403 and 404 or by mechanical stabilization.

6. In conditions where salt concentration is in excess of 0.2%, a capillary cut-off of coarse sand should be provided below the subgrade as shown in the drawings to check the upward movement of moisture from below.

7. For a road in cutting, prepare the subgrade in accordance with subsection 302 to receive a sub-base course.

8. Ensure that the subgrade is compacted and finished to the design strength consistent with other physical requirements.

9. Maintain the surface of subgrade, at all times during construction, at such a cross fall as will shed water and prevent ponding.

B. Quality Control Requirements

1. Materials

(i) The material used for subgrades shall be soil, moorum, gravel, a mixture of these or any other approved material. Material considered unsuitable for embankment construction as per subsection 301 shall not be used for sub-grade.

(ii) The material for subgrade shall be non-expansive in nature.

(iii) 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.

(iv) Any fill material which yields a maximum dry laboratory unit weight of less than 16.5 kN / m^3 determined as per IS:2720 (Part 7) shall be considered unsuitable for use in subgrade.

(v) The size of coarse material in the soil shall ordinarily not exceed 50 mm when placed in the subgrade.

2. Surface Level

The permissible tolerances in surface levels of subgrade shall be (+) 20 mm and (-) 25 mm.

3. Surface Regularity

The maximum allowable difference between the subgrade and underside of a 3 m straight edge shall not exceed 20 mm for longitudinal profile and 15 mm for cross profile.

4. Quality Control Tests

4.1 The Quality Control Tests on Earthwork for Subgrade (in cutting or filling) and their frequency, prior to construction, shall be as per Table 301.4 (B).

4.2 The Field Quality Control tests during construction shall be as per Table 301.5.

4.3 The Quality Checks shall be as per Table 301.6 (B).

C. Do's and Don'ts

Do's	Don'ts
1. Do ensure that borrow area material for use in sub-grade satisfies the specified requirements and design CBR.	1. Do not proceed with sub-grade work until the foundation for sub-grade has been duly approved by the Engineer.
2. Do ensure that all layers in sub-grade are compacted to 100% Proctor Density as per IS: 2720 (Part 7).	2. Do not allow construction traffic or other vehicular traffic over the prepared surface of sub-grade.

304. ROCK CUTTING

I Rock Excavation

A Methodology

1. Guidelines on 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. Detailed safety aspects are given in **Annex-300.2** of Specifications for Rural Roads.

(ii) the magazine for the storage of explosive is built to the designs and specifications of the Inspection General Explosives, Nagpur and located at the approved site.

(iii) no unauthorized person is admitted into the magazine.

(iv) no match sticks or inflammable material shall be allowed in the magazine.

(v) all explosives are stored in a secure manner and such storage places shall be clearly marked.

(vi) the blasting operations remain in the charge of competent and experienced supervisors and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations.

(vii) 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.

(viii) all public utility companies having structures in proximity of the site of work are notified sufficiently in advance of the blasting work.

(ix) for blasting work within 50 m of any railway track or structures, the concerned Railway Authority is notified sufficiently in advance of the blasting work.

(x) red danger flags are displayed prominently in all directions during the blasting operations. The flags are planted 200 m from the blasting site in all directions.

(xi) sufficient safety arrangements shall be made, including positioning of manpower at proper locations to ensure that all persons including workmen are excluded from the flagged area at least 10 minutes before the firing.

(xii) blasting is as light as possible, consistent with thorough breakage of material.

(xiii) when blasting is done with powder or dynamite, the procedure outlined in Clause 304.2.4 of MoRD Specifications for Rural Roads is followed.

(xiv) at a time, not more than 10 charges are prepared and fired.

(xv) 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.

2. In case of misfire, follow the procedure laid down in clause 304.2.5 of Specifications for Rural Roads.

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

4. Sufficient arrangements should be made like posting of guards at proper locations so that no person enters the area of influence during the blasting operations.

B. Quality Control Requirements

1. All the materials, tools and equipment used for blasting operations shall be of approved type.

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

3. The magazine shall have a lightning conductor.

4. The fuse to be used in wet locations shall be sufficiently water-resistant as to be unaffected when immersed in water for 30 minutes.

5. 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.

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

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

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

C Do's and Don'ts

Do's	Don'ts
1. Provide information describing pertinent blasting procedures, and dimensions to Engineer prior to starting any phase of the operation, 2. Display prominently the following information in the lobby of magazine: (a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar. (b) A statement of up-to-date stock in the magazine. (c) A certificate showing the latest date of testing of the lightning conductor. (d) A notice that smoking is strictly prohibited. 3. Do intimate the hours of blasting to the people in vicinity. 4. Do drill the charge holes to required depths and at suitable places. 5. Do ensure that the man-in-charge counts the number of explosions and ensures that all the charges have exploded before allowing workmen back to the site.	1. Do not perform blasting operation without written permission of Engineer. 2. Do not store explosives closer than 300 m from the road or from any building or camping area or place of human occupancy. 3. Do not keep any damaged blasting powder, explosives, detonators fuses etc. at site. 4. Do not use any method of blasting which leads to overshooting. 5. Do not undertake blasting after sunset. 6. Do no expose dynamite to the sun or allow it to get damp. 7. Do not ram or pound the charge but press firmly into place.

II Presplitting Rock Excavation Slopes

A Methodology

1. Prepare a 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 presplit, production drilled and blasted to excavate sufficient material for acceptance of the method.

2. Remove all overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the drilling limits, or the end of the excavation, before drilling the presplitting holes.

3. Ensure that the slope holes for presplitting are drilled along the line of the planned slope within the specified tolerances. The drill holes shall be not less than 60 mm or more than 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 presplit holes shall not exceed 900 mm on centres.

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

5. Where stemming is required to achieve satisfactory presplit face, stemming material shall be dry free-running passing 11.2 mm sieve and 90 percent of which is retained on 2.80 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

B Quality Control Requirements

1. Quality control requirements for rock cutting mentioned in Para IB above shall apply.
2. Drilling operations shall be controlled by the use of proper equipment and technique.
3. Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in pre split holes.
4. The presplit face shall not deviate by more than 300 mm from the plane passing through adjacent holes.
5. 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.
6. In no case shall any portion of the slope encroach on the side drains.

C Do's and Don'ts

Do's and Don'ts for rock cutting mentioned in Para IC shall apply, in addition to the following:

Do's	Don'ts
1. Ensure that drill holes are not less than 60 mm or more than 75 mm in diameter.	1. Do not drill any portion of production hole within 2.5 m of a presplit plane. 2. Do not allow any portion of the slope to encroach on the side drains.

306. FLYASH EMBANKMENT CONSTRUCTION

A Methodology

1. Preparation of foundation for embankment, setting out, dewatering, stripping of top-soil shall be as for Embankment Construction detailed in sub-section 301.

2. The side soil cover, of required width shall be provided along with the flyash core and shall be simultaneously compacted as the embankment progresses upwards.

3. Spread fill material to specified width, grade and slope by mechanical means. For small works manual method may be used.

4. Depth of loose layer shall vary from 100 mm to 400 mm depending upon the weight and type of roller used for compaction as indicated in Table 306.1.

TABLE 306.1 THICKNESS OF LAYER FOR FLYASH EMBANKMENT CONSTRUCTION

Thickness of Layer (loose) in mm	Weight of static roller used in kN	Weight of vibratory roller used in kN
Not exceeding 200	80 to 100	
Not exceeding 400		80 to 100
250		60 to 80
100 to 150		10 to 15

5. Moisture content of fill material before commencement of compaction, shall be within (±) 2% of the optimum moisture content when determined as per IS:2720 (Part-7). Moisture content of the cover soil shall be maintained at OMC.

6. If water is required to be added to the fill material, the same shall be sprinkled from a water bowser without flooding. The water shall be mixed thoroughly by blading, discing or harrowing.

7. Compaction of flyash should start as early as possible after spreading. Each layer of flyash shall be thoroughly compacted to the specified density. When vibratory roller is used for compaction, two passes without vibration followed by 5 to 8 passes with vibration shall normally be sufficient to compact each layer.

8. The compaction of flyash core and earth cover on the sides shall proceed simultaneously. After construction, flyash embankment shall conform to the following:

(i) Minimum dry density after compaction as percentage of maximum dry density determined as per IS 2720 (Part-7) 98%

(ii) Minimum dry density after compaction, when used in bridge abutments for embankment length equal to 1.5 times the height of the embankment, as percentage of maximum dry density determined as per IS 2720 (Part 7) 100%

9. On the top of flyash embankment, at least 500 mm thick selected earth embankment shall be provided, out of which top 300 mm shall be sub-grade as per sub-section 303.

10. Following precautions should be taken while handling flyash:

(i) Flyash (Pond Ash) should be delivered to site in covered dumper trucks to minimize loss of moisture and dusting preferably during night.

(ii) Stockpiling of flyash at site should be avoided.

(iii) If stockpiling at site cannot be avoided, dusting shall be prevented by spraying water on stockpiles at regular intervals and by keeping the stockpile covered with tarpaulin or a thin layer of material not subject to dusting e.g. soil or granular material.

(iv) Traffic should be restricted in areas where flyash is temporarily stockpiled at site.

B. Quality Control Requirements

1. Material

(a) Flyash (Pond Ash):

Particle size analysis, Maximum Dry Density and Optimum Moisture Content as per IS:2720 (Part-7), Graph of dry density plotted against moisture content for this test shall be submitted for approval of Engineer, before execution of work.

(b) Soil:

Soil for cover to the flyash embankment shall satisfy the requirements of a suitable material for embankment construction as per sub-section 301.

(c) Sub-grade:

Sub-grade shall conform to the requirements of sub-section 303.

2. Quality control tests and their frequency shall be as indicated in Table 301.4 to 301.5.

C Do's and Don'ts

Do's	Don'ts
1. Check the placement moisture content of fill material which should be within (±) 2% of the OMC.	1. Do not allow addition of side cover subsequent to the construction of the flyash core.
2. Place subsequent layer only after finished layer has been tested for density requirements and duly approved by the Engineer.	2. Do not allow traffic in areas where flyash is temporarily stockpiled and kept moist to avoid dusting.
3. Remove the material in soft areas where requisite density requirements have not been achieved and replace the same by approved material, bring moisture content to permissible limits and recompact to the required density.	3. Do not allow construction traffic or other vehicular traffic directly over the prepared surface of embankment/ sub-grade.
4. Do transportation of fly-ash, normally at night.	

307. SURFACE DRAINS

A. Methodology

1. Ensure that the surface drains / roadside ditches are provided strictly according to the Drainage Plan for the road.

2. Excavate to the specified lines, grades, levels and dimensions.

3. 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.

4. Ensure that the excavated bed and sides of the drains are in conformity with the specified dimensions, levels and slopes.

5. Protect the surface of drains / roadside ditches with turf cover or other suitable lining as shown on the drawings. Consult the local agricultural department for selecting the appropriate species of grass / vegetation.

6. Provide proper gradients and fix the invert for quick disposal of water to the outfall.

7. 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.

8. Any sharp edges, where cut / fill surfaces meet the ground level, should be rounded off to prevent erosion and promote turfing.

9. Provide safe outlets to natural or artificial water courses.

10. 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.

B. Quality Control Requirements

1. Materials

(a) Where the soil is erodible, line the drain with random masonry coursed with 1:5 cement-sand mortar, as per subsection 700 or any other suitable material as shown on the drawings.

(b) The turf and variety of grass used for erosion control must meet the specified requirements for use in the area.

(c) The materials used for other types of linings like brick masonry, stone masonry etc. must meet the relevant specifications given in Sections 600 & 700 respectively.

2. Dimensions

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

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that the gradients are adequate for free flow of water to the outlet without overflowing or ponding or undue siltation.	1. Do not provide ordinarily side slopes steeper than 2:1 to avoid damage by erosion.
2. Do ensure that grass, when used as a lining forms a firm dense turf.	2. Do not leave any roadside ditch / drain unlined even if it be a grass lining.
3. Take special precautions in built-up areas to make sure that water from any adjacent habitations does not flow over the road.	3. Do not leave any sharp edges within the cross-section to avoid damage by erosion.
4. Take care to see that a drain / roadside ditch is deep enough to drain the sub-base / base course.	4. Do not allow the bottom of roadside ditch / drain to be below the bed of the cross-stream at an outlet.
	5. Do not provide any catch water / intercepting drain in any slide area / unstable area.

SECTION 400

GRANULAR SUB-BASES, BASES & SURFACINGS

401. GRANULAR SUB-BASE

A Methodology

1. Obtain materials from approved sources. The material should be natural sand, moorum, gravel, crushed stone, crushed slag, brick metal, kankar or a combination thereof and it shall conform to grading and physical requirements indicated in Table 401.1

2. Remove all vegetation and other extraneous material etc. from the subgrade already prepared, lightly sprinkle with water, if necessary, and roll with two passes of 80-100 kN road roller or any other suitable compactor / vibratory other?

3. The sub-base material should be spread in layers not exceeding 100 mm compacted thickness. If suitable vibratory rollers are available, the compacted thickness of layer can be upto a maximum of 225 mm.

4. When the sub-base material consists of a combination of materials, mixing shall be done mechanically by the mix-in-place method, except for small sized jobs.

5. Each layer shall be uniformly spread and thoroughly compacted. Spreading and compaction shall be carried out as per Clause 401.4.2 of the MORD Specifications.

6. Compaction should be carried out at OMC, with a tolerance limit of (±) 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 it has more water than the optimum, it should be left exposed to sun and aeration till the moisture content is acceptable for compaction. Each layer should be compacted to 100 per cent maximum dry density as per standard Proctor Test-IS 2720 (Part 7).

7. Approval of the Engineer should be obtained for each layer. Such an approval would require surface level and compaction control tests.

8. The earthen shoulders should be constructed simultaneously with the sub-base construction.

B Quality Control Requirements

1. **Materials**

   (i) **Grading:** The grading for granular sub-base (GSB) should conform to the requirements given in Table 401.1.

TABLE 401.1: GRADING FOR GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Per cent by Weight Passing the IS Sieve		
	Grading I	Grading II	Grading III
75 mm	100	-	-
53 mm		100	
26.5 mm	55-75	50-80	100
4.75 mm	10-30	15-35	25-45
0.075 mm (75 micron)	< 10	< 10	< 10

(ii) Atterberg limits: the material passing 425 micron sieve when tested according to IS: 2720 (part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

(iii) On clayey subgrades, the material passing IS Sieve 0.075 mm should not exceed 5 per cent.

(iv) CBR value: The material with a minimum CBR value of 20 will be acceptable for granular sub-base. In case the subbase material of the requisite CBR is not available within economical leads, the subbase material meeting any of the specified grading and other requirements with a soaked CBR of not less than 15 can be permitted with the approval of the competent authority.

(v) The wet aggregate Impact Value (IS:5640) shall not exceed 50.

2. Horizontal Alignment

The edges of the sub-base shall be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm for hilly terrain.

3. Surface Levels

The tolerance in surface level for granular sub-base will be restricted to (+) 10 mm and (-) 20 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.

4. Surface Regularity

The maximum permitted difference between the sub-base and 3 m straight edge shall be 12 mm for longitudinal profile and 10 mm for cross profile. The cross profile should conform to the required camber.

5. Degree of Compaction

Density shall be 100 per cent of maximum dry density for the material determined as per IS:2720, Part 7.

6. Quality Control Tests

6.1 Tests Prior to Construction

(i) The quality control tests to be carried out prior to construction are indicated in Table 401.2.

(ii) For existing approved sources, the test frequency shall be as indicated in Table 401.2.

(iii) For new sources, test frequencies shall be increased to atleast three tests for each source (average of three tests).

(iv) The samples shall be taken at representative locations and at mean depth of proposed excavation.

TABLE 401.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Soil Classification as per IS:1498. i) Wet Sieve Analysis, except for cohesionless soils ii) Liquid and Plastic Limits	Average of three tests from each source.
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 combined material for 500 m length of road or part thereof.
3.	Proctor Compaction Test (IS:2720 Part 7).	One test on the material from each source or on the combined material, as the case may be.
4.	Wet Aggregate Impact Value Test (IS:5640) where soft / marginal aggregates are used e.g, Laterite, Kankar, Brick Ballast etc.	One test from each source identified by the Contractor.
5.	CBR test (IS:2720 Part 16) on representative sample compacted at 100% Proctor dry density.	One test per km length. (average of a set of three specimens).

Note: Where materials from more than one source are to be combined in the desired proportions, the tests at Sl. Nos. 2, 3 and 5 should be carried out on the combined material.

6.2 Tests During Construction

The field quality control tests during construction are indicated in Table 401.3.

TABLE 401.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Wet Sieve Analysis (IS:2720 Part 4) on the GSB material combined in the design proportions from various sources.	Atleast one test to be carried out daily.
2.	Liquid and Plastic Limit tests (IS:2720 Part 5).	-do-
3.	Placement Moisture Content: Any of the rapid methods for determination of moisture content can be used. (IS:2720 Part 2)	Atleast 3 tests to be carried out daily, well spread over the day's work.
4.	Insitu Density measurements (IS:2720 Part 28).	-do-
5.	Thickness of Compacted layer	At random

6.3 Quality Control Checks by AE/EE

The quality control checks by AE / EE are indicated in Table 401.4.

TABLE 401.4 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Top of the First Layer before placing the next GSB layer	(i) Degree of Compaction (IS:2720 Part 28)	(i) Minimum 3 tests for two km length or part thereof; (ii) Individual test values of the degree of compaction attained shall not be less than 1% of the specified degree of compaction. For example, for the required degree of compaction of 100% Proctor Density, the individual test values shall not be less than 99% of Proctor Density and the average of three (or more) tests carried out in a day shall not be less than 100% Proctor Density).	AE
	(ii) Surface Regularity and Transverse Profile	Random Checking	EE
2. Finished GSB Layer	(i) Degree of compaction (IS:2720 Part 28)	(a) Three tests per 2 km length or part thereof.	AE
		(b) One test for each km length or part thereof.	EE
	(ii) Surface Regularity and Transverse Profile (Camber / crossfall / superelevation)	Random Checking	AE

C Do's and Don'ts

Do's	Don'ts
1. Ensure uniform mixing of GSB material and water by mechanical means like tractor towed implements. 2. Ensure that on clayey subgrades, the percent fines passing 75 micron in the GSB material do not exceed 5 percent. 3. Do provide aggregate plugs at the exposed edges of GSB where extended over the full formation width. 4. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly.	1. Do not permit organic or other deleterious materials. 2. Do not use materials, which do not conform to the specified requirements, shall not be used. 3. Do not allow rejected material to remain at site to prevent its reuse. The rejected material shall be marked with lime.

402. GRAVEL/SOIL-AGGREGATE BASE AND SURFACE COURSE

Gravel / Soil-Aggregate is natural gravel or a mix of crushed stone, crushed gravel, crushed slag, moorum, sand, fine sized particles or combination thereof depending on the grading and plasticity requirements for use in base or surface course for rural roads.

A. Methodology

1. The Gravel / Soil-Aggregate in base and surface course shall meet all the physical requirements set forth in Para B and conform to the gradings given in Table 402.1 for base course and in Table 402.2 for surface course.

2. Before receiving the Gravel / Soil-Aggregate material, the sub-base / base, as the case may be, shall be prepared to the specified lines and cross fall. Any existing ruts, predominant irregularities or soft yielding places should be corrected and rolled until a firm surface is obtained.

3. The Gravel / Soil-Aggregate material meeting all the specified requirements shall be spread on the prepared surface with the help of a grader of adequate capacity, for maintaining the required slope and grade.

4. Where combination of different materials is required for obtaining the Gravel / Soil-Aggregate meeting the specified requirements, mixing shall be done mechanically by the mix-in-place method.

5. The equipment for mix-in-place shall be a tractor-towed rotavator or similar equipment capable of mixing the materials to the desired degree.

6. It must be ensured that prior to compaction, the moisture content is within 2 percent of the optimum moisture content, making due allowance for evaporation losses. After adding the required quantity of water, the material should be processed by mechanical means like tractor-towed disc harrows / rotavators until the layer is uniformly wet.

7. Rolling shall be carried out as per Para 402.4.2 of MoRD Specifications.

8. The density to be achieved should be 100% of the maximum dry density for the material determined as per IS:2720 (Part 7).

9. Any loose, segregated or otherwise defective areas should be made good to full thickness of layer and re-compacted.

B. Quality Control Requirements

1. Materials

(i) The grading for Gravel / Soil-Aggregate Base shall conform to the requirements given in Table 402.1 while the grading for Gravel / Soil-Aggregate Surface Course shall conform to the requirements given in Table 402.2. For the fraction passing 4.75 mm, wet sieve analysis should be done.

TABLE 402.1: GRADING AND PLASTICITY REQUIREMENTS FOR BASE COURSE

IS Sieve desperation	Per cent by Weight Passing IS Sieve		
	Grading A	Grading B	Grading C
53 mm	100		
37.5 mm	97–100	100	
26.5 mm		97–100	100
19 mm	67–81		97–100
9.5 mm		56–70	67–79
4.75 mm	33–47	39–53	47–59
425 µ	10–19	12–21	12–21
75 µ	4.0–8.0	4.0–8.0	4.0–8.0

Note: The Liquid Limit shall not exceed 25 and PI shall not exceed 6.

TABLE 402.2: GRADING AND PLASTICITY INDEX REQUIREMENTS FOR SURFACE COURSE

IS Sieve Designation	Per cent by Weight Passing IS Sieve
26.5 mm	100
19 mm	97–100
4.75 mm	41–71
425 µ	12-28
75 µ	9–16
Plasticity Index	4–10

(ii) Wet Aggregate Impact Value (IS:5640) shall not exceed 40 and 30 when used in base and 30 when used in surfacing.

(iii) Flakiness Index (IS:2386 Part I) shall not exceed 25 percent when used in base and 20 when used in surfacing.

(iv) In high rainfall areas (annual rainfall of 1500 mm or above), coastal areas and where local soils are salt infested, if the water absorption value of the coarse aggregate is greater than 2 percent, the Soundness test shall be carried out on the material delivered to the site as per IS:2386 (Part 5).

(a) Loss with Sodium Sulphate, 5 cycles : 12 per cent maximum

(b) Loss with Magnesium Sulphate, 5 cycles : 18 per cent maximum

(v) If crushed slag is used, Clause 405.2.5 of MORD specifications shall apply.

(vi) If crushed gravel / shingle is used, not less than 90 per cent by weight of the gravel / shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces.

(vii) The needed gradation shall be obtained by crushing, screening and blending processes as necessary.

(viii) Fine aggregate material passing 4.75 mm sieve shall consist of natural or crushed sand and fine mineral particles.

2. Horizontal Alignment

The edges of the Base shall be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm for hilly areas. The edges of the carriageway with Gravel / Soil-Aggregate Surfacing shall be correct within (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Levels

The tolerance in surface level for Gravel / Soil-Aggregate Base and Surface will be restricted to (±) 10 mm. A grid of 10 m by 2.5 m may be formed to check the surface level.

4. Surface Regularity

The maximum permitted difference between the Gravel/Soil-Aggregate layer and 3 m straight edge shall be 12 mm for longitudinal profile and 10 mm for cross profile. The cross profile should conform to the prescribed camber.

5. Degree of Compaction

Density shall be 100 per cent of maximum dry density for the material determined as per IS:2720 Part 7.

6. Quality Control Tests

The quality control tests and their frequency for gravel/soil-aggregate base and surface construction shall be as per Tables 401.2, 401.3 and 401.4.

C. Do's and Don'ts

Do's	Don'ts
1. While preparing the subbase/base, where predominant irregularities exist, make sure that the surface profile is corrected before spreading the Gravel/Soil-Aggregate Mix.	1. Do not permit any organic or deleterious material.
2. For the equipment used for mix-in-place construction, carry out trial runs to establish the suitability for the work	2. Do not allow Manual mixing should unless the width of laying is not adequate for mechanical operations, as in small-sized jobs.
3. Look for soft patches, if any and rectify them by removing or adding fresh material and compacting the same thoroughly.	3. Do not allow the speed of the roller to exceed 5 km per hour.
4. For obtaining the needed uniformity of mixing of water with Gravel/Soil-Aggregate, sufficient passes of mechanical equipment like tractor-towed disc harrows/rotavators should be ensured.	

403. LIME TREATED SOIL FOR IMPROVED SUBGRADE/ SUB-BASE

Lime treatment is generally adopted for silty clays and clayey soils, including black cotton soils. Reduction in plasticity index and development of strength in lime soil mixes depend upon the type and content of clay in the soil.

A Methodology

1. The amount of lime required for stabilization of the soil, should be determined on the basis of mix design to achieve the required CBR value.

   By way of general guidelines, lime content for different types of soil is normally as under:

Alluvial soils and Moorum (PI : 10-15)	3%
Clays/ BC soil of medium plasticity (PI : 15-30)	3-5%
Highly expansive Clays (PI : over 30)	5-6%

2. The pulverization of soil clods and mixing of pulverized soil should be accomplished by using tractor-towed implements. The pulverization of clods shall meet the requirements of Table 403.1.

TABLE 403.1 SOIL PULVERISATION REQUIREMENTS FOR LIME STABILIZATION

IS Sieve Designation	Percent passing
26.5 mm	100
5.6 mm	80

3. The thickness of any layer to be treated shall be 100 mm when compacted. The maximum thickness shall be 200 mm provided the plant is accepted by the Engineer.

4. Lime may be mixed with the prepared material either in slurry form or dry state as approved by the Engineer. The top of windrowed material may be flattened or slightly trenched to receive the lime. The distance to which lime is to be spread upon the prepared material ahead of mixing operation shall be determined by the Engineer for which trial runs are advisable.

5. It is good practice to pre-condition the soil by addition of 2% lime in the first instance and leaving it overnight before adding the remaining portion of lime the next day.

6. Appropriate tractor-towed equipment, approval by the Engineer, are suitable for various operations in the construction process, like pulverization of soil clods by tractor-towed disc harrows and mixing of soil with lime by tractor-towed Rotavator. Manual mixing may be permitted only where the width of laying is not adequate for mechanical operations as in small-sized jobs.

7. The moisture content of soil-lime mix at compaction shall be within (±) 2% of optimum moisture content determined on the basis of IS:2720 (Part 7). Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out. During rolling, the surface shall be checked for grade and camber. A density of at least 100% of the maximum dry density of the material, as determined in accordance with IS:2720 (Part 7) shall be achieved.

8. The sub-base shall be cured by moist curing with water for a period of 7 days after which subsequent pavement courses shall be laid to prevent the surface from drying out and becoming friable.

B Quality Control Requirements

1. Materials

(i) **Soil:** For the lime treatment to be effective in bringing about significant reduction in PI and increase in the CBR value, the PI of the soil to be treated should generally be higher than 10.

(ii) **Lime**: Lime for lime-soil stabilization work shall be commercial dry lime slaked at site or pre-slaked lime delivered to the site in suitable packing. The lime shall have purity of not less than 70% by weight of CaO when tested in accordance with IS:1514

(iii) **Water**: The water to be used for lime stabilization shall be clean and free from injurious substances. Potable water shall be preferred.

2. Horizontal Alignment

The edges of the sub-base shall be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface levels for lime-treated improved subgrade shall be (+) 20 mm and (-) 25 mm; while for the lime-treated soil subbase shall be (+) 10 mm and (-) 20 mm. A grid of 10 m by 2.5 m may be formed to check the surface level.

4. Surface Regularity

The maximum permitted difference between the sub-base and 3 m straight edge shall be 12 mm for longitudinal profile and 10 mm for cross profile.

In case of improved subgrade, the maximum permitted difference shall be 20 mm for longitudinal profile and 15 mm for cross profile. The transverse profile shall conform to the prescribed camber.

5. Degree of Compaction

When lime is used for improving the subgrade, the soil-lime mix shall be tested for CBR value. When lime stabilized soil is used in a sub-base it shall be tested for CBR value/ unconfined compressive strength (UCS).

The laboratory CBR/ UCS value shall be atleast 1.5 times the minimum field value of CBR/ UCS stipulated in the Contract.

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 403.2.

Table 403.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Purity of Lime (IS:1514)	One test for each lot of lime
2.	Determination of optimum quantity of lime to attain the specified reduction in PI and/or to achieve the specified CBR	Mean of two tests.
3.	Plasticity Index test (IS:2720 Part 5) of the lime-treated soil (mixed with the required amount of lime)	Mean of two tests per km length on the representative sample of a lime-treated soil mix with the required amount of lime.
4.	CBR (IS:2720 Part 16) or Unconfined Compressive Strength (IS:4332 Part 5) if specified.	One test on a set of 3 specimens per km length.

6.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 403.3.

Table 403.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test		Frequency
1.	Pulverization of soil clods	Atleast 3 tests daily, well spread over the day's work.
2.	Placement Moisture Content (IS:2720 Part 2)	-do-
3.	Insitu Density measurements (IS:2720 Part 28)`	-do- (i) Average of 3 test results shall not be less than the specified degree of compaction. (ii) Individual test values of the degree of compaction attained shall not be less than 1% of the specified degree of compaction.
4.	Thickness of Compacted layer.	At random

6.3 Quality Control Checks by AE/EE

The quality control checks by AE/EE are indicated in Table 403.4.

TABLE 403.4 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Compacted lime-treated layer	(i) Degree of Compaction (IS:2720 Part 28)	(a) Minimum 3 tests for each two km length or part thereof; allowable tolerance in test values as per Table 403.3	AE
		(b) Minimum 1 test per km length or part thereof	EE
	(ii) Plasticity Index of the lime-treated mix from the layer.	Minimum 3 tests for each km length or part thereof.	AE
	(iii) Unconfined Compressive Strength (IS:4332 Part 5) when specified, sample extracted from the compacted layer.	(a) One test for each 500 m length or part thereof.	AE
		(b) One test for each km length or part thereof.	EE
	(iv) Surface Regularity and Transverse Profile.	Random Checking	AE

C Do's and Don'ts

Do's	Don'ts
1. Use lime with purity not less than 70% by weight of CaO. Where lime of the minimum specified purity is not locally available, the total amount of lime to be added shall be proportionately increased with the approval of the Engineer ensuring that the amount of CaO in the total amount of lime added is not lower than the specified value.	1. Do not allow the spread lime to be blown away.
2. Ensure uniformity of mixing of lime with soil by mechanical means like tractor-towed rotavator.	2. Do not accept the completion of the mixing process if any white streaks or pockets of lime are visible.
3. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly.	3. Slaked lime supplied in airtight bags should not be stored for more than 3 months.
	4. Do not allow any traffic other than mixing equipment to pass over the spread lime till mixing has been completed.
	5. Do not allow traffic until the lime treated layer is cured for atleast 7 days.

404. CEMENT TREATED SOIL SUBBASE AND BASE

For soils which do not respond to lime treatment and where comparatively higher and faster development of strength and durability characteristics is needed, especially for waterlogged and high rainfall areas, soil stabilization with cement is resorted to. Granular and sandy soils are most suitable for cement stabilization

A. Methodology

1. Mix Design should be worked out to determine the optimum quantity of cement to be added to soil for stabilization. A minimum laboratory 7-day unconfined compressive strength of 2.76 MPa is required for use in base courses, whereas in sub-base courses, a minimum laboratory 7-day unconfined compressive strength of 1.7 MPa is considered acceptable.

2. By way of broad guidelines, the requirements of cement content for different soil types are as under:-

   Sands / Sandy soils / Soil-Gravels 3 to 5 percent

   Silts / Silty clays of low P1 (<15) 4 to 8 percent

   For heavy clays (with PI>30), pre-treatment with lime is resorted to in the first stage to reduce plasticity and to facilitate pulverization.

3. The pulverization of soil clods, meeting the requirements of Table 404.1 and mixing of pulverized soil should be accomplished by tractor-towed implements.

TABLE 404.1: SOIL PULVERIZATION REQUIREMENTS FOR CEMENT STABILIZATION

IS Sieve Designation	Percent passing
26.5 mm	100
5.6 mm	80

4. Cement should be properly stored to avoid prolonged exposure to the atmosphere.

5. The compacted thickness of any layer to be treated should not be less than 100 mm and not be greater than 200 mm provided the plant is accepted by the Engineer.

6. The cement stabilized soil subbase / base should be constructed by mix-in-place method of construction . Manual mixing can be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs.

7. The equipment used for mix-in-place construction should be a tractor-towed Rotavator or similar approved equipment capable of pulverizing and mixing the soil with additive and water to specified degree to the full thickness of the layer being processed and of achieving the desired degree of mixing and uniformity of the stabilized material.

8. The mixer should be equipped with an appropriate device for controlling the depth of processing and the mixing blades should be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

9. Appropriate tractor-towed equipment, approved by the Engineer, are suitable for performing various operations in the construction process, like pulverization of soil clods by tractor-towed disc harrows and mixing of soil with stabilizer by tractor-towed Rotavator.

10. The surface to receive the stabilized soil layer should be prepared to the lines, grade and camber.

11. Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out. The moisture content of soil-cement mix at compaction should be within(±) 2% of optimum moisture content (as per IS-2720 Part 7). During rolling, the surface shall be checked for grade and camber. A density of at least 100% of the maximum dry density of the material, as determined in accordance with IS:2720 Part 7 should be achieved.

12. Compaction of cement stabilized material shall be completed within two hours of its mixing.

13. The compacted soil-cement mix should be cured by moist curing with water for a period of 7 days after which subsequent pavement courses should be laid to prevent the surface from drying out and becoming friable.

B. Quality Control Requirements

1. Materials

(i) Materials to be stabilized: The material for cement treatment includes sand, gravel, laterite kankar, brick aggregate, crushed rock, slag or flyash or combination of these. Material for subbase / base should conform to the grading given in Table 404.1

TABLE 404.1: GRADING LIMITS OF MATERIALS FOR STABILIZATION WITH CEMENT

IS Sieve	Per cent by Weight Passing IS Sieve	
	Sub-base Finer Than	Base wihtin the Range
53.0 mm	100	100
37.5 mm	95	95-100
19.0 mm	45	45-100
9.5 mm	35	35-100
4.75 mm	25	25-100
600 micron	8	8-65
300 micron	5	5-40
75 micron	0	0-10

For use in base course, the Liquid limit and Plasticity Index shall not exceed 45% and 20% respectively.

(ii) Cement: Cement shall comply with the requirements of IS:269, 455 or 1489

(iii) Lime: (If needed for pretreatment) as per Sub-section 403.

(iv) Water: The water for cement stabilization shall be clean and free from injurious substances.

2. Horizontal Alignment

The edges of the cement stabilized soil layer should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrains and (±)50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface levels for cement treated soil sub-base will be restricted to (+) 10 mm and (–) 20 mm while for cement-treated soil base, it will be restricted to (±) 10 mm. A grid of 10 m x 2.5 m may be formed to check the surface levels.

4. Surface Regularity

The maximum permitted difference between the cement stabilized soil layer and 3 m straight edge shall be 12 mm for longitudinal profile and 10 mm for cross profile.

5. Minimum Compressive Strength

For use in base and sub-base courses, minimum 7-day unconfined compressive strength of 2.76 MPa and 1.7 MPa respectively is required.

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 404.2.

Table 404.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Quality of cement and Purity of Lime (IS:1514) (if used for pre-treatment)	One test for each lot
2.	Unconfined Compressive Strength Test (IS:4332 Part 5)	One test on a set of 3 specimens per km length.

6.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 404.3.

Table 404.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Pulverization of soil clods	Atleast 3 tests daily, well spread over the day's work.
2.	Placement Moisture Content (IS:2720 Part 2)	-do-
3.	Insitu Density measurements (IS:2720 Part 28)	-do- (i) Average of 3 test results shall not be less than the specified degree of compaction. (ii) Individual test values of the degree of compaction attained shall not be less than 1% of the specified degree of compaction.
4.	Thickness of Compacted layer	At random

6.3 Quality Control Checks by AE/EE

The quality control checks by AE/EE are indicated in Table 404.4.

TABLE 404.4: QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Top of the compacted cement-treated layer	(i) Degree of Compaction (IS:2720 Part 28)	Minimum 3 tests for each two km length or part thereof; allowable tolerance in test values as per Table 403.3	AE
	(ii) Unconfined Compressive Strength (IS:4332 Part 5) sample extracted from the compacted layer.	(a) One test for each 250 m length or part there of.	AE
		(b) One test for each 500 m length or part there of.	EE
	(iii) Surface Regularity and Transverse Profile.	Random Checking	AE

B. Do's and Don'ts

Do's	Don'ts
1. Insist on uniformity of mixing of soil with cement by using tractor–towed implements.	1. Do not allow soil clods larger than 26.5 mm in size before mixing of soil with cement.
2. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly.	2. Do not permit any organic or other deleterious material in the soil.
3. It must be ensured that the compaction of cement stabilized materials is completed within two hours of its mixing.	3. Do not carry out soil-cement stabilization with air temperature less than 10^0C.
4. Lime, if used for pretreatment should have a minimum purity of 70% by weight of CaO.	4. Do not allow any traffic other than mixing equipment to pass over the spread cement till mixing has been completed.
5. A sample of the field mix should be brought to the laboratory for conducting various tests.	5. Do not allow any traffic until the surface is cured for 7 days.

405. WATER BOUND MACADAM SUB-BASE/BASE/SURFACING

A Methodology

1. The surface to receive the WBM course should be prepared 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.

2. Where the WBM is laid over a fine grained soil subgrade, it is advisable to lay a 100 mm thick intervening layer of screenings or coarse sand.

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

4. The coarse aggregate should meet the physical and grading requirements laid down in Table 405.1 and Table 405.2. Coarse aggregate can be crushed or broken stone, crushed slag, over burnt brick aggregate, kankar, laterite meeting the prescribed requirements.

5. The spreading of coarse aggregate shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case the aggregate shall be dumped in heaps directly on the surface prepared to receive the aggregates nor shall hauling over uncompacted or partially compacted base be permitted.

6. The coarse aggregate shall be spread uniformly on the prepared subgrade, 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 100 mm for Grading 1 and 75 mm for Gradings 2 and 3. The appropriate quantity of aggregates is given in Table 405.4. The surface should be checked with templates and all high or low spots remedied.

7. 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 soft aggregates, compaction shall be continued until the aggregates are thoroughly keyed. Rolling shall proceed from inner edge to outer edge at the super-elevated portions and from the edges towards the centre in other portions. The edge should be first compacted with roller running forward and backward.

8. Check the profile transversely and longitudinally with templates / straight edge. Correct the irregularities 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.

9. 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.

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

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

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

13. 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.

14. In case the screenings are not of crushable type such as moorum or gravel, 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 Generally, the quantity required for 10 m^2 of 75 mm thickness of WBM is 0.06 to 0.09 m^3 and for 100 mm thickness, the corresponding quantity would be 0.08 to 0.10 m^3.

    In case WBM surface is not to be covered with Bituminous surfacing, PI of binding material shall be between 4 and 10.

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

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

17. The earthen shoulders should be constructed simultaneously with the WBM construction in accordance with Sub-Section 407.

18. The finished surface of WBM should conform to the prescribed tolerances given in Para B. 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.

B 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 surfacing should conform to the requirements given in Table 405.1. If the water absorption of aggregate is greater than 2 per cent, Soundness test should be carried out.

TABLE 405.1: PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WBM

Test	Sub-base	Base	Surfacing
Aggregate Impact value	Less than 50	Less than 40	Less than 30
Flakiness index	Less than 30	Less than 25	Less than 20
Soundness test -Loss with Sodium Sulphate -Loss with Magnesium Sulphate	 Less than 12% Less than 18%	 Less than 12% Less than 18%	 Less than 12% Less than 18%

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 405.2.

TABLE 405.2: GRADING REQUIREMENTS OF COARSE AGGREGATE FOR WBM

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

Note: The compacted thickness for layer with Grading 1 shall be 100 mm while for layer with Grading 2 and 3, it shall be 75 mm. Grading 1 shall be used for sub-base only. For base course, Grading 2 or 3 shall be used. For surfacing, Grading 3 shall be used.

(i) 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 405.3.

TABLE 405.3: GRADING FOR SCREENINGS

Grading Classification	Size of Screenings	IS Sieve Designation	Per cent by weight passing the IS Sieve
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 5.6 mm 180 micron	100 90-100 15-35

Approximate quantities of coarse aggregate and screenings required for 100 mm compacted thickness of WBM Grading 1, and 75 mm compacted thickness of WBM Grading 2 and 3 are given in Table 405.4.

TABLE 405.4: APPROXIMATE QUANTITIES OF COARSE AGGREGATE AND SCREENINGS REQUIRED FOR 100/ 75 mm COMPACTED THICKNESS OF WBM SUB-BASE/BASE/ SURFACING COURSE FOR 10 m^2 AREA

Classification	Course Aggregate			Screenings			
	Size Range	Compacted thickness in mm	Loose Quantity m^3	Stone Screenings		Crushable screenings such as Moorum or gravel	
				Grading classification & Size mm	For WBM Sub-base/ Base course (loose quantity) m^3	Properties	Loose Quantity m^3
Grading 1	90 to 45 mm	100	1.21 to 1.43	Type A13.2	0.27 to 0.30	LL<20:PI<6 Percent passing 0.075 mm <10	0.30 to 0.32
Grading 2	63 to 45 mm	75	0.91 to 1.07	Type A13.2	0.12 to 0.15	-do-	0.22 to 0.24
Grading 2	63 to 45 mm	75	0.91 to 1.07	Type B11.2	0.20 to 0.22	-do-	0.22 to 0.24
Grading 3	53 to 22.4 mm	75	0.91 to 1.07	Type B11.2	0.18 to 0.21	-do-	0.22 to 0.24

(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 less than 6 for subbase / base course and 4 – 10 for surfacing course as determined 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: 75 Quantity for 75 mm compacted thickness WBM = 0.06 – 0.09 m^3 / 10 m^2.

Quantity for 100 mm compacted thickness WBM = 0.08 – 0.10 m^3 / 10 m^2.

2. Horizontal Alignment

The edges of the WBM sub-base / base will be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain. The edge of carriageway with WBM surfacing shall 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 levels of the WBM would be as under:

(a) Sub-base course (+) 10 mm, (-) 20 mm

(b) Base course (±) 15 mm

(c) Surfacing Course (±) 10 mm

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

4. Surface Regularity

The maximum allowable difference between the road surface and 3 m straight edge shall be as per Table 405.5.

TABLE 405.5: MAXIMUM PERMITTED UNDULATIONS MEASURED WITH 3 M STRAIGHT EDGE

Type of Construction	Maximum permissible difference	
	Longitudinal Profile	BasCross Profile
WBM Grade 1	15 mm	12 mm
WBM Grade 2/Grade 3	12 mm	8 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 405.6.

Table 405.6: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Aggregate Impact Value Test (IS:2386 Part 4)	One test from each identified source.
2.	Aggregate Water Absorption Test (IS:2386 Part 3)	-do-
3.	Soundness Test of Aggregates (where water absorption, as at 2 above, exceeds 2%) (IS:2386 Part 5).	-do-
4.	Grading, LL and PI of Crushable Screenings (IS:2720 Part 5) (where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed).	-do-
5.	LL and PI of the Binding Material, when used.	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 405.7.

TABLE 405.7 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Grading of Stone Aggregates and Screenings (IS:2386 Part 1)	Atleast 2 tests to be carried out for a day's work.
2.	Flakiness Index of Stone Aggregates (IS:2386 Part 1	-do-
3.	PI of Crushable Screenings/binding material (IS:2720 Part 5)	Atleast 2 tests to be carried out for a day's work.
4.	Aggregate impact value (IS:2386-Part 4)	At random one test per km
5.	Thickness of Compacted layer.	At random

5.3 Quality Control Checks by AE/EE

The quality control checks to be carried out by the AE / EE are indicated in Table 405.8.

TABLE 405.8 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Top of the Finished WBM Layer	(i) Volumetric analysis	(a) One test for each 200 m length of the layer. (b) One test for each 500 m length of the layer.	AE EE
	(ii) Plasticity Index	One test for each 500 m length of the layer (mean of two tests)	AE
	(iii) Surface Regularity and Transverse Profile	Random Checking	EE

C Do's and Don'ts

Do's	Don'ts
1. Check aggregates for Soundness test when water absorption is more than 2 percent.	1. Do not use any material derived from rocks e.g. phyllites, shales or slates.
2. Soft aggregate should be tested for wet aggregate impact value.	2. Do not use local soil and clayey material as screenings or binding material unless it meats the requirements of PI mentioned in para B1 (iii).
3. Construct shoulders simultaneously along with WBM layers.	3. Do not use binding material if screenings are of crushable type.
4. Use inverted choke over fine grained soil sub-grade.	4. Do not spread coarse aggregate more than 3 days in advance of any subsequent operations.
5. Remove BT surface before WBM is laid on an existing black top road.	5. Do not roll if sub-grade is soft or yielding or causes a wave like motion while rolling.
6. Remove defective macadam to full depth and replace by fresh material and recompact.	6. Do not lay WBM layer on lime treated sub-base until it has attained its strength.
	7. Do not use screenings to make up depressions.
	8. Do not allow traffic till WBM is fully set.

406. WET MIX MACADAM BASE

A Methodology

1. The surface to receive Wet Mix Macadam (WMM) shall be prepared as per sub-section 405.

2. WMM shall be prepared in an approved mixing plant with mixing arrangements like the pug mill or pan type mixer of concrete batching plant. For small quantities of WMM, the Engineer may permit the use of concrete mixers.

3. Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part 7) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size.

4. Lateral confinement for WMM should be provided by laying material in adjoining shoulders along with the wet mix layer, refer Sub-section 407.

5. Immediately upon mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-base, in required quantities. In no case should the material be dumped in heaps, directly on the area where it is to be laid. The mix may be spread either by a paver-finisher or motor grader.

6. Thickness of a single compacted WMM layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted thickness of up to 200 mm may be adopted.

7. The surface of aggregate shall be carefully checked with templates and all high or low spots should be remedied by removing/ adding aggregate as required. The thickness of layer shall be tested with depth blocks.

8. No segregation of large and fine aggregates shall be allowed.

9. After the mix is laid to proper thickness, grade and cross fall/ camber, the same shall be uniformly compacted with a suitable roller. Rolling shall be continued till the density achieved is at least 100% of the maximum dry density as per IS:2720 (Part 7).

10. If the surface irregularity of WMM course exceeds the permissible tolerances, the full thickness of layer shall be scarified over the affected area, reshaped by adding premixed material or removed and replaced with fresh premixed material as applicable and re-compacted. The area treated in this manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and un-graded materials or fines.

11. After final compaction of WMM, the road shall be allowed to dry for at least 24 hours.

12. Preferably no vehicular traffic should be allowed on the finished WMM surface till it has dried and the wearing course has been laid.

B Quality Control requirements

1. Materials

(i) Physical Requirements

Coarse aggregate shall be crushed stone. If crushed gravel is used, not less than 90% by weight of gravel / shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregate shall conform to the requirements of Table 406.1

TABLE 406.1: PHYSICAL REQUIREMENTS OF COARSE AGGREGATE FOR WET MIX MACADAM FOR BASE COURSES

Test	Test Method	Requirements
1. Aggregate Impact Value	IS:2386 (Part 4) or IS: 5640	40 % (maximum)
2. Flakiness Index	IS :2386 (Part 1)	25 % (maximum)
If water absorption value of coarse aggregate is greater than 2 %, soundness test shall be carried out.		

(ii) Grading Requirements

The aggregate shall conform to the grading requirements indicated in Table 406.2

TABLE 406.2: GRADING REQUIREMENTS OF AGGREGATE FOR WET MIX MACADAM FOR BASE COURSES.

IS Sieve Designation	Maximum percent by weightPassing the sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600 micron	8-22
75 micron	0-8
Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6	

(iii) Optimum Moisture Content :

Optimum Moisture Content shall be determined in accordance with IS:2720 (Part 7)

2. Horizontal Alignment

The edges of WMM base will be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

3. Surface Level

The tolerance in surface levels of the WMM would be (±) 10 mm: (A grid of 10 m by 2.5 m may be formed to check the surface levels).

4. Surface Regularity

The maximum permissible undulation measured with a 3 m straight edge, in the longitudinal profile shall be 10 mm and for cross profile the irregularity shall not exceed 8 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 406.3.

TABLE 406.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Aggregate Impact Value Test (IS:2386 Part 4)	One to two tests on representative sample from each source identified by the Contractor, depending on ariability.
2.	Flakiness Index Test (IS:2386 Part 1)	-do-
3.	Water Absorption Test (IS:2386 Part 3)	-do-
4.	Soundness Test, if the water absorption exceeds 2%	-do-
5.	Grading Test (IS:2386 Part 1)	-do-
6.	Atterberg Limits of portion of aggregate passing 425 micron sieve (IS:2720 Part 5)	-do-
7.	Proctor Compaction Test (IS:2720 Part 7) (after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size) alongwith Dry Density-Moisture Content Relationship	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 406.4.

Table 406.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Grading Test (IS:2386 Part 1)	Atleast one test per day.
2.	Aggregate impact value (IS:2386-Part 4)	At random one test per km
3.	Placement Moisture Content (IS:2720 Part 2)	Atleast three tests per day.
4.	Density of Compacted Layer (IS:2720 Part 28)	-do-
5.	Thickness of Compacted Layer	At random

5.3 Quality Control Checks by AE/EE

The quality checks by AE/EE are indicated in Table 406.5.

TABLE 406.5: QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Top of the Finished WMM Layer	(i) Density of the compacted layer (IS:2720 Part 28)	(a) One test for every 500 m length or part there of for each layer	AE
		(b) One test for every 1000 m length or part thereof for each layer	EE
	(ii) Surface Regularity and Transverse Profile	Random Checking	EE

C Do's and Don'ts

Do's	Don'ts
1. Ensure compliance of all material and plant requirements. 2. Check aggregate for soundness test when water absorption is more than 2 %. 3. Build shoulders simultaneously along with WMM layers. 4. Remove BT surface before WMM is laid on an existing road.	1. Do not use material other than crushed stone. 2. Do not allow segregation or pockets of coarse / fine material on the layer. 3. Do not allow any traffic on the WMM surface without covering it with a wearing course.

407. Shoulder Construction

A. Methodology

1. The construction of shoulders (whether hard / 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.

2. The shoulders with specified dimensions should be constructed in layers, each layer matching the thickness of adjoining pavement layer.

3. 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.

4. 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.

5. 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.

6. For earth shoulders with brick / stone edging, the bricks / stone 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 and made flush with the finished pavement level.

7. Earth / gravel shoulder should be compacted to at least 100 per cent of maximum dry density as per IS:2720 Part 7.

8. 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.

B. 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 (as per IS:2720 Part 7) and LL and PI not to exceed 25 and 6 respectively or granular material quarry waste conforming to the requirements of GSB as per Subsection 401.

(ii) For earth shoulders with brick or stone block edging, the bricks should conform to Subsection 602.4. The stone blocks should conform to Subsection 702.4 and should be of size 225 mm x 110 mm x 75 mm.

2. Horizontal Alignment

The edges of the shoulders should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

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.

4. Surface Regularity

The maximum permitted difference between the shoulder and 3 m straight edge will be 12 mm for longitudinal profile and 10 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 Sub-section:

Earth Shoulders	-	Sub-section 303
Hard Shoulders	-	Sub- section 401
Brick Edging	-	Section 600
Stone Edging	-	Section 700

C. Do's and Don'ts

Do's	Don'ts
1. Construct shoulders simultaneously with the pavement layers such that each layer of the shoulder matches the thickness of adjoining pavement layer.	1. Do not resort to box cutting for the construction of shoulders.
2. For protection of earth shoulders, do provide the pavement with brick / stone block edging.	2. Do not compact the shoulder layer before the compaction of the adjoining pavement layer.
3. The material for earth shoulders should be good quality, ordinarily not inferior to the subgrade material.	3. Do not allow stacking of shoulder material on the carriageway nor should any spilled shoulder material be dragged on to the pavement surface.
4. Provide turfing over earth shoulders.	

408. Local materials for road construction

1. The local materials for rural road construction cover the locally available soils and aggregates (including low grade / marginal aggregates) which are both, suitable and economical, for incorporation as such or after suitable processing in lieu of the conventionally used high quality materials.

2. It is always economically and technically prudent to use locally available materials as much as possible instead of transporting conventional quality materials from long distances involving uneconomical leads.

3. Usually some processing of the locally available materials is required to make their best use. This Sub-section brings out the quality aspects of processing the locally available materials to use them to the maximum potential.

4. Construction aspects for the use of these materials are similar to the conventional quality materials and as such, reference to the relevant Sub-sections have been made as to their methodology for construction.

5. To achieve the maximized use of locally available materials, it is essential that adequate soil and materials surveys in the vicinity of the project site are carried out rather than only depending on the well-established old pre-investigated quarries. The general guidelines regarding the field surveys of locally available soils, moorums, gravels and aggregates are given in Annex 408.1.

A. Methodology

1. The representative samples of naturally occurring soils, moorums, gravels, soft / hard aggregates, any industrial wastes and stabilizers like lime etc. should be subjected to laboratory testing. The tests to be carried out should be relevant to their use in specific layer(s) for which reference may be made to previous subsections.

2. When the locally available naturally occurring materials or industrial wastes do not meet the engineering properties required for use in any layer of the pavement crust, appropriate processing like modification / stabilization technique required to render these materials suitable for use in any of the pavement layer(s) should be carried out as per the guidance given in Tables 408.1 and 408.2.

3. Where the naturally occurring Gravels / Soil-Gravel mixtures meet both the grading and plasticity requirements for use in sub-base and base courses, these can be used as such. However, if these materials are found to be deficient in grading only, processing by mechanical stabilization technique can be resorted to so as to meet the grading requirements. Where these local materials are found to be overly plastic, mixing with local sand in the required proportion is often the best solution.

4. Out of the possible alternative uses of the local materials as such or after suitable processing, select the ones which are both, suitable and economical.

TABLE 408.1 APPROPRIATE PROCESSING/STABILIZATION TECHNIQUES

Sl. No.	Soil/Aggregate Properties	Processing/Stabilization Technique	Test Procedure
1.	Sands, moorums /gravels having missing fractions and clayey soils.	Mechanical Stabilization to meet the prescribed grading and plasticity requirements.	Refer Sub-sections 401 and 402.
2.	Medium and heavy clays having PI>10 and containing atleast 15 percent of material finer than 425 micron.	Lime Stabilisation to meet the specified LL and PI requirements and to improve the CBR value.	Refer Sub-section 403.
3.	Granular soils deficient in cohesion for adequate compaction and strength.	Cement Stabilization to improve strength (CBR / UCS).	Refer Sub-section 404.
4.	Soils of medium plasticity and clayey soils not reactive to lime.	Lime-flyash Stabilization to reduce PI and increased strength in terms of CBR / UCS.	Refer Sub-section 409
5.	Heavy clays with PI>30 and very low CBR value.	Two-stage Lime / Cement Stabilization and increased strength.	Refer Sub-section 404.

TABLE 408.2 APPROPRIATE PROCESSING AND USE OF LOCAL MATERIALS IN SUBBASE/BASE

Sl.No.	State of Occurrence of Material	Manner of Use in the Pavement	Test/Quality Requirements
1.	Kankar, Laterite, Dhandla etc. found in blocks or large discrete particles.	As WBM without screenings / filler after breaking the material, broadly meeting the required sizes.	Wet Aggregate Impact Value (IS:5640) not to exceed 50, 40 and 30 when used in sub-base, base and surfacing respectively.
2.	Naturally occurring gravels without appreciable amount of soil.	Directly as a granular layer for sub-base / base course.	PI should not exceed 6 when used in lower courses. Evaluated for strength by soaked CBR.
3.	Soil-gravel with appreciable amount of soil.	Directly as soil-gravel for sub-base / base.	The material should be well-graded and the PI restricted as for Sl. No. 2 above. Evaluated for strength by soaked CBR value.

5. For construction procedure, relevant Sub-sections apply, as under:-

(a) Use of locally available aggregates:-

1. As WBM — Clause 405.3 shall apply
2. As GSB — Clause 401.4 shall apply
3. As soil-gravel mix for subbase, base or surfacing — Clause 402.4 shall apply

(b) Use of stabilized soil:-

1. Mechanical Stabilization — Clause 401.4 shall apply
2. Lime Stabilization — Clause 403.3 shall apply
3. Cement Stabilization — Clause 404.3 shall apply
4. Lime-Flyash Stabilization — Clause 409.5 shall apply
5. Two-stage (Lime-Cement) Stabilization — Clause 404.3 shall apply

B. Quality control requirements

1. Materials

The quality requirements of local materials when used as (a) WBM (b) granular layer for subbase / base (c) soil-gravel for sub-base / base are given in Table 408.2, column (3).

2. Horizontal Alignment

The edges of subbase and base courses constructed with maximised use of local materials should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrains and (±) 50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface levels of sub-base courses constructed with local materials will be restricted to (+) 10 mm and (–)20 mm. For base courses constructed with local materials, the tolerance in surface levels will be restricted to (±) 10 mm. A grid of 10 m x 2.5 m may be formed to check the surface levels.

4. Surface Regularity

For sub-base courses constructed with local materials, the maximum permitted difference between the sub-base and a 3 m straight edge shall be 12 mm for longitudinal profile and 10 mm for cross profile. For WBM base constructed with local materials, the maximum permitted difference between the base and a 3 m straight edge shall be 12 mm for longitudinal profile and 8 mm for cross profile.

5. Quality Control Tests and their Frequency

For the quality control tests and their frequency during construction of sub-base / base courses built with local materials as such or after appropriate processing, please refer to the relevant Sub-section of this Handbook.

C. Do's and Don'ts

Do's	Don'ts
1. A comprehensive field survey for the locally available materials, industrial wastes, locally available lime etc. as detailed in Annex 408.1 should be considered an essential requirement for any rural road project.	1. Do not immediately arrive at the use of hard stone metal in sub-base or even base course without considering the results of soil and materials survey especially when hard stone has to be brought from long distances.
2. Look for any difficult and problematic materials and local experience on their use in the past.	2. Do not decide on the percentage of stabilizer for use in base course without working out scientifically, the design of mixes.
3. Choose the most appropriate soil stabilization technique based on the properties of locally available soils and materials.	3. Do not use lime treated soil in the base course considering the durability aspects of soil-lime mixes.
4. In case of an expansive clay, if a particular unconfined compressive strength is aimed at, a two-stage stabilization with pretreatment of lime in the first stage and cement in the second stage should be resorted to.	4. Do not adopt mechanical stabilization without ascertaining the available quantities of materials to be combined.
5. Ensure prior testing for satisfying the various requirements before using industrial wastes like flyash and slag.	

Annex 408.1

Guidelines for carrying out Soil and Materials Survey

- Examine any existing information on the geological and soil conditions likely to be met.
- Along the centre line, have a single line of borings/ test pits made, wherever there is a visible change in the soil type. If same soil conditions prevail, at least 3 borings/test pits per kilometre length or a double line offset 15 m to 30 m.
- Test pits 1 m x 1 m may be taken to a depth upto 1.5 m, generally the maximum depth of borrow pits.
- Use of hand-operated post hole auger will help.
- For a high embankment, boring to be taken to a depth about twice the height of the embankment, if possibility exists of a soft underlying material.
- Get indication of the depth of Ground Water Table(GWT) and its fluctuations.
- Note change in vegetation, indicative of subsoil conditions.
- Carry out field identification of the local materials by hand-feel tests.
- Samples to be collected for classification tests from each boring (generally 2 to 5 kg sample is enough). Location and depth of strata to be tagged on to the sample bag.
- For each soil type or group, a 20 kg sample will be required for compaction and strength (CBR) tests.
- Neighbouring quarries and cuttings should be inspected and representative samples of all aggregates (soft and hard) collected for laboratory testing.
- Besides collecting representative samples of naturally occurring soils, moorums, gravels, soft/ hard aggregates, any industrial wastes and stabilizers like lime from roadside kilns etc. should also be collected for laboratory testing.

409. LIME-FLYASH STABILIZED SOIL SUB-BASE

The Lime-Flyash Stabilized Soil is a mixture of soil and flyash, when stabilized with lime.

A. Methodology

1. Before receiving the lime-flyash stabilized soil sub-base, the subgrade should be shaped to the desired profile and checked for line, grade and cross-section. Any irregularities beyond the permitted tolerance, soft and yielding spots should be corrected and adequately compacted.

2. The soil free from any organic or deleterious material should conform to the pulverization requirements as under:

   Percent weight of soil passing IS Sieve 26.5 mm - 100%

   Percent weight of soil passing IS Sieve 5.6 mm - 80%

   Where required, suitable equipment like tractor-towed disc harrows should be deployed for meeting the pulverization requirements.

3. On the prepared sub-grade, the pulverized soil should be spread uniformly, the uncompacted thickness being about one-third more than the specified compacted thickness, determined through field trials.

4. Lime and Flyash in the required quantities should be spread uniformly over the soil, taking care to prevent raising of dust.

5. A tractor-towed Rotavator or similar equipment should be used for mixing. The process of mixing should be continued till the required uniformity of mixing has been obtained.

6. Prior to compaction, the specified moisture content should be (±) 2 percent of the optimum moisture content. Where required, water should be added uniformly using a Water Bowser fitted with a Sprinkler.

7. Water should be uniformly mixed with the soil-lime-flyash mix by discing or harrowing using tractor-towed disc harrows or similar equipment.

8. Manual mixing, when permitted by the Engineer shall be carried out as per Clause 409.5.4 of MoRD Specifications.

9. Immediately after spreading, grading and leveling of the mixed material, compaction should be carried out, till 100% of the maximum dry density of the material as per IS:2720 Part 7 is achieved.

10. Not more than 60 minutes should elapse between the start of moist mixing and start of the compaction process. Normally, compaction should be completed within 3 hours of mixing.

11. Curing of the compacted layer should be carried out for a minimum period of 7 days by spreading moist straw / wet gunny bags or sand and periodically sprinkling water.

12 At the end of the day's work, a transverse construction joint for full depth should be made by chamfering at an angle of 30^0.

B. Quality Control Requirements

1. Materials

(a) **Flyash** should conform to the requirements given in Tables 409.1 and 409.2. The chemical requirements specified in Table 409.1 may be ascertained from the source of supply.

TABLE 409.1 : CHEMICAL REQUIREMENTS FOR FLYASH AS A POZZOLANA

Characteristics		Requirements for Flyash		
		AnthraciticFlyash	LigniticFlyash	Methodof Test
1.	SiO_2+Al_2O_3+Fe_2O_3 in per cent by mass, Min	70	50	IS:1727
2.	SiO_2 in per cent by mass, Min	35	25	IS:1727
3.	MgO in per cent by mass, Max	5.0	5.0	IS:1727
4.	SO_3 in per cent by mass, Max	2.75	3.5	IS:1727
5.	Available alkalies as Na_2O in per cent by mass, Max	1.5	1.5	IS:4032
6.	Total chlorides in per cent by mass, Max	0.05	0.05	IS:1727
7.	Loss in ignition in per cent by mass, Max	5.0	5.0	IS:1727

TABLE 409.2 : PHYSICAL REQUIREMENTS FOR FLYASH AS A POZZOLANA

Characteristics		Requirement
1.	Fineness–specific surface in m^2/kg by Blaine's permeability test, Min	250
2.	Particles retained on 75 micron IS Sieve, Max	40
3.	Lime reactivity in N/mm^2, Min	3.5
4.	Soundness by autoclave test-expansion of specimen in per cent, Max	0.8
5.	Soundness by Lechatelier method–expansion in mm, Max	10

(b) **Lime** should have a purity of not less than 70% by weight of CaO when tested as per IS:1514. Quick lime which has been pre-slaked at site should be used within 7 days. Slaked lime supplied in airtight bags should not be stored for more than 3 months.

(c) **Soil** should have a PI between 4 and 20; soil with PI more than 20 may be used provided strength requirements are satisfied.

(d) **Water** should be free from injurious salts, organic matter and other deleterious matter. Potable water is satisfactory.

2. Horizontal Alignment

The edges of the lime-flyash stabilized soil sub-base should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface levels for lime-flyash stabilized soil subbase will be (+) 10 mm and (–) 20 mm. A grid of 10 m x 2.5 m may be formed to check the surface level.

4. Surface Regularity

The maximum permitted difference between the lime-flyash stabilized soil subbase layer and 3 m straight edge should be 12 mm for longitudinal profile and 10 mm for cross profile.

5. Minimum Compressive Strength

The mix proportion should be designed to obtain a minimum unconfined compressive strength of 1.5 MPa after 28 days of moist curing. The component of soil in the lime-flyash-soil mix can be omitted, provided the specified minimum strength requirement is achieved.

6. Quality Control Tests

Quality Control tests for Lime-Flyash Stabilized Soil Subbase and their frequency should be the same as indicated in Tables 403.2, 403.3 and 403.4 for Lime Treated Soil for Improved Subgrade/ Subbase.

C. Do's And Don'ts

Do's	Don'ts
1. While spreading lime and flyash, ahead of mixing, take care to prevent raising of dust.	1. Do not carry out Lime-flyash soil stabilization when air temperature in the shade is less than 10^0C.
2. The thickness of uncompacted layer to yield the specified compacted thickness after compaction should be determined by field trials.	2. Do not allow any soil clods larger than 26.5 mm in size.
3. The suitability of a particular equipment for pulverization of soil clods, for mixing and for compaction should be verified on a test strip.	3. Do not allow any soft yielding spots, ruts etc. on the subgrade before laying the subbase.
4. Compaction should be completed within 3 hours of mixing or such shorter periods as may be necessary during dry weather.	4. Do not allow more than 60 minutes to elapse between the start of moist mixing and start of the compaction process.
5. Ensure that the final surface is well closed, free from movement under compaction planes, ridges, cracks or loose material.	5. Do not allow the roller to bear directly on hardened or partially hardened treated material previously laid other than those what may be necessary for achieving the specified compaction at the joint.
6. All loose or segregated or otherwise defective areas on the completed surface should be made good to the full thickness of the layer and re-compacted.	6. Do not allow traffic to ply during the curing period.

410. INDUSTRIAL WASTES FOR ROAD CONSTRUCTION

This Subsection covers two commonly used industrial wastes, viz, (a) Flyash (waste material from Thermal Power Stations) in road embankment, subbase/base courses and (b) Slags (waste materials from Iron and Steel industries)

A. Methodology

I. Flyash (Pond Ash)

1. Use in flyash embankment construction: As per Sub-section 306.
2. Use in lime-flyash stabilized soil sub-base: as per Sub-section 309.
3. Use in Lime-flyash bound macadam:

The lime-flyash bound macadam is essentially Water Bound Macadam wherein the filler material used is a mixture of lime, flyash and soil / moorum. The methodology for Lime-flyash bound macadam is as given in Sub-section 405. The filler material shall be a mixture of lime, flyash and soil / moorum, typically in the proportions 1:2:9.

For the construction of Soil-Aggregate Base / Surface, where crushed slag is used as coarse-aggregate, the methodology given in Sub-section 402 will apply. For WBM construction, where crushed slag is used as coarse aggregate, the methodology given in Sub-section 405 will apply. When crushed slag is used in cement bound granular material, the methodology given in Sub-section 404 will apply.

B. Quality Control Requirements

1. Materials

(i) Flyash (Pond Ash)

The quality of flyash varies a great deal from plant to plant. Typical Geotechnical properties of Flyash are given in Table 410.1

TABLE 410.1: TYPICAL GEOTECHNICAL PROPERTIES OF FLYASH

Parameter	Normal Range
Specific Gravity	1.90–2.55
Plasticity	Non-Plastic
Maximum Dry Density (gm / cc)	0.9–1.60
Optimum Moisture Content (%)	38.0–18.0
Cohesion (kN / m^2)	Negligible
Angle of Internal Friction (j)	30^0–40^0
Coefficient of Consolidation C_V (cm^2 / sec)	$1.7x10^{-5}$–$2x10^{-3}$
Compression Index C_C	0.05–0.40
Permeability (cm / sec)	$8x10^{-6}$–$7x10^{-4}$
Particle Size Distribution (% of materials)	
Clay size fraction (less than 0.002 mm)	1–10 %
Silt size fraction (0.075 to 0.002 mm)	8–85 %
Sand size fraction (4.75 to 0.075 mm)	7–90 %
Gravel size fraction (80 to 4.75 mm)	0–10 %
Coefficient of Uniformity	3–11 %

The Flyash to be used in lime-flyash stabilization of soil, should conform to the requirements given in Tables 409.1 and 409.2

(ii) Slag

The broad types of slag used in Base / sub-base construction are:-

1. Blast Furnace Slag
2. Granular Blast Furnace Slag
3. Steel Slag

Physical characteristics of Blast furnace slag and steel furnace slag are given in Table 410.2

TABLE 410.2: TEST RESULTS SHOWING PHYSICAL CHARACTERISTICS OF BLAST FURNACE SLAG AND STEEL FURNAGE SLAG

Physical Properties	Test Method	Blast Furnace	Steel Slag
Aggregate impact value (%)	IS:2386 (Part 4)	18–24	8–11
Aggregate crushing value (%)	IS:2386 (Part 4)	24–26	15–18
Los Angeles abrasion value (%)	IS:2386 (Part 4)	28–32	9–10
Water absorption (%)	IS:2386 (Part 3)	1.5–2.5	1–1.4
Specific gravity	IS:2386 (Part 3)	2.65	3.22

It may be noted that some varieties of Steel Slag are found lacking in stability in the presence of water. Such varieties need to be left for weathering in stockpiles for sufficiently long periods of time to render them suitable for road works. In general, the unit weight of slag should not be less than 11.2 kN / m^3.

2. Horizontal Alignment

When used in subbase and base courses, the edges should be correct within tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

3. Surface Levels

When used in sub-bases, the tolerance in surface levels will be (+)10 mm and (–) 20 mm. When used in base courses, the tolerance in surface levels will be restricted to (±) 10 mm. A grid of 10 m x 2.5 m may be formed to check the surface level.

4. Surface Regularity

When used in sub-base courses, the maximum permitted difference between the subbase layer and 3 m straight edge should be 12 mm for longitudinal profile and 10 mm for cross profile. However, when used in base courses, the permitted differences should be 12 mm for longitudinal profile and 8 mm for cross profile.

5. Quality Control Tests

(a) Flyash (Pond Ash)

- For use of flyash in embankment construction, the Quality Control tests given in Sub-section 306 shall apply.
- For use of flyash in Lime-flyash stabilized soil subbase, the Quality Control tests given in Sub-section 409 shall apply.

- For use of flyash in Lime-flyash bound macadam, the Quality Control tests given in Sub-section 405 shall apply.

(b) Slag

- For use of slag in a Gravel/Soil-Aggregate base/surface, the Quality Control tests given in Sub-section 402 will apply.
- For use of slag in WBM construction, the Quality Control tests given in Sub-section 405 will apply.
- For use of slag in Cement Treated Sub-base/Base, the Quality Control tests given in Sub-section 404 will apply.

C. Do's and Don'ts

Do's	Don'ts
1. Flyash embankments should be covered on the sides and top by selected soil to prevent erosion. Thickness of earth cover on side slopes is typically 1 to 3 m.	1. Do not stockpile flyash at the site.
2. The work on flyash embankment should be so organized that the supply of flyash to the site equals the Contractor's demand for an efficient rate of placement.	2. Do not transport flyash in open trucks without cover to avoid dust nuisance & environmental pollution.
3. The flyash to be used in road works should always be tested in the laboratory to ensure that it meets the required geotechnical properties or as a pozzolana as the case may be.	3. Do not use crushed slag as coarse aggregate without laboratory testing and verifying that it meets all the specified requirements.
4. The compaction of flyash core and soil cover must be carried out simultaneously.	4. Do not use those varieties of steel slag which lack stability in the presence of water owing to the hydration of calcium oxide. If such varieties are to be used, these should be left for weathering in stockpiles for sufficiently long periods of time.
5. The lime used in Subbase/Base courses must have a purity of not less than 70% by weight of CaO.	

411. CRUSHER RUN MACADAM BASE

A. Methodology

1. The existing surface to receive the crushed stone base should be prepared 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.
2. Lateral confinement for constructing the crushed stone aggregate base should be provided as per Sub-section 406.
3. The aggregate should be uniformly deposited on the prepared surface and distributed over the surface to the specified depth. After distribution, the material shall be blade mixed to full depth of layer by alternately blading the entire layer to the center and back to the edges of road. The material shall then be spread and finished to the required cross-sectional levels, lines and grades by means of suitable tractor –towed appliances.
4. Water should be applied before and during the blading, spreading and construction.
5. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 kN or vibratory roller to 100% of maximum dry density determined as per IS:2720 (Part 7)

6. The thickness of single compacted layer should not be more than 100 mm with smooth wheel roller and 200 mm with vibratory roller.

B. Quality Control Requirements

1. Materials

The material shall be crushed rock. If crushed gravel / shingle is used, not less than 90% by weight of the gravel / shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregate shall conform to the physical requirements and grading indicated in Tables 411.1 and 411.2

TABLE 411.1: PHYSICAL REQUIREMENTS OF AGGREGATES

	Test	Test Method	Requirements
1	Aggregate Impact Value.	IS:2386 (Part 4) or IS:5640	30 Maximum
2	Flakiness Index	IS: 2386 (part 1)	25 Maximum
3	Water Absorption.*	IS:2386 (Part 3)	2% maximum
4	Liquid limit of material passing 425 micron.	IS:2720 (part 5)	Not more than 25
5	Plasticity Index of material passing 425 micron.	IS:2720 (Part 5)	Not more than 6

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

TABLE 411.2: AGGREGATE GRADING REQUIREMENTS

IS Sieve Designation	Percent Passing by weight	
	53 mm Max. size	37.5 mm Max. size
63 mm	100	
45 mm	87-100	100
22.4 mm	50-85	90-100
5.6 mm	25-45	35-55
600 micron	10-25	10-30
75 micron	2-9	2-9

2. Horizontal Alignment: As per Sub-section 406

3. Surface Level

The tolerance in surface levels of crusher run macadam base shall be (±) 10 mm for machine laid and (±) 15 mm for manually laid course.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 12 mm for longitudinal profile and 8 mm for cross profile respectively.

5. Quality Control Tests

Quality Control tests for Crusher Run Macadam Base and their frequency shall be the same as indicated in Tables 406.3, 406.4 and 406.5 for Wet Mix Macadam Base.

C. Do's and Don'ts

Do's	Don'ts
1. If crushed gravel is used ensure that not less than 90% by weight of crushed gravel/ shingle, retained on 4.75 mm sieve shall have at least two fractured faces. 2. Use templates at about 6 m apart to check surface to profile. 3. Ensure that the quantity of water applied is sufficient to prevent segregation of the fine and coarse particles and to achieve the requisite compaction with maximum dry density as per IS: 2720 (Part 7) 4. Build up shoulders alongwith crusher run macadam base.	1. Do not use material other than crusher run material. 2. Do not use any filler material. 3. Do not spread aggregate more than 3 days in advance of the construction operations.

412. BRICK SOLING

A. Methodology

1. The edges of soling shall be marked with the help of stakes and string.
2. The subgrade shall be prepared to the required grade and camber and made free of dust and other extraneous material. All ruts, deformations and soft spots shall be corrected and rolled.
3. The side shoulders shall be constructed in advance to a thickness corresponding to the brick layer. Alternatively, mud walls may be constructed to provide lateral confinement.
4. The bricks shall be laid in herring bone bond or in header and stretcher bond laid on edge or flat in layers, as specified.
5. The joints shall not exceed 10 mm in thickness.
6. After laying bricks, sand shall be spread over the bricks to a thickness of about 25 mm.
7. The soling shall be lightly rammed.

B. Quality Control Requirements

1. Materials

(i) Straight burnt clay bricks shall be used conforming to the requirements of IS:1077, except that the minimum compressive strength, when tested flat shall not be less than 8.4 MPa for individual bricks and 10.6 MPa for average of 5 specimens.

(ii) The bricks shall have rectangular faces. The size may vary according to local practice with a tolerance of (±) 5%.

(iii) The bricks should emit a clear ringing sound when struck.

2. **Horizontal Alignment**: As per Sub-section 401

   The edge of the brick sling shall be within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm for hilly terrain.

3. **Surface Evenness**

   The maximum allowable difference between the brick soling surface and a 3 m straight edge shall not exceed 10 mm for both the longitudinal and cross profiles, when placed parallel with, or at right angles to the centerline.

C. Do's and Don'ts

Do's	Don'ts
1. Trim the inside of shoulders vertical and remove any spillage. 2. Allow sand to remain on soling till a subsequent pavement layer is laid.	1. Do not excavate into the finished formation layer. 2. Do not allow any traffic on brick soling.

413. STONE SET PAVEMENT

A Stone Set Pavement has a pavement crust comprising of 100 mm compacted GSB, 75 mm WBM (Grading 2) Base and 150 mm thick hammer-dressed Stone sets paved on a bedding sand layer over the WBM Base. It is best suited where good quality stones are locally available as also craftsmen with knowledge of stone paving.

A. Methodology

1. Over a suitably prepared subgrade as per Sub-section 303, construction of 100 mm thick compacted GSB will be carried out as per Sub-section 401.

2. The construction of 75 mm thick WBM (Grading 2), will be carried out as per Sub-section 405.

3. A properly graded coarse sand bedding layer of 40 mm compacted thickness will be laid over the WBM Base.

4. This will be followed by laying of hammer-dressed stones in the herringbone or stretcher bond pattern.

5. The stones will be compacted into bedding sand over the WBM Base, bounded by Edgestones laid with their longitudinal axis parallel to the length of the road.

6. The joint gaps will be filled with fine sand, stone dust, or sand-cement mortar as specified. Joints can also be sealed with hot sand-bitumen mix.

7. If sand-cement mortar is used for filling joints, moist curing is required for at least one week.

8. Stone sets should be laid in sections not exceeding 12 m in length, with longitudinal axis of the stone sets parallel to the length of the road.

B. Quality Control Requirements

1. Materials

(i) The quality control requirements for the materials in the subgrade, 100 mm GSB and 75 mm WBM (Grading 2) Base as given in Sub-section 303. 401 & 405 shall apply.

(ii) The Stone sets should be rectangular in shape, 250-300 mm in length, 150- 200 mm in width and 150 mm in depth, with tolerance of (±) 12 mm.

(iii) Edge stones should be 350 – 400 mm in length, 150-200 mm in width and not less than 350 mm in depth

(iv) The Stone set should meet the following physical requirements.

(a) Aggregate Impact Value (IS:2386 Part 4) not more than 30

(b) Water Absorption (IS:2386 Part 3) not more than 2%

(c) Polished Stone Value (BS:812 Part 114) not less than 55

(v) Stones normally used are Granite, Basalt, Sandstone and Limestone. Stones from Sedimentary rock should not be used.

(vi) The stone sets should be hammer-dressed on top to the extent that the maximum depression of the dressed surface from a straight edge applied across any part of the surface does not exceed 20 mm. The dressing on the sides should be similarly carried out so as to obtain a mortar joint not exceeding 20 mm in width.

2. Horizontal Alignment

The edges of the stone set pavement should be correct within a tolerance limit of (±)20 mm in plain and rolling terrains and (±) 30 mm in hilly terrain.

3. Surface Levels

The tolerance in surface levels of a Stone Set Pavement will be restricted to (±) 15 mm. A grid of 10 m x 2.5 m may be formed to check the surface level.

4. Surface Regularity

The maximum permitted difference between the Stone Set Pavement and 3 m straight edge should be 12 mm for longitudinal profile and 10 mm for cross profile.

C. Do's and Don'ts

Do's	Don'ts
1. The Stone sets should not only be tested for AIV and water absorption, but also for the Polished Stone Value. 2. The types of Stones normally found suitable are Granite, Basalt Sand-stone or Limestone. 3. Make sure that the bedding layer is a properly graded coarse sand with a compacted thickness of 40 mm.	1. Do not use any Sedimentary stone in the Stone Set Pavement. 2. Do not open the road immediately to traffic if sand-cement mortar is used for filling joints. 3. Do not leave the stone sets uncompacted into the bedding layer.

SECTION 500

BITUMINOUS CONSTRUCTION

501. PREPARATION OF SURFACE

This Subsection deals with preparing an existing granular or black-topped surface prior to laying a bituminous course.

A. Methodology

1. Preparing an existing granular surface

(i) All loose and extraneous materials should be removed and surface 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 slightly watered and the granular course laid.

(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.

(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-section' 502.

2. Scarifying an existing bituminous surface

(i) Where an existing bituminous layer is required to be removed, it should be done by hand picking without causing undue disturbance to the underlying layers. Any underlying material which may have been disturbed should be removed and fresh base material supplemented, if necessary and compacted.

(ii) The compacted granular surface, finished to line, level and cross-slope should be primed as per specified procedure.

3. Preparing an existing bituminous surface

The surface shall be cleaned and any pot holes and cracks repaired before laying bituminous treatment.

(a) Pothole and Patch Repairs

(i) The existing bituminous surface should be inspected and all pothole and patch areas made free of any loose, defective material. 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 and loose 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 (meeting requirements of IS:8887) depending on whether the lower area is granular or bituminous in nature. The sides of the excavated position should be painted with tack coat material using a hand brush / sprayer.

(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 proud of the 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 litre / m^2 of the specified emulsion, using 0.5-1.0 litre / m^2 of the specified emulsion, using an approved hand-held 'sprayer. For sites in sub-zero temperatures, Medium Curing Cutback as per IS 217can be used.

(ii) The wide cracks (more than 3 mm in width) should be filled with crusher dust or other approved fine material passing 4.75 mm sieve to a level about 5 mm below the road surface level. After sweeping the surface clear of dust, Slow Setting emulsion should be poured into the cracks, minimizing any spillage. If spillage does occur, crusher dust should be applied to blot up the spillage. Isolated areas, with wide cracks, shall be cut and patched as per Section 501.

4. Profile Corrective Course

(i) Where specified, a profile corrective course should be provided.

(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) A tack coat as per Sub-section 503 should be applied over a primed granular surface or an existing bituminous surface prior to laying the bituminous profile corrective course.

(iv) Short sags or depressions in the surface should be corrected by laying profile corrective course in the form of flat wedges (layers).

The thickness of layer at any point should not be more than 100 mm.

Where the profile corrective course is laid in more than one layer, successive layers should completely extend over and fully cover the underlying layer.

B. Quality Control Requirements

1. Material

(i) Crusher stone dust for crack filling should be a fine-grained 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 Slow Setting bituminous emulsion (SS-1 grade) as per IS:8887. For sub-zero temperatures, however, a Medium Curing (MC) Cutback conforming to IS:217 can be used. Prime coat should be applied as per Sub-section 502.

(v) The binder for tack coat and its application should be as per sub-section 503.

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

(i) Horizontal Alignment

Edges of the pavement layer	(±) 30 mm in plain and rolling terrain	(±)50 mm in hilly terrain

(ii) Surface levels

Granular Surface	(±)15 mm
Bituminous Surface	(±) 10 mm

(iii) Surface Regularity

Granular / Bituminous Surface

Longitudinal Profile	12 mm
Transverse Profile	8 mm

C. Do's and Don'ts

Do's	Don'ts
1. Remove dust from the surface being prepared by air jet or other approved means.	1. Do not lay a bituminous layer without properly preparing the surface.
2. Where required, an existing bituminous layer should be scarified carefully without undue disturbance to the underlying layers	2. Do not lay any bituminous material on a granular surface without priming the surface.
3. The edges of all potholes should be cut / trimmed vertically	3. Do not use a bituminous mixture to fill the portion below the level of bituminous construction while filling a pothole.
4. In the final layer, the mix should be spread slightly proud of the surface.	4. Do not allow any spillage of binder on the surface while pouring the binder into wide cracks.
5. After back filling in layers, an excavated pothole, ensure the compaction of each layer by a small Roller / Plate Compactor or at least a Rammer	5. Do not allow traffic over profile corrective course.

502. PRIME COAT OVER GRANULAR BASE

A Methodology

1. Bituminous primer should be slow setting bitumen emulsion, use of cutback being restricted to areas having subzero temperature or for emergency operations.

2. 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 swept clean of dust and loose particles and where required, lightly and uniformly sprinkled with water to moist the surface.

3. The primer should be sprayed uniformly over the dry surface of absorbent granular base, using suitable bitumen pressure distributor or sprayer capable of spraying primer at specified rates and temperature so as to provide a uniformly unbroken spread of primer. Normal temperature range of spraying emulsion should be 20°C to 60°C. The rate of application depends upon the porosity characteristics of the surface to be primed and is given in Table 502.1

TABLE 502.1: RATE OF APPLICATION OF BITUMINOUS EMULSION FOR PRIME COAT

Porosity	Type of surface	Viscosity at 60°C		Rate of application per 10 sq m(kg)
		Kinematic Viscosity (Centistokes)	Saybolt Furol (seconds)	
Low	WMM / WBM	30 – 60	14 –28	6 – 9
Medium	Cement stabilized soil base	70 – 140	33 – 66	9–12
High	Gravel base	250 – 500	117 - 234	12- 15

4. A very thin layer of coarse sand may be applied to the surface of the primer to prevent it from getting picked up under the wheels of vehicles delivering materials for construction of bituminous layer

5. The surface should be allowed to cure preferably for 24 hours. Unabsorbed primer should be blotted with sand using the minimum quantity possible.

B. Quality Control Requirements

1. The viscosity requirements for bitumen emulsion will depend upon the type of surface as already given in Table 502.1.

2. A priming grade bitumen emulsion (slow setting) conforming to IS:8887 should 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 502.2. These tests shall be carried out on the bitumen binders (Emulsion / Cutback) brought on the site by the Contractor for use in the work.

TABLE 502.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Viscosity (using Saybolt Furol Viscometer) (IS:8887)	One test for each lot
2.	Residue on 600 micron sieve (IS:8887)	-do-
3.	Storage Stability Test (IS:8887)	-do-
4.	Flash Point Test, where bituminous cutback is to be used (IS:217)	-do-
5.	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-

3.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 502.3.

TABLE 502.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	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 day.
3.	Curing of Primer	Before any subsequent treatment.

3.3 Quality Control Checks

The Junior Engineer shall carry out checks daily and record the result in his own handwriting.

C. Do's and Don'ts

Do's	Don'ts
1. Use slow setting emulsion and restrict the use of cutback to subzero temperature conditions or emergency operations.	1. Do not apply primer when the atmospheric temperature in shade is less than 10°C or when the weather is foggy, rainy or windy.
2. Use only pressure sprayers.	2. Do not allow pouring of primer using perforated cans.
3. Preferably lay a trial section.	3. Do not allow traffic on primed surface.
4. The Contractor to demonstrate at a spraying trial to ensure that the equipment is capable of producing a uniform spray.	4. Do not apply bituminous material to a wet surface.

503. TACK COAT

A. Methodology

1. Use a rapid setting bitumen emulsion for applying a tack coat, the use of cutback being restricted to areas having sub-zero temperature or for emergency applications.

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

3. The surface should be prepared as per sub-section 501.

4. The binder should be sprayed uniformly over the surface using suitable bitumen pressure sprayer capable of spraying bitumen and emulsion at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen emulsion. For smaller jobs, a pressure hand sprayer may be used. Normal range of spraying temperature should be 20°C-60°C in case of emulsion and 50°C-80°C in case of cutback. The rate of application depends upon the type of surface and is given in Table 503.1.

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

B. Quality Control Requirements

1. Materials

(i) Binder for Tack Coat

Rapid setting bituminous emulsion Grade RS-1 complying with IS:1887 as specified in Contract. For sites at sub-zero temperature: Cutback Bitumen (Medium Curing Grade) as per IS:217.

(ii) Rate of application of Binder

TABLE 503.1: RATE OF APPLICATION OF BINDER FOR TACK COAT

Type of Surface	Quantity of emulsion per sqm area (kg)
Normal Bituminous surfaces	0.20 to 0.25
Dry and hungry bituminous surfaces	0.25 to 0.30
Granular (primed)	0.25 to 0.30
Cement Concrete Pavement	0.30 to 0.35

2. Quality Control Tests

The quality control tests and their frequencies would be same as for Prime Coat in Tables 502.2 and 502.3.

C. Do's and Don'ts

Do's	Don'ts
1. Plan the work so that no more than the necessary tack coat for the day's operation is placed on surface. 2. Handle bituminous cutback carefully to avoid fire mishap.	1. Do not apply tack coat when atmospheric temperature is less than 10^{O}C or when weather is foggy, rainy or windy. 2. Do not apply tack coat on a wet surface. 3. Do not allow any equipment or vehicles on Tack Coat.

504. Bituminous Macadam

A. Methodology

1. Prepare the base on which bituminous macadam course is to be laid and shape to the specified lines, grade and cross-section.

2. Apply tack coat over the base preparatory to laying of the bituminous macadam.

3. 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 504.1.

TABLE 504.1: MANUFACTURING AND ROLLING TEMPERATURES FOR BITUMINOUS MACADAM

Bitumen Penetration	Bitumen Mixing (°C)	Aggregate Mixing (°C)	Mixed Material (°C)	Laying (°C)	Rolling (°C)
35	160-170	160-175	Max. 170	Min. 140	Min. 110
65	150-165	150-170	Max. 165	Min. 130	Min. 100
90	140-160	140-165	Max.155	Min. 130	Min. 100

4. Transfer the mixed material quickly to site of work and lay by means of an approved self-propelled mechanical paver.

5. Commence initial rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. On super elevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement. Thereafter, do intermediate rolling with vibratory or pneumatic tyred road rollers. This should be followed by final rolling while the material is still workable.

6. 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. Each pass should have an overlap of at least one-third of the track made in the preceding pass. Rolling should be continued till all rolIer marks have been eliminated.

7. For single lane roads no longitudinal joint is required, while for double-lane roads longitudinal joints may be required depending on the paver width.

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

9. 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.

B. Quality Control Requirements

1. Material

The Bituminous Macadam shall be composed of aggregate meeting the physical requirements indicated in Table 504.2 and a paving bitumen of penetration 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 504.3.

TABLE 504.2: PHYSICAL REQUIREMENTS FOR AGGREGATES FOR BITUMINOUS MACADAM

Property	Test	Specification
Particle Shape	Flakiness Index IS:2386 Part 1	Max. 25 per cent
Strength	Aggregate Impact Value IS:2386 Part 4	Max. 30 per cent
Durability	Soundness IS:2386 Part 5 Loss in Weight SodiumSulphate Magnesium Sulphate	 Max. 12 per cent Max. 18 per cent
Water Absorption	Water Absorption IS:2386 Part 3	Max. 2 per cent
Stripping	Coating and Stripping of bitumen- aggregate mixtures IS:6241	Min. retained coating: 95 per cent.

TABLE 504.3: COMPOSITION OF BITUMINOUS MACADAM

IS Sieve (mm)	Cumulative Per cent Passing by weight of Total Aggregate
26.5	100
19	90-100
13.2	56-88
4.75	16-36
2.36	4-19
0.03	2-10
0.075	0-5
Bitumen content, % by weight of total mixture	3.3-3.5
Bitumen penetration Grade	35 to 90

In colder regions of India or where the percent passing 0.075 mm sieve is on the higher side of the range, appropriate bitumen contents may be upto 0.5 percent higher, subject to the approval of the Engineer.

2. Horizontal Alignment

The edges of the bituminous macadam base should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain

3. Surface Level

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

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge would be 12 mm for longitudinal profile and 8 mm for 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 504.4.

TABLE 504.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Type of Test	Frequency
1. Quality of Binder (Straight-run Bitumen) (IS:73) (a) Penetration Test (b) R&B Softening Point Test (c) Ductility Test	 One test per lot -do- -do-
2. Quality of Binder (Modified Bitumen) (IS 15462) (a) Penetration Test (b) R&B Softening Point Test (c) Elastic Recovery Test (d) Separation Test	 -do- -do- -do -do-
3. Aggregate Impact Value Test (IS:2386 Part 4)	One test on representative sample per km length from each source identified by the Contractor
4. Flakiness Index Test (IS:2386 Part 1)	Two tests per source
5. Bituminous Stripping of Aggregate Test (IS:6241)	One test per source
6. Water Absorption (IS:2386 Part 3)	-do-
7. Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 504.5.

Table 504.5: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Grading of Aggregate (IS:2386 Part 1)	Atleast one test per day.
2.	Binder Content	Atleast two tests per day.
3.	Density of Compacted Layer	Atleast one test per day.
4.	Temperature of Binder before mixing	Regularly
5.	*Temperature of mix during laying and compaction	Regularly
6.	Thickness of compacted layer	Regular, at close intervals
7.	Aggregate impact value (IS:2386-Part 4)	At random one test per km

**Temperature measurement will be done by using metallic contact thermometer with digital display*

5.3 Quality Control Checks by AE/EE

The quality checks by AE/EE are indicated in Table 504.6.

Table 504.6: QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Finished Bituminous Macadam Base Layer	(i) Density of compacted layer	(a) One test for every 500 m length or part thereof	AE
		(b) One test for every one km length	EE
	(ii) Binder Content part thereof	One test for each 500 m length or	AE/EE
	(iii) Surface Regularity and Transverse Profile	Random Checking	EE

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that stone aggregate conforms to the physical requirements and grading requirements and are dry and clean.	1. Do not undertake the work in foggy, rainy or windy weather or when the atmospheric temperature in the shade is less than 10^{O}C.
2. In case the aggregate has poor affinity to bitumen use anti stripping agent with the approval of Engineer.	2. Do not allow the difference in temperature of binder and aggregate to increase beyond 14^{O}C at any time.
3. While transporting the mixture it should be suitably covered by tarpaulin.	3. Do not allow the premix material to adhere to the roller wheels. (Do not use excess water for the purpose. Light sprinkling should do.)
4. Rolling operations should be completed before the mix becomes unworkable	4. Do not use lubricating oil on the wheels of the roller to prevent mix from adhering.
5. Maintain strict control on temperature while mixing and rolling.	5. Do not allow traffic until the mix has been covered with a wearing course.
6. Regulate the rate of delivery of material to paver to enable it to operate continuously.	6. Do not move roller at a speed more than 5 km/h.

505. BUILT-UP SPRAY GROUT

A. Methodology

1. Prepare the base on which built-up spray grout course is to be laid to the specified lines, grade and cross-section.

2. Apply tack coat over the base preparatory to laying of the built-up spray grout.

3. Spread the coarse aggregates uniformly by mechanical means or other suitable method at the rate of 0.5 cum per 10 sqm area. Remedy all high spots and depressions by removing or adding aggregates.

4. Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. On superelevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement.

5. Correct any irregularities noticed after the roller has passed over the whole area once by loosening the surface and removing or adding the coarse aggregates followed by rolling. Care should be taken not to over compact the aggregate layer which may prevent free and uniform penetration of bitumen.

6. Heat the bitumen to the temperature appropriate to the grade of bitumen and spray uniformly on aggregate layer at the rate of 15 kg per l0 sqm (measured in terms of residual bitumen content) by mechanical sprayers. Any excessive deposits caused by starting or stopping of the sprayers or for any other reason must be removed and made good.

7. Immediately after first application of bitumen, spread the second layer of coarse aggregates and repeat the process indicated in paras 4 and 5 above.

8. Apply a second bitumen spray of 15 kg per l0 sqm uniformly on the second layer of aggregate.

9. Immediately thereafter, spread the key aggregates uniformly and evenly at the rate of 0.13 cum per l0 sqm area so as to cover the surface completely and roll. Rolling should continue until the key aggregates are firmly embedded in position.

10. Provide a wearing course immediately after laying the built-up spray grout. If there is any delay in laying of wearing course, a seal coat would be required before opening to traffic.

B. Quality Control Requirements

1. Materials

(a) **Coarse Aggregates and Key Aggregates**

(i) **Physical requirements**: Aggregates should satisfy various physical requirements given in Table 504.2

(ii) **Grading:** The coarse aggregates and key aggregate should conform to the grading given in Table 505.1

TABLE 505.1: GRADING FOR COARSE AGGREGATES AND KEY AGGREGATES FOR BUILT-UP SPRAY GROUT

IS sieve designation (mm)	Cumulative percent by weight of total aggregate	
	Coarse Aggregate	Key Aggregate
53.0	100	—
26.5	40 - 75	—
22.4	—	100
13.2	0 - 20	40 -75
5.6	—	0 -20
2.8	0-5	0-5

(b) **Bitumen**

The binder should be paving bitumen of penetration grade complying with IS:73 or an appropriate grade of emulsion complying with IS:8887, where permitted or specified in the contract.

2. Horizontal Alignment

The edges of the Built-up Spray Grout layer should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the Built-up spray grout should be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge should be 12 mm for longitudinal profile and 8 mm for 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 505.2.

TABLE 505.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Quality of Binder (Straight-run Bitumen) (IS:73) (a) Penetration Test (b) R&B Softening Point Test (c) Ductility Test	 One test per lot -do- -do-
2.	Quality of Binder (Modified Bitumen) (IS:15462) (a) Penetration Test (b) R&B Softening Point Test (c) Elastic Recovery Test(d) Separation Test	 -do- -do- -do-
3.	Aggregate Impact Value Test (IS:2386 Part 4)	One test on representative sample per km length from each source identified by the Contractor
4.	Flakiness Index Test (IS:2386 Part 1)	-do-
5.	Bitumen Stripping of Aggregate Test (IS:6241)	-do-
6.	Water Absorption (IS:2386 Part 3)	-do-
7.	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 505.3.

Table 505.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Rate of spread of binder	At least one test daily
2.	Rate of Spread of aggregates	-do-
3.	Aggregate Grading (IS:2386 Part 1)	-do-
4.	Temperature of binder during spraying	Regularly, at close intervals
5.	Thickness of compacted layer	At random

5.3 Quality Control Checks by AE/EE

The quality checks to be exercised by AE/EE are indicated in Table 505.4.

TABLE 505.4 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
Completed layer of Built-up Spray Grout/Modified Penetration Macadam	Surface Regularity and Transverse profile	Random Checking	EE

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that aggregates conform to grading specified and are dry and clean at the time of laying. 2. Maintain the temperature of bitumen appropriate to the grade of bitumen. 3. Remove excessive deposits of binder during spray operation.	1. Do not undertake the work in foggy. rainy or windy weather or when the atmospheric temperature in the shade is less than 10^0C. 2. Do not allow any traffic over Built up spray grout without laying wearing course or seal coat.

506. MODIFIED PENETRATION MACADAM

A. Methodology

1. Prepare the base on which modified penetration macadam course is to be laid to the specified lines, grade and cross-section.

2. Apply a tack coat, over the base preparatory to laying of the modified penetration macadam.

3. Ensure that the coarse aggregates comply with the physical requirements laid down in Table 504.2. The coarse and key aggregates shall be 40 mm size hand broken metal and 12 mm size stone chips respectively. Upto 30% of total quantity of 40 mm metal may be crusher broken. The quantities of material shall be as per Tables 506.1 and 506.2.

TABLE 506.1 RATE OF APPLICATION OF AGGREGATE PER 10 SQM AREA

Description	Thickness of Modified Penetration Macadam layer			
	75 mm		50 mm	
	On Bituminous surface(cum)	On WBM surface(cum)	On WBM 100 surface(cum)	On Bituminous surface(cum)
40 mm size hand broken metal	0.90	0.90	0.6	0.6
12 mm size stone chips	0.18	0.18	0.12	0.12

TABLE 506.2 RATE OF APPLICATION OF BITUMEN PER 10 SQM AREA

Description	Thickness of Modified Penetration Macadam layer			
	75 mm		50 mm	
	On Bituminous surface(kg)	On WBM surface(kg)	On WBM 100 surface(kg)	On Bituminous surface(kg)
Bitumen for grouting	20	20	17.50	17.50
Tack Coat	As per Sub-section 503			

4. Spread coarse aggregate of 40 mm size metal uniformly at the rate of 0.9 cum for 75 mm thickness (0.6 cum for 50 mm thickness) per 10 sqm area to proper camber/ super-elevation Remedy all high spots and depressions by removing or adding aggregates.

5. Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. On superelevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement.

6. Correct any irregularities noticed after the roller has passed over the whole area once by loosening the surface and removing or adding the coarse aggregates followed by rolling. Continue rolling till the entire surface has been rolled to desired compaction such that there is no crushing of aggregates and all roller marks have been eliminated. Each pass of roller should overlap not less than one-third of the track made in the preceding pass.

7. Heat bitumen (paving grade S-35 to S-90) to a temperature of 160^0C to 180^0C and spray uniformly on aggregate layer at the rate of 20 kg per 10 m^2 for 75 mm thick layer and 17.5 kg per 10 m^2 for 50 mm thick layer.

8. Immediately after application of bitumen, spread 12 mm size key aggregates at a uniform rate of 0.18 cum for 75 mm thickness (0.12 cum for 50 mm thickness) per 10 m^2 so as to cover the surface completely and roll. Rolling should continue until the key aggregates are firmly embedded in position and stop moving under roller.

9. Provide a wearing course over the modified penetration macadam immediately within 2 days. If there is to be any delay in laying of wearing course, a seal coat would be required before it is opened to traffic.

B. Quality Control Requirements

1. Materials

Aggregates should satisfy the requirements given in Table 504.2

Bitumen shall be of paving grade S-35 to S-90

2. Horizontal Alignment

The edges of the Modified Penetration Macadam layer should be correct within a tolerance limit of (±) 30 mm in plain and rolling terrains and (±) 50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface level of the Modified Penetration Macadam should be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge would be 12 mm for longitudinal profile and 8 mm for cross profile.

5. Quality Control Tests

The quality control tests and their frequencies would be as per Table 505.2, 505.3 and 505.4.

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that aggregates conform to grading specified and are dry and clean at the time of laying. 2. Maintain the temperature of bitumen appropriate to the grade of bitumen. 3. Remove excessive deposits of binder during spray operation.	1. Do not undertake the work in foggy. rainy or windy weather or when the atmospheric temperature in the shade is less than 10^0C. 2. Do not allow any traffic over Built up spray grout without laying wearing course or seal coat.

507. SURFACE DRESSING

A. Methodology

1. Design the surface dressing following the guidelines given in IRC 10:-2005 to determine the rate of spread of binder and stone chippings for actual conditions covering traffic level, type and size of chippings, existing surface and climate. 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.

2. Prepare the base on which surface dressing is to be laid to the specified lines, grade and cross-section as per Sub-section 501. If the base is of granular material, a prime coat should be applied as per Sub-section 502.

3. Apply the binder (at specified temperature) as per rate of spread of binder given in Table 507.1 or as designed with 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.

TABLE 507.1: NOMINAL RATES OF SPREAD OF BINDER AND CHIPPINGS.

Nominal Chipping Size (mm)	Binder (Penetration grade bitumen) kg/m^2	Bitumen emulsion (kg/m^2)	Aggregate (cum/m^2)
13.2	1.0	1.5	0.010
9.5	0.9	1.4	0.008
6.3	0.75	1.1	0.004

4. The application temperature for the penetration grade binder used shall be as specified in Table 507.2. In case of modified binder application temperatures shall be as indicated in Sub-section 512.

TABLE 507.2: SPRAYING TEMPERATURES FOR BINDERS.

Binder	Whirlinq spray Jets		Slot Jets	
	Min ^{0}C	Max ^{0}C	Min ^{0}C	Max ^{0}C
Penetration Grade 80/100	180	200	165	175
Penetration Grade 180/200	170	190	155	165

5. Immediately after application of binder, spread clean dry stone aggregate at the rate given in Table 507.1 or as designed with the help of a mechanically operated chip spreader, in a single layer. In case of emulsion as a binder, the aggregate may be slightly damp.

6. Immediately after spreading of aggregates, roll the surface with the help of suitable road rollers. Commence rolling from the edges and progress towards the center 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 one-third of the track made in the preceding 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.

7. Where two-coat surface dressing is specified in the contract, the second coat should be applied after the first coat is exposed to traffic for 2 to 3 weeks. Procedures stated here-in-above will apply. 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 20 km/h until the following day.

8. Where use of precoated chips is specified, the first step will be to precoat chips. The stone chips will be heated to 160^{0}C and mixed with 0.75 to 1% of paving bitumen by weight heated to its application temperature. The precoated chips shall be cured for one week or till such time as they become non-sticky.

B. Quality Control Requirements

1. Materials

(a) Stone Chippings

(i) Physical requirements:

Stone chippings should satisfy the requirements given in Table 504.2 except that water absorption shall be 1% maximum.

(ii) Grading:

The stone chippings should conform to the Grading given in Table 507.4

TABLE 507.4 GRADING REQUIREMENTS FOR CHIPS FOR SURFACE DRESSING

IS Sieve Designation (mm)	Cumulative percent by weight of total aggregate passing for the following nominal sizes(mm)		
	13.2	9.5	6.3
19.0	100	-	-
13.2	85-100	100	-
9.5	0-40	85-100	100
6.3	0-7	0-35	85-100
4.75	-	0-10	-
3.35	-	-	0-35
2.36	0-2	0-2	0-10
0.60	-	-	0-2
0.075	0-1.5	0-1.5	0-1.5
Minimum 65% by weight of aggregate	Passing 13.2 mm retained 3.35 mm	Passing 9.5 mm retained 9.5 mm	Passing 6.3 mm retained 6.3 mm

(b) Bitumen

The binder should be bituminous material, which may be as per the contract, or as decided by the Engineer.

- Paving grade bitumen (IS 73)
- Modified bitumen (IS 15462)
- Rapid setting bitumen emulsion (IS 8887)

(c) Where aggregate fails to pass the stripping test, an approved adhesion agent may be added to the binder, in accordance with the manufacturers instructions.

2. **Horizontal Alignment**

The edges of the Surface Dressing 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 for machine laid and (±) 10 mm for manually laid surface dressing.

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 12 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 507.5.

Table 507.5 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Quality of Binder (Straight-run Bitumen) (IS:73)	
	(a) Penetration Test (b) R&B Softening Point Test (c) Ductility Test	One Set of tests per lot (Average of three tests) -do- -do-
2.	Quality of Binder (Bitumen Emulsion) (a) Viscosity (IS:8887) (b) Residue on 600 micron sieve (IS:8887) (c) Storage Stability Test (IS:8887)	 -do- -do- -do—
3.	Quality of Binder (Modified Bitumen) (IS:15462) (a) Penetration Test (b) R&B Softening Point Test (c) Elastic Recovery Test(d) Separation Test	 -do- -do- -do—do-
4.	Aggregate Impact Value Test (IS:2386 Part 4)	One test per km length on representative sample from each source identified by the Contractor
5.	Flakiness Index Test (IS:2386 Part 1)	-do-
6.	Bitumen Stripping of Aggregate Test (IS:6241)	-do-
7.	Water Absorption (IS:2386 Part 3)	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 507.6.

TABLE 507.6 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Rate of spread of binder	At least two tests per day
2.	Rate of Spread of aggregate (Annex – IV)	-do-
3.	Grading of Aggregate (IS:2386 Part 1)	At least one test per day
4.	Temperature of binder during spraying (Annex - I)	Regularly, at close intervals.
5.	Storage stability Test for Bitumen Emulsion	One test per day
6.	Aggregate impact value (IS:2386-Part 4)	At random one test per km

5.3 Quality Control Checks by AE/EE

The quality checks to be exercised by AE/EE are indicated in Table 507.7.

Table 507.7 : QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Finished Course of Surface Dressing	(i) Uniform spread of aggregate	Whole length	AE
	(ii) Any defects in the form of Loss of Aggregate/ Streaking etc	-do-	AE
	(iii) Surface Regularity and Transverse profile	Random Checking	EE

C. Do's and Don'ts

Do's	Don'ts
1. Ensure correct rate and uniform spread of binder based on field trials.	1. Do not carry out work when atmospheric temperature is less than 10^0C or when weather is foggy, rainy or windy.
2. Add approved Anti-Stripping agent to binder where aggregate fails to pass the stripping test.	2. Do not carry out the work on wet surface.
3. Alternatively use precoated chips.Correct any excessive deposit of bitumen by blotting before spreading the chips.	3. Do not resort to excessive rolling as that may crush the stone chips.
	4. Do not allow traffic to ply on any newly laid surface dressing till the following day except with restricted speed.

508. 20 mm THICK PREMIX CARPET

508.1 Open graded Premix Surfacing using Bitumen

A. Methodology

1. Prepare the base on which premix carpet is to be laid to the specified lines, grade and cross-section.

2. Apply a prime coat followed by tack coat over a granular base preparatory to laying of the carpet.

3. The quantities of material required for 20 mm thick premix carpet should be as indicated in Table 508.1.1.

TABLE 508.1.1 : QUANTITIES OF MATERIAL REQUIRED FOR 10 m^2 AREA

Aggregate	Quantity
(a) Nominal size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve)	0.18 m^3
(b) Nominal size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve)	0.09 m^3
Total	**0.27 m^3**
Binder	
(a) For 0.18 m^3 of 13.2 mm nominal size stone at 52 kg bitumen per m^3	9.5 kg
(b) For 0.09 m^3 of 11.2 mm nominal size stone at 56 kg bitumen per m^3	5.1 kg
Total	**14.6 kg**

Prepare the mix in a hot mix plant of suitable size with separate dryer arrangement for aggregate.

4. 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 150^0 C to 163^0 C and that of aggregates 155^0C to 163^0C, provided that the difference between the temperature of aggregate and the binder should not exceed 14^0C. If modified bitumen is used, temperature should be as recommended in Subsection 512. The temperature at the time of discharge of the mixture should be between l30°C and 160°C.

5. 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.

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

7. Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. (On superelevated portions, rolling should progress from lower to upper edge parallel to centre 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.

8. Correct any high spots or depressions noticed after the roller has passed over the whole area once by removing or adding premixed material and recompacting.

9. Provide a seal coat to the surface immediately after laying the carpet as per details in Sub-section 510.

10. Ordinarily, the road may be opened to traffic after laying the seal coat with restrictions given in Subsection 510.

B. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 508.1.2

TABLE 508.1.2 PHYSICAL REQUIREMENTS OF STONE AGGREGATE

Property	Test	Specification
Particle shape	Flakiness index (IS:2386 Part 1)	Max. 25 %
Strength	Aggregate Impact Value (IS:2386 Part 4)	Max. 30 %
Durability	Soundness (IS:2386 Part 5) Sodium sulphate Magnesium sulphate	 Max. 12 % Max. 18 %
Water absorption	Water Absorption (IS:2386 Part 3)	Max. 1 %
Stripping	Coating and stripping of bitumen aggregate mixture. (IS:6241)	Minimum retained coating 95 %

(b) Binder

The binder shall be a penetration grade bitumen of a suitable grade S-65/90 depending on climatic condition of the area or of the type as specified in the Contract. Where modified binder is specified Subsection 512 should be followed.

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 for machine laid work and (±) 10 mm for work executed manually.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 8 mm for both the longitudinal profile and 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 508.1.3.

Table 508.1.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

1.	Quality of Binder (Straight-run Bitumen) (a) Penetration Test (IS:73) (b) R&B Softening Point Test (IS:73) (c) Ductility Test (IS:73)	 One set of tests per lot -do- -do-
2.	Quality of Binder (Bitumen Emulsion)	
	(a) Viscosity (IS:8887) (b) Residue on 600 micron sieve (IS:8887) (c) Storage Stability Test (IS:8887)	-do- -do- -do-
3.	Quality of Binder (Modified Bitumen) (IS 15462)	
	(a) Penetration Test (b) Softening Point Test (c) Elastic Recovery Test (d) Separation Test	-do- -do- -do- -do-
4.	Aggregate Impact Value Test (IS:2386 Part 4)	One test per km length on representative sample from each source identified by the Contractor
5.	Flakiness Index Test (IS:2386 Part 1)	-do-
6.	Bitumen Stripping of Aggregate Test (IS:6241)	-do-
7.	Water Absorption (IS:2386 Part 3)	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 508.1.4.

TABLE 508.1.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Grading of Aggregates (IS:2386 Part 1)	At least two tests per day
2.	Binder Content before seal coat	At least two tests per day
3.	Temperature of Binder	Regular close intervals
4.	Thickness of layer	Regularly at close intervals
5.	Aggregate impact value (IS:2386-Part 4)	At random one test per km

5.3 Quality Control Checks by AE/EE

The quality checks to be exercised by AE / EE are indicated in Table 508.1.5.

TABLE 508.1.5: QUALITY CONTROL CHECKS BY AE/EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Finished Pre Mix Carpet Surfacing	(i) Binder Content before providing seal coat	One test for every 500 m length of the layer	AE
	(ii) Visual inspection of finished surface	Full length	EE
	(iii) Surface Regularity and Transverse profile	Random Checking	AE

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that aggregates for premix carpet and seal coat conform to the prescribed physical and grading requirements and are clean and dry. 2. Exercise strict control over mixing and laying temperature as per specifications using appropriate thermometers. 3. Rolling operations should be completed before the temperature of the mix falls below 100oC.	1. Do not allow manual mixing. 2. Do not undertake the work in foggy, rainy or windy weather or when the atmospheric temperature in the shade is less than 10°C or when the surface is wet. 3. Do not allow the premix material to adhere to the roller wheels. Do not use excess water for the purpose. Light sprinkling should do. 4. Do not allow the roller to stand on newly laid material. 5. Do not allow any traffic without laying seal coat over the premix carpet.

508.2 PREMIX CARPET USING BITUMEN EMULSION

A. Methodology

1. Prepare the base on which premix carpet is to be laid to the specified lines, grade and cross section

2. Apply a tack coat over an existing prepared black top surface.

3. The quantities of material required for 20 mm thick premix carpet should be as indicated below

   (i) Aggregate as per Table 508.1.1 of Sub-section 508.1

   (ii) Binder : Cationic Bitumen Emulsion

(a) For 0.18 m3 of 13.2 mm nominal size stone at 78 kg cationic bitumen emulsion per m3	14.0 kg
(b) For 0.09 m3 of 11.2 mm nominal size stone at 84 kg cationic bitumen emulsion per m3	7.5 kg
Total	**21.5 kg**

4. Premix bitumen emulsion and aggregates in a suitable mixture such as cold mixing plant as per IS:5435 (revised) or concrete mixture

5. Spread the premix to the desired thickness, grade, cross fall within 10 minutes of applying the tack coat and ensure that all levelling, raking is completed within 20 minutes of the mixing.

6. Roll the surface as per Para 6 & 7 of the methodology described in Sub-section 508.1

7. Provide a seal coat as specified in the contract within 4-6 hours after laying the premix carpet. Follow Sub-section 510 for the work on seal coat.

8. Preferably, the road should be opened to traffic after 24 hours of laying the seal coat. In single lane roads traffic may ordinarily be allowed after 6-8 hours with the care that the speed is rigorously restricted to not more than 16 km / h.

B. Quality Control Requirements

(i) Materials

(a) **Aggregates**

Aggregates shall conform to the requirements given in Table 508.1.2 of Sub-section 508.1

(b) **Binder**

The binder for premix carpet shall be bitumen emulsion of Medium Setting (MS) grade complying with IS:8887 and having a bitumen content of 65% minimum by weight.

Emulsion for liquid seal coat shall be of RS grade or MS grade where specified. Emulsion for premix seal coat shall be of SS (Slow Setting) grade.

(ii) Horizontal Alignment, surface levels, Surface regularity and Quality Control Tests and their frequency should be exercised in accordance with the requirements given in Sub-section 508.1

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that the aggregates and binder satisfy the specified requirements. 2. Before opening the bitumen emulsion drum, roll the drum at slow speed, to and fro at least five times for a distance of about 10 m to ensure proper distribution of storage sedimentation. 3. As far as possible use suitable cold mixing plant.	1. Do not allow manual mixing. 2. Do not undertake work in foggy, rainy or windy weather or when the minimum air temperature is less than 10^{O}C. 3. Do not allow any traffic unless the emulsion is properly set and the surface has acquired adequate stability

509. MIX SEAL SURFACING

A. Methodology

1. Follow the methodology described in Sub-section 508.1, except that the quantities of materials shall be as given in Para 2 below.

2. The total quantity of aggregate for Type A or Type B close-graded premix surfacing shall be 0.27 cum per 10 sqm area. The quantity of binder shall be 22 kg and 19 kg per 10 sqm area for Type A and Type B Mix Seal Surfacing respectively.

B. Quality Control Requirements

1. **Materials**

(a) Aggregates

(i) Physical Requirements:

Coarse aggregate shall conform to the physical requirements indicated in Table 508.1.2 of Sub-section 508.1.

The fine aggregates shall be crushed rock, quarry sand, natural gravel / sand or a mixture of both free from organic and deleterious substances.

(ii) Aggregate Grading:

The combined coarse and fine aggregates shall conform to one of the gradings given in Table 509.1

TABLE 509.1 AGGREGATE GRADATION FOR MIX SEAL SURFACING

IS sieve designation (mm)	Cumulative percent by weight 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

(b) Binder

Requirements specified in Sub-section 508.1 shall apply.

2. **Horizontal Alignment**

Surface levels, surface regularity and quality control tests and frequencies shall be exercised as per the requirement given in Sub-section 508.1

C. Do's and Don'ts

(i) Follow do's and don'ts given under Sub-section 508.1

(ii) Generally, Mix Seal Surfacing should not be placed directly over WBM base.

510. SEAL COAT

The seal coat shall be any of the three 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.

Type C : Premixed seal coat comprising of an application of 6.7 mm size stone chips premixed with bituminous binder.

A. 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 150^0C and 163^0C 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 80-100 kN rollers (3-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. On super elevated portions, rolling should progress from lower to upper edge parallel to centre 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.

2. Type A seal coat with emulsion

(i) Apply emulsion uniformly over the prepared surface by mechanical sprayers.

(ii) Immediately after application of emulsion, spread aggregate uniformly and evenly by mechanical means;

(iii) Roll the surface following the procedure given in Para 1 (iii) above.

3. Type B seal coat with bitumen

(i) Follow the methodology described in Paras 4 & 5 for preparing the premix in Sub-section 508.1

(ii) Roll the surface with 80 to 100 kN roller as per procedure given in Para 8 & 9 of methodology in Sub-section 508.1

(iii) Continue rolling of the mix until the voids in the bituminous surface are completely sealed and a smooth and uniform surface is obtained.

4. Type B seal coat with emulsion

Follow the methodology described in Sub-section 508.2 except that for small jobs manual mixing may be required.

5. Type C seal coat

Paras 4 to 7 of Sub-section 508.1 dealing with methodology for premix carpet may be referred to for preparation of the mix, spreading and rolling the same.

6. Traffic on Type B and Type C seal coat may be allowed after completion of rolling operations and the surface is at ambient temperature. Traffic on Type A seal coat may be allowed only on the following day. In exceptional circumstances the road with Type A seal coat my be opened to traffic immediately after rolling but the traffic speed should be restricted to 16 km/h until the following day.

B. Quality Control Requirements

1. **Materials**

(a) Aggregates

Aggregate shall conform to the physical requirements indicated in Table 508.1.2. Quantities and grading requirements for aggregates are given in Table 510.1.

TABLE 510.1 : QUANTITY AND GRADATION REQUIREMENT OF AGGREGATE FOR SEAL COAT

Type of seal coat	Quantity of aggregate requiredper 10 sqm area	Gradation 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
Type C	0.09 cum	9.5 mm	2.36 mm

(b) Binder

The requirements of Sub-section 508.1 and 508.2 shall apply. The quantities required for seal coat are given in Table 510.2.

TABLE 510.2: QUANTITIES OF BINDER REQUIRED FOR SEAL COAT

Type of seal coat	Per 10 sqm area	
	Bitumen in kg	Bituminous Emulsion in kg
Type A	9.8	12 to14
Type B	6.8	10 to12
Type C	4.5% by weight of total mix	9 to 11

2. Quality Control Tests

The quality control tests and their frequencies would be as per Tables 507.5. 507.6, 507.7 for Type A Seal Coat and 508.1.3, 508.1.4 and 508.1.5 for Type B and C.

C. Do's and Don'ts

Do's	Don'ts
1. Use angular fragments of clean, hard, tough and durable rock of uniform quality throughout as an aggregate for seal coat.	1. Do not use soft or disintegrated stone, organic or other deleterious material as an aggregate for seal coat.
2. Ensure that Stone chippings conform to the specified size and are dry and clean at the time of mixing.	2. Do not undertake the work in foggy, rainy or windy weather or when the atmospheric temperature in the shade is less than 10°C.
3. Ensure that the seal coat results in a smooth, uniform and closed surface.	3. Do not allow the premix material to adhere to the roller wheels. Use light sprinkling of water for this purpose. Do not use lubricating oil on the wheels of the roller to prevent mix from adhering.
4. Maintain requisite temperature control at the time of mixing and rolling if bitumen is used as a binder	4. Do not allow traffic on Type A seal coat till the following day.

512. MODIFIED BITUMEN

This Sub-section deals with the handling of the Modified Bitumens and important tests to be carried out during execution of the works in which their use is specified.

A. Methodology

1. Use Modified Bitumen, blended at the Refinery or at an approved Central Plant or Proprietary products. Ensure that the product meets the various quality requirements laid down in Clause 512 of MORD Specifications on the basis of certification of the manufacturers and further essential testing. The Manufacturers / Refinery certification should be supported by the test results from a recognized Laboratory.

2. The modified bitumen, supplied hot in tankers or supplied in drums, should be agitated in melted condition with suitable device for achieving homogeneity of the blend.

3. Tests for Penetration, Softening point, Separation and Elastic Recovery should be conducted as a minimum requirement for a lot of 10 tonnes of Modified Bitumen.

4. Ensure that the material used at appropriate temperatures of mixing and rolling. The mixing and rolling temperatures are higher for Modified Bitumen compared to normal bitumen.

5. The broad range of viscosity and temperature for different stages are given in Table 512.1

TABLE 512.1: BROAD RANGE OF VISCOSITY AND TEMPERATURE REQUIREMENTS FOR MODIFIED BINDERS

Stage of Work	Viscosity (Poise)	Indicated Temperature (°C)
Binder at mixing	Maximum 2	165-185
Mix at mixing plant	Maximum 4	140-160
Mix at Laying site	Maximum 5	130-150
Rolling at laying site	10-100	115-135

6. The specification covering construction operations for various bituminous constructions using modified bitumen are by and large the same as those for normal bitumens covered in previous Sub-sections except for any special requirements indicated by the Manufacturer.

B. Quality Control Requirements

1. The modified Binder shall be subjected to the essential tests for quality control before and during execution. The minimum requirements are indicated in Table 512.2 to 512.5. Besides these, various other requirements to which the product should conform are given in Tables 500.19 to 500.22 of MORD Specifications of Clause 512.3.

TABLE 512.2: REQUIREMENTS OF POLYMER MODIFIED BINDERS (PMB) (ELASTOMERIC THERMOPLASTIC BASED)

Designation	Grade and Requirements			Method Test
	PMB 120	PMB 70	PMB 40	
Penetration at 25°C, 0.1 mm, 100 g, 5 sec	90 to 150	50 to 90	30 to 50	IS:1203-1978
Softening Point (R&B),°C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of half thread in ductilometer at 15°C, %, minimum	75	75	75	
Separation, Difference in softening point, R&B, °C, maximum	3	3	3	

- Test Procedure outlined in IRC:SP:53-2002

TABLE 512.3: REQUIREMENTS OF POLYMER MODIFIED BINDERS (PMB) (PLASTOMERIC THERMOPLASTIC BASED)

Designation	Grade and Requirements			Method Test
	NRMB 120	NRMB 70	NRMB 40	
Penetration at 25°C, 0.1mm, 100 g, 5 sec	90 to 150	50 to 90	30 to 50	IS:1203-1978
Softening Point (R&B),°C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of half thread in ductilometer at 15°C, %, minimum	50	50	50	
Separation, Difference in softening point, R&B, °C, maximum	3	3	3	

- Test Procedure outlined in IRC:SP:53-2002 / IS 15462:2004

TABLE 512.4: REQUIREMENTS OF NATURAL RUBBER MODIFIED BINDERS (NRMB)

Designation	Grade and Requirements			Method Test
	NRMB 120	NRMB 70	NRMB 40	
Penetration at 25°C, 0.1mm, 100 g, 5 sec	90 to 150	50 to 90	30 to 50	IS:1203-1978
Softening Point (R&B),°C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of half thread in ductilometer at 15°C, %, minimum	50	40	30	
Separation, Difference in softening point, R&B, °C, maximum	4	4	4	

- Test Procedure outlined in IRC:SP:53-2002

TABLE 512.5 : REQUIREMENTS OF CRUMB RUBBER MODIFIED BINDERS (CRMB)

Designation	Grade and Requirements			Method Test
	CRMB 50	CRMB 55	CRMB 60	
Penetration at 25°C, 0.1 mm, 100g, 5 sec	< 70	<60	<50	IS:1203-1978
Softening Point (R&B), °C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of half thread in Ductilometer at 15 °C, %, minimum	50	50	50	
Separation, Difference in softening point, R&B, °C, maximum	4	4	4	*

● Test Procedure outlined in IRC:SP:53-2002

2. The essential quality control tests and their frequencies would be as per Tables 512.6.

TABLE 512.6 : ESSENTIAL TESTS AND THEIR FREQUENCY

Test	Test Method	Frequency
Quality of Binder	● Penetration IS:1203· ● Softening Point IS:1205· ● Elastic Recovery IS:15462-2004· ● Separation IS:15462-2004	One Test per lot of 10 tonnes for each source.

C. DO's and Don'ts

Do's	Don'ts
1. Agitate modified bitumen using suitable mechanical stirrers from time to time to avoid separation. 2. Obtain tests certificates and details of other essential requirements to be followed in its use.	1. Do not modify bitumen at site. 2. Do not multiple heat modified bitumen.

ANNEX- I

DETERMINATION OF TEMPERATURE OF BINDER

The temperature of bituminous binder shall be determined with the help of a calibrated metallic contact thermometer with digital (LCD/LED) display. The range of thermometer for different types of bituminous material and their accuracy shall be as under:

(1)	Melted Bitumen	: ambient to 200°C	accuracy ± 1°C
(2)	Cutback bitumen	: ambient to 100°C	accuracy ± 0.5°C
(3)	Bitumen emulsion	: ambient to 80°C	accuracy ± 0.5°C

ANNEX- II

RATE OF SPREAD OF BINDER IN SURFACE DRESSING AND MODIFIED PENETRATION MACADAM

Light metal trays of 200 mm x 200 mm and 30 mm depth are weighed and numbered. These are placed at intervals along the road in the path of bitumen distributor between the wheel tracks. After the distributor has passed over, the trays are removed and wrapped in weight sheets of paper so that they can be handed, stocked and weighed as soon as convenient. The spacing and the number of trays can be varied to suit the particular conditions at the construction site, but at least five trays should normally be used. The tray test gives a measure of variation in rate of spread of bitumen along the road and a good approximation to the average rate of spread of bitumen.

The trays are weighted correct to first place of decimal. The maximum longitudinal distribution error in rate of spread of bitumen should be within ±10 per cent of the specified rate of spread of bitumen. Similarly transverse distribution of bitumen can be checked by placing a number of trays to collect bitumen sprayed over each 50 mm width of spray bar. The variation in transverse distribution should be within ± 20 per cent from the mean. The extreme 150 mm width at either side of the sprayed area need not be taken into account.

ANNEX- III

DETERMINATION OF IN-SITU DENSITY OF BITUMINOUS COURSE

The metallic tray of the field density is kept on a level spot of the bituminous surface and a hole, 100 mm in diameter, is cut up to the full thickness of the layer. All bituminous materials removed from the hole are carefully collected and weighted. The thickness of the layer is also recorded.

A known weight of dry standard sand passing 600 micron sieve and retained on 300 micron sieve, is taken in the sand-pouring cylinder. The cylinder is kept directly over the hole, and the shutter of the cylinder is released without any jerk and closed when the hole is filled with the sand. The quantity of the residual sand in the cylinder as well as the quantity filling the cone of the cylinder are separately weighed.

The In-situ density of the layer is calculated as follows:

In-situ density = $(A*D)/(W-(W_1 + W_2))$ g/cc

Where,

A = Weight of bituminous materials removed from the hole cut in the layer, g

W = Initial weight of sand taken in the cylinder, g

W_1 = weight of sand filling the cone of the cylinder, g

W_2 = weight of sand remaining in the cylinder, g

D = bulk density of sand, g/cc

Prior calibration for depth of hole, in necessary.

ANNEX- IV

D. RATE OF SPREAD OF AGGREGATE IN SURFACE DRESSING

The rate of spread of aggregate by the aggregate spreader or any other suitable means can be checked by measuring the area covered by each lorry/truck/any other device of known capacity. This can also be checked by removing the spread aggregate from small areas of the road surface and weighing them. A 200 mm square metal frame is laid on the new surface dressing, and all the aggregate within the enclosed area are collected, washed in solvent to remove bitumen and then weighed, and the rate of spread of aggregate is calculated. It is measured along the road at intervals of between 4 m to 8 m. The variation in the rate of spread of aggregate should be within $\pm$ 20 per cent of the mean.

ANNEX- V

DETERMINATION OF BITUMEN CONTENT IN BITUMINOUS MIX

The test is intended for determination of bitumen content in the bituminous mix by cold solvent extraction method. The mineral aggregate recovered from the test can be used for checking their gradation. A representative bituminous mix sample of about 500 g by weight is accurately weighted and placed in the bowl of extraction apparatus and covered with commercial grade of trichloroethylene. Sufficient time (not more than one hour) is allowed for dissolving the bitumen in solvent. The filter ring of the extractor is dried, weighed and then fitted around the edge of the bowl. The cover of the bowl is clamped tightly. A beaker is placed under the drain to collect the extract. The macinhe is revolved slowly and then gradually the spped is increased to a maximum of 3600 rpm. The speed is maintained till the solvent ceases to flow from the drain. The machine is allowed to stop, 200 ml of solvent is added and the above procedure is repeated. A number of 200 ml solvent additions (not less than three) are used till the extract is clear and not darker than light straw colour. The filter ring from the bowl is removed, dried first in air and then in oven at 115°C to constant weight, and weighed. The fine materials that might have passed through the filter paper are collected back from the extract preferably by centrifuging. The material is washed and dried to constant weight as before. The percentage of binder in the bituminous mix is calculated as follows:

$$\text{Percentage of Binder} = \frac{W_1 - (W_2 + W_3 + W_4)}{W_1} \times 100$$

W_1 = weight of sample, g

W_2 = weight of sample after extraction, g

W_3 = weight of fine material recovered from the extract, g

W_4 = increase in weight of filter ring, g

ANNEX-VI

SIMPLE/HANDFEEL TESTS

600

600.1 Bricks

The bricks should be sound, of compact structure (as seen when broken) free from cracks and flaws. They should be regular in shape and of uniform size (dimensional accuracy) with plane faces and sharp edges. The colour should be uniform and of deep red or copper colour. The quality of bricks is generally assessed by compressive strength, efflorescence, dimensional accuracy, water absorption and evenness of baking. Some of the simple tests to fairly assess the quality of bricks are given below:

(i) In efflorescence test, a sample brick is soaked in water for 24 hours and its appearance after removal from water, should be free from white patches, the total area not exceeding 50%. In case the surface area exhibiting, patches exceed 50% of total area both the brick and water samples shall be subjected to further testing for ascertaining suitability.

(ii) In water absorption test, a brick should not absorb more than $1/5^{th}$ of its dry weight after immersion in water for 24 hours.

(iii) Bricks are considered good when clear ringing sound is heard when two bricks are struck against each other. A sample brick should not break when dropped flat on hard ground from a height of about 1 m.

Correct firing promotes toughness. The bricks should not be under-burnt. A well burnt brick when scratched with a finger nail should leave no impression.

600.2 Cement-Lime (Composite) mortar

Refer to 700.2 and 800.4

700 Stone Masonry

700.1 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 colour.

(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.

700.2 Cement-Lime (Composite) Mortar

Lime is classified as quick and hydraulic lime. The quick lime is obtained by calcination of pure lime stone, chalk or sea shells. It is nearly white and increases in bulk two or three times its original volume when slaked. It does not set but dissolves in water and has no cementing property.

Hydraulic lime is obtained by burning clayey lime stones or kankar and it sets and hardens under water. In Rural Road works only class A and B (hydraulic and semi-hydraulic type) lime mortars conforming to IS:712 are permitted in composite mortar. Use of quick lime is not permitted.

Strict control over mix proportion (Cement:Lime:Sand) shall be exercised to ensure that the mortar mix confirming to the mix proportion specified in the contract. Normally, a proportion of 1:3:9 (Cement:Lime:Sand) is used in masonry works.

Purity of lime shall be determined in accordance with IS:1514.

700.3 Cement Mortar

Refer to 800.4

800 Concrete for Structures

800.1 Water

Water should be clean and free from oils, acids, alkalies, vegetable and other organic impurities. Water shall be got tested before the start of works, thereafter each monsoon till completion of works. Some of the simple tests to fairly judge the suitability of water in cement-concrete works are given below:

(i) Presence of acids or alkalies in water can be tested by litmus paper. If blue litmus paper turns red, it indicates acidity; which the red litmus paper turning blue indicates alkalinity. Rapid change in colour of litmus paper indicates significant amounts of acids or alkalies.

(ii) Make two identical pats of 75 mm dia and 12 mm thick of neat cement paste, one with water under test and the other with water of known suitability. Place the pats on a clean non-absorbent surface and leave for 48 hours, and setting and hardening time observed for both the pats. If the quality of water under test is not upto mark, both setting and hardening time of the pat would be different than the one of known quality.

800.2 Cement

Cement more than three (3) months old shall be got tested to ascertain its quality and satisfy the acceptability requirements as per Table 800.11. The quality of cement can be roughly judged by the following:

(i) Thrust a hand into a cement bag. It must give cool feeling. There should be no lump inside.

(ii) Take a pinch of cement and feel between the fingers. It should give a smooth and not a gritty feeling.

(iii) Take a handful of cement and throw it in a bucket full of water. The particles should float for sometime before they sink.

(iv) Take about 100 gm of cement and mix it with water to make a stiff paste. Make a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket, without disturbing the shape of cake. After 24 hours, the cake should retain its original shape and gain some strength.

(v) Setting time: Make a stiff paste of neat cement and water, and form it into a pat of about 75 mm dia and 12 to 25 mm thick. The pat should commence to set in 30 to 60 minutes. The commencement of setting can be roughly estimated by pressing the uncut end of a lead pencil into mass. The resistance to piercing increases suddenly when setting commences. In 18 to 24 hours, the pat should have hardened sufficiently so that a scratch can be made with a thumb nail.

(vi) Soundness: Boil the set pat (as above) in water for about 5 hours. The pat should remain sound and hard and should not swell, crack or disintegrate, but may show only hair cracks. Reject cement if pat shows radial cracks or curl or crumble.

(vii) Fineness: In the sieve test, 100 gm cement is correctly weighed and placed on 90 micron sieve. Air set lumps, if any, are broken down with fingers. The sample is sieved for 15 minutes and the residue left on the sieve is weighed. The amount of residue should not exceed 10% for OPC.

800.3 Sand or Fine Aggregate

The sand should be sharp, clean, chemically inert, coarse and gritty to the touch and free from silt / clay and organic impurities. The general quality of sand can be assessed as below:

(i) Presence of Silt or Clay: Rub a sample of sand between damp hands and note the discolouration caused on the palm. If the sand is clear, the palm would be stained slightly. If the hands stay dirty after sand has been thrown away, it indicates too much of silt or clay.

(ii) Sedimentation: Place, without drying, a sample of sand in a 200 ml measuring cylinder upto 100 ml mark. Add clean water upto 150 ml mark. Shake the contents vigorously and allow it to settle for 3 hours. The height of the silt visible as a layer above the sand is expressed as a percentage of the sand below.

(iii) Organic impurities: Shake the sample with an equal volume of 3% solution of NaOH (Caustic soda) and allow it to settle for 24 hours. Examine the colour of the liquid above the sand. Clear or pale yellow colour shows that the sample is tolerably free from organic impurities. Dark yellow or brown tinge shows that the sand should be washed and tested again. If on retesting, dark yellow colour persists, the sand should be rejected.

800.4 Cement-Mortar

(i) The cement mortar if unused for more than 30 minutes after addition of water shall be rejected and removed from site.

(ii) The mix proportion of cement: sand can be checked as follows:

Take about 200 gm of green cement mortar and add 100 ml of water in a measuring jar and shake the contents well and allow the contents to settle. While the sand gets deposited at the bottom, cement shall settle above. From the volumes of each, the approximate proportion of cement and sand can be determined.

(iii) Consistency: Mortar consistency can be checked by the following:

(a) If a small quantity of mortar is dropped from a trowel, the trowel ought to be left perfectly clean.

(b) A little mortar worked gently in the hands should be easily moulded into a ball; on the surface of which water would appear.

(c) When the ball is dropped from a height of half a meter (500 mm) on a hard surface, it must retain its rounded shape.

800.5 Coarse Aggregates

Coarse aggregates shall be hard, strong, non-porous, free from friable, elongated and laminated particles. They shall be clean and free from clay, coal, vegetable and other organic material.

Two simple tests to check the suitability of stone aggregates are given below:

(i) If the aggregates of a known quantity absorb more than 10 percent of their weight after 24 hours immersion in water, they are considered porous and are avoidable.

(ii) If Mica inclusions persist on the surface, the stone aggregates shall be rejected as presence of Mica affects durability of concrete.

However, the detailed tests indicated in Table 800.13 are to be conducted before the use of coarse aggregates in concrete bridge works.

800.6 Cement Concrete

The principal requirements of concrete include workability, strength, durability, impermeability, and volume changes. Some of the simple tests to determine quality of concrete are described below:

(i) **Consistency**: The concrete can be considered to satisfy consistency requirement if an ordinary iron rammer sinks into concrete mixture by its own weight. It shall run-off a showel unless showelled very quickly; and shall spread out and settle to a level surface after wheeling for about 8 m distance in a wheel barrow.

(ii) **Workability**: Take a handful of concrete in left hand and make a round ball with both hands. If a ball can be maintained for a while, it is indicative of a 'workable mix'. Any low or high content of water cannot make a good ball of concrete.

(iii) **Alkali Silica Reaction (ASR)**:

Alkali Silica reactivity is noticed in aggregates crushed with siliceous rock. When aggregates are immersed in water, a slight increase in volume occurs. If alkali content in Portland cement is less than 0.6 percent by weight, no harmful reaction occurs.

The Basalt rocks found in parts of Deccan plateau, Madhya Pradesh, Kathiawar peminsula of Gujarat, J&K, Jharkhand and West Bengal should be viewed with caution. Similarly, some lime-stones containing chert modules occurring in Madhya Pradesh, Rajasthan, Punjab and Assam are reactive.

Due to ASR, normally damp patches are visible at the junction of cracks, the edges of cracks often appear light in colour, the concrete often has an uncharacteristic pinkish appearance in the affected areas. There will be negligible spalling of concrete but exudation may occur from some of the cracks.

If aggregates are suspect of likely positive ASR on the basis of past performance or any evidence, it is always recommended that the aggregates are tested as per IS:2386 part 7 before they are approved for the use for making concrete.

SECTION 600

BRICKWORK FOR STRUCTURES

600 : BRICKWORK FOR STRUCTURES

A. Methodology

A1 General Brickwork

1. Soak all bricks for a minimum period of one hour before use and remove from tank sufficiently in advance so that they are skin dry before actual laying.

2. 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 layer of 150 mm (average) thickness in concrete of M10 grade.

3. Lay all brickwork in English bond, even and true to line, plumb or specified batter and level. Break all joints in successive courses and lay joints accurately.

4. 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.

5. Build brickwork in uniform layers so that no part of brickwork shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing.

6. Remove all loose bricks and mortar while joining partially set or entirely set brick masonry with new one and roughen and wet with cement slurry to achieve proper bond. In case of vertical and inclined joints, achieve proper bond by inter locking the bricks.

7. Tool all joints on exposed faces to give a concave finish, the thickness of joint not exceeding 10 mm.

8. Keep masonry work in cement mortar constantly moist on all faces for a minimum period of seven days. Leave the top of masonry work flooded with water at the close of the day. During hot weather wet or cover all finished or partly completed work to prevent rapid drying of brickwork. Maintain watering and curing at the close of day's work or for other period of cessation of works.

9. Erect single scaffolding for plastering, pointing and any finishing in which one end of the put-logs / 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.

A2 Brick masonry arch

1. Erect scaffolding to withstand design loads and allowing approach to each part of work.

2. Erect centering to the correct curvature, supported on joints themselves or independently from the ground below.

3. Lay full scale shape of arch on a leveled platform near the site and mark size of brick and mortar. Place alternate brick lengthwise and widthwise in outer rings of arch. Place remaining bricks in the inner part of arch to have uniform length.

4. Build the courses as shown in drawings. Adjust beds properly to bring them to radial planes. Make the radial joints in planes parallel to the transverse axis of the arch.

5. Dress intrados face sufficiently to permit the bricks to rest properly on the centering. Cut the bricks of the spandrel wall at their junctions with the extrados of the arch, to fit in the curvature of the arch.

6. Commence laying of arch for both ends towards the crown and carry out work symmetrically about the crown. Lay bricks in full mortar beds with tightly filled joint. Fit each dry brick first, before it is finally laid into mortar and fixed in its bed.

7. Strike the wedge in pairs from the crown outwards to the springing line, loosening them gradually without shock to the arch. In case of multiple arch spans centering shall not be struck and stripped before construction of adjoining arch. Keep one or two arches undisturbed between the arch last built and the arch being stripped off.

A3 Miscellaneous Items

1. For a surface which is subsequently plastered or pointed, make out the joints to a depth of 15 mm while mortar is green.

2. 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.

3. Execute plastering using mortar of proportion where shown on the drawings but not leaner than 1:4 by volume of cement and sand to the specified thickness which will not be higher than average thickness by 3 mm.

4. Commence curing as soon as the mortar or pointing / plastering has hardened sufficiently. Keep the surface wet for a period of atleast 7 days.

5. Provide weep holes to masonry structures higher than 2 m to drain water from back filling. Use 100 mm dia AC 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.

6. Provide architectural 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

B. Quality Control Requirements

1 Materials

(i) Cement and Lime

Cement of any of the following types shall be used meeting the physical requirements given in Table 600.1.

TABLE 600.1: CEMENT AND LIME

Type	Grade	IS Code
Ordinary Portland Cement	33	IS: 269
Blast Furnace Slag Cement	-	IS:455
Portland Pozzolana Cement	Fly ash based	IS:1489-Part1
Portland Pozzolana Cement	Calcined Clay Based	IS:1489-Part II
Sulphate Resistance Portland Cement *	-	IS:12330
Lime in Cement-Lime (Composite) Mortar	Type A and B	IS:712

** Use in masonry structures which are likely to be affected by the presence of sulphates in surrounding soil or in ground water in concentration of 0.2 percent and 0.03 percent respectively.*

(ii) Sand/Stone Dust/Marble Dust

Sand or Stone Dust or Marble Dust shall consist of hard, durable and clean particles of natural sand, crushed gravel, crushed marble or suitable combinations there of and shall conform to the requirements given in Table 600.2

TABLE 600.2: SAND/STONE/MARBLE DUST

Material	IS Code
Sand	IS:2116
Stone / Marble Dust	IS:383

(iii) Cement Sand Mortar

Cement Sand mortar shall in general conform to IS:2250 and its consistency and water retentivity shall be determined as per the code.

The recommended values of consistency and water retentivity are given in Table 600.3

TABLE 600.3 CONSISTENCY AND WATER RETENTIVITY

Property	Work	Value
Consistency	- Laying of solid brick walls	90-130mm
	- Filling cavities	130-150 mm
Water retentivity(Flow of suction)	Masonry work with high suction characteristics	More than 70% of flow before suction

Refer to Sub-section 800 for the strength requirement of mortar using 33 Grade cement.

(iv) Bricks

First class bricks of any of the following two types shall be used in masonry works. The physical requirements of bricks are given in Table 600.4

TABLE 600.4: PHYSICAL REQUIREMENTS

Item	Requirements
Burnt Clay bricks	IS:1077
Clay Flyash bricks	IS:13757
Fly ash	Grade 1 or 2 of IS:3812
Minimum Compressive Strength	Value specified in drawing or 7 MPa whichever is higher
Water absorption	Upto 20% by weight (IS:3495 Part 2)
Efflorescence	'Moderate' upto 50% of exposed area of brick covered ith a thin deposit of salt but unaccompanied by powdering or flaking of Surface (IS:3495 Part 3)
Preferred size	190 x 90 x 90 mm or 230 x 110 x 70 mm

(v) Storage of material

Store cement bags on wooden platforms minimum 200 mm above the floor level and minimum 600 mm above ground level whichever is higher in perfectly dry and water tight sheds. Stack and store different types of cement separately, in a manner to facilitate their removal and use in an ordinary manner.

Store lime in weather proof sheds. Store hydrated lime in the same manner as cement and the period of storage shall not be more than one month

Store bricks in regular tiers as they are unloaded to minimize breakage and defacement. Stock bricks for use in different situations or different types separately.

Store sand, stone dust, marble dust etc. at proper place so as to prevent contamination of foreign material due to wind etc. When stacked on ground, do not remove them from stock pile within 300 mm of the ground.

2 Workmanship and Tolerances

Permissible values of workmanship and tolerances for bricks and brick

masonary are given in Table 600.5

Table 600.5: WORKMANSHIP AND TOLERANCES

Item	Permissible Value
Dimensions of Bricks	± 5 per cent in size
Compressive Strength of Bricks	+ 2.5 MPa (No negative tolerance) on value specified or 7 MPa whichever is higher
Thickness of joints for general brick work	Not more than 10 mm
Thickness of joints for Arches	5 mm to 15 mm
Plaster furnish	Surface thickness, not less than specified thickness by more than 3 mm.

3 Quality Control Tests

3.1 Tests prior to construction.

The tests / checks to be carried out prior to construction are indicated in Table 600.6.

TABLE 600.6: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material	Test / Check	Frequency
1.	Bricks	a) Colour 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 3 samples at source or after In case of doubt, at source3
2.	Cement	a) Setting time of cement (IS:4031 part 5)	3 samples of same type and grade of cement.
3.	Lime	Purity (IS:1514)	One test for each lot
4.	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
5.	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

3.2. Tests during construction

The tests to be carried out during construction are indicated in Table 600.7

TABLE 600.7: QUALITY CONTROL TESTS DURING CONSTRUCTION

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 / lime by weight) b) Consistency and water retentivity (IS:2250) c) Compressive Strength (IS:2250)	Each batch As required at close interval 3 samples of cubes where specified
6.	Arches(Additional Tests)	a) Dimensions of abutment-pier for multiple arches (IS:2118) b) Centering for arch c) Compaction and thickness of filling material over crown and haunches d) Thickness of Joints	Regularly For each span Regularly Regularly

**Refer to hand feel tests also.*

3.3. Quality Control checks by AE / EE

The quality checks by AE / EE are indicated in Table 600.8.

TABLE 600.8: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material / Work	Test / Check	Frequency	Designation of Inspecting Officer
1.	Brick masonry	Verticality of Brick work and horizontality of courses/ general workmanship and compressive strength (IS 3495 Part 1).	Once in each inspection	AE / EE
2.	Weep holes	Location, size and spacing	For each work	AE
3.	Mortar for Joints	a) Consumption per m^3 of brick masonry b) Quality of Mortar*	For each work, as recorded by JE -do-	AE AE
4.	Structural components	Thickness, dimensions and laying	For each work	AE

** Refer to hand feel tests also.*

C. Do's and Don'ts

Do's	Don'ts
1. Test the cement if it is more than 3 months old.	1. Do not Substitute 33 Grade Cement with 43 Grade or 53 Grade
2. Use lime undamaged by rain, moisture or air slaking	2. Do not mix Blast Furnace Slag with OPC at site
3. Use bricks of rectangular faces with sharp corners	3. Do not use sand containing dust lumps soft or flaky particles, mica or other harmful materials.
4. Mix Cement mortar in a mechanical mixer operated manually or by power for large works.	4. Do not use cement mortar 30 minutes after addition of water or initial setting whichever is earlier
5. Break joints in successive courses and length of lap between the joint of stretcher course with the header course not less than one fourth of the length of the brick.	5. Do not use brick bats or cut bricks except to obtain dimensions of different courses.
6. For arch construction ensure proper centering and simultaneous commencement of work from both ends.	6. Do not start masonry work earlier than 48 hours of casting foundation block
	7. Do not build brick masonry arch bridges having spans more than 6 m in seismic zones IV and V

SECTION 700

STONE MASONRY FOR STRUCTURES

700 : STONE MASONRY FOR STRUCTURES

A. Methodology

A1 General Stone Masonry Work

1. Dress the stones of required size (least dimension not less than 150 mm) and quantity and immerse in water for 24 hours before use. Use only rectangular shaped bond stones or headers.

2. 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 tool every stone on all bed joints with faces full and true.

3. Lay outer layers of masonry first, fix the location of headers and bond stones and lay them. Lay stones in the hearting on their broadest face to ensure filling the spaces between stones.

4. 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.

5. 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.

6. 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.

7. Before laying first course of stone masonry on rock, place concrete levelling course (of M 10 grade) of average thickness of 150 mm.

8. 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.

9. 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).

10. Use selected quoin stones and arrange to bond alternately long and short in both directions.

11. 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.

A2 Stone Masonry Arches

1. Erect scaffolding and centering as per Sub-section 600

2. Lay a full scale shape of arch on a leveled platform near the construction site and mark size of each stone and mortar thickness.

3. Cut stones sizes accordingly. For outer ring of arch, choose long length and short length stones alternately. For inner part of arch, choose uniform length of stones, as far as possible.

4. Adopt full size voussoirs throughout, with bond not less than their thickness as shown in the drawings.

5. Adjust beds to bring them to radial planes. Keep the planes of radial joints, parallel to the transverse axis of the arch.

6. Sufficiently dress the intrados face, to permit the stones to rest properly on the centering.

7. Cut the stones of the spandrel wall at their junctions with extrados of arch, to fit in the curvature of arch.

8. Commence laying of arches from both ends towards the crown and carryout work systematically with stones being placed in full mortar beds and joints grouted if required.

A3 Miscellaneous items

1. Carryout pointing, finishing and curing as detailed in Sub-section 600.

2. Provide architectural stone or concrete coping of 150 mm thick over stone masonry. Provide vertical joints as specified in Sub-section 600.

3. Provide weep holes as specified in brick masonry. Alternatively, locate the weep holes at the same height of course on which they are formed, the size being not less than 80 x 150 mm.

B. Quality Control Requirements

1. Materials

(i) Cement and lime

Same as in Section 600

(ii) Sand or Stone Dust or Marble Dust

Same as in Section 600

(iii) Cement Sand Mortar

Same as in Section 600

Adopt Cement mortar not leaner than 1:5, above bed ground level and 1:4 below bed / ground level. Mix proportion for arches not leaner than 1:4

(iv) Stone

Use stone which is hard, sound, free from cracks, decay, 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 700.1

TABLE 700.1: REQUIREMENTS OF STONES

	Item	Requirements
1.	Least Dimension (IS:1597 Part 1)	150 mm
2.	Water Absorption in stone (IS:1124)	5 percent of its weight

(v) Stone Masonry

Normally use Coursed Rubble (CR) Masonry (first sort) for load bearing structures, CR masonry (second sort) for culverts, wing / return walls of small bridges and Random Rubble (RR) Masonry for wing / return / toe walls of height less than 3 m.

The specifications and requirements of Stone Masonry shall satisfy those given in Table 700.2

TABLE 700.2: REQUIREMENTS OF STONE MASONRY

Item		Requirements
1.	Dressing of Stone	IS:1129 and IS:1597
2.	Minimum height of individual course	160 mm
3.	Consumption of mortar in stone masonry	0.25 – 0.30 m^3 for each cum of stone masonry

(vi) Precast concrete bond blocks

In case natural bond stones of requisite size are not available, use precast concrete (M15) bond blocks of size given in Table 700.3

TABLE 700.3: SIZE OF PRECAST CONCRETE BOND BLOCKS

Size	Height of course(mm)	Minimum Acceptable size of of Face Stones (mm)	Preferable Size of Force Stones (mm)	Size of Longer Stones 1/3rd of Total face Stone (mm)	Size of precast concrete bond blocks (mm)
A	160	150x150 x 200	150 x 180 x 225	150 x 180 x 300	150 x 180 x 450
B	180	170 x 170 x 210	170 x 210 x 255	170 x 210 x 340	170 x 210 x 500
C	220	190 x 190 x 225	190 x 225 x 280	190 x 225 x 380	190 x 225 x 600

(vii) Storage of Cement

Same as in Section 600

(viii) Storage of Sand/Stone Dust/Marble Dust

Same as in Section 600

2 Thickness of Joints

The thickness of cement sand mortar joints for different types of masonry is given in Table 700.4

TABLE 700.4: THICKNESS OF JOINTS

Type of Masonry	Joint Thickness (mm)	Remarks
CR Masonry (I sort) CR Masonry (II sort) RR Masonry	≤10 mm ≤ 20 mm ≤ 20 mm	The thickness should be adequate to prevent stone to stone contact and the joint completely filled with mortar

3. Workmanship

The water cement ratio for different cement mortars* used in stone masonry is given in Table 700.5

TABLE 700.5: WATER-CEMENT RATIO

Location	Ratio
Above bed / ground level	1:5
Below bed / ground level	1:4

** The cement mortar shall be of the materials and proportions intended for use in construction mixed to a consistency equal to 110 to 115, and the cube samples (of 70.7 mm size) shall be tested as per IS: 1728*

4 Quality Control Tests

4.1. Tests prior to construction

The tests / checks to be carried out prior to construction are indicated in Table 700.6

TABLE 700.6: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1.	Stones	a) Shape and Dimension (IS:1597 part 1) b) Water absorption (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)	As per Table 600.5.
3.	Lime(If used)	Purity (IS:1514)	As per Table 600.5
4.	Sand	a) Gradation (IS:2116) b) Deleterious materials and organic impurities (IS:2386 part 2)	As per Table 600.5
5.	Water	If impurities are present test as per IS:3025 (parts 17,24, 32)	As per Table 600.5
6.	Precast concrete bond blocks When natural stone of appropriate size not available	a) Size (Table 700.2) b) Cube strength of mix used	3 samples for each size (A, B, C) on receipt at site 3 samples
7.	Mortar for Joints	a) Consistency and water. etentivity (IS:2250) b) Mix proportions for different works c) Compressive Strength (IS:2250)	As required Daily 3 samples of cubes where specified

4.2. Tests / checks during construction

The tests / checks to be carried out during construction are indicated in Table 700.7

TABLE 700.7: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency/ Stage
1.	Bond and Plumbness	For stability and appearance with plumb bob	While laying each course
2.	Laying in mortar	Horizontality of courses verticality and staggering of joints	- do -
3.	Individual course	Height Joint Thickness and laying (IS:1597 part 1 & 2 and IS:2212)	- do -
4.	Arches(Additional checks)	a) Centering and simultaneous commencement of work from both ends (IS:2118) b) Compaction and thickness of filling material over crown and haunches c) Erection of abutment pier for multiple arches d) Thickness of Joints	Check during erection As and when work is on hand As and when such work is on hand Check during construction
5.	Top of coping (If provided)	Sloping to drain off water	Once on either side of para pet

4.3 Quality control checks by AE / EE

Quality checks to be exercised by AE / EE are indicated in Table 700.8

TABLE 700.8: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material / Work	Test / Check	Frequency	Designation of Inspecting Officer
1.	Stone Masonry	Verticality of stone masonry work, Horizontality of courses and Architectural features.	Once in each inspection	AE / EE
2.	Mortar	a) Quality of Mortar* b) Consumption per m^3 of stone masonry work	For each work as recorded -do-	AE- -do-
3.	Weep holes	Location, size and spacing	For each work	AE
4.	Structural Components	Thickness, dimensions and laying	For each work	AE
5.	General Workmanship	Colour, aesthetics, elegance, Pin headers, corner stones and plumbness etc.	For each work	EE

**Refer to hand feel tests also*

C. Do's and Don'ts

Do's	Don'ts
1. Fit each stone dry, correct in accuracy by cutting, before finally laid in mortar and fixed in bed.	1. Do not have any dry or hollow space in masonry nor use water to push mortar into joints.
2. Mix mortar thoroughly and pour fluid mortar in joints.	2. Do not dress or hammer masonry once placed in position
3. Restrict use of chips to fill interstices	3. Do not use quantity of chips more than 20 per cent of the quantity of stone masonry.
4. Ensure that mortar is confined to joints without smearing the faces.	4. Do not use stone masonry arch bridges having span more than 6 m in seismic zones IV and V
5. Protect stone masonry during construction against rain or frost.	

SECTION 800

CONCRETE FOR STRUCTURES

800 CONCRETE FOR STRUCTURES

A. Methodology

A 1 General

1. Plan all activities before mixing and placing of concrete in Works. This includes procurement of materials, sample testing of cement, coarse and fine aggregates, water and trial mix of the ingredients to achieve the desired strength and workability.

2. Estimate the total quantity of concrete required for the day's work besides additional quantity required for sampling (cubes, cylinders, beams) and plan production of concrete. All ingredients of concrete shall be specified by weight.

A 2 Production of Concrete

1. Designate concrete in grades viz M10, M15, M20, M25, M30 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 (based on 20 mm aggregate) together with cement content, maximum water-cement ratio for different exposure conditions indicated in Table 800.1.

TABLE 800.1: CEMENT CONTENT AND WATER CEMENT RATIO

	Grade of Concrete		Minimum Cement Content (kg/m^3)		Minimum Water Cement Ratio	
Condition of Exposure	Normal	Severe	Normal	Severe	Normal	Severe
a) Plain Cement Concrete (PCC)	M 15	M 20	250	310	0.50	0.45
b) Reinforced Cement Concrete (RCC)	M 20	M 25	310	400	0.45	0.40

4. 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 litre capacity having integral weigh batching facility, automatic water measuring and dispensing device.

5. 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.

6. Use Admixtures where necessary to meet specific requirements of concrete.

A 3 Transportation, Placing and Compaction of Concrete.

1. After mixing, transport concrete to the formwork as quickly as possible in wheel borrows to site. Transport and place concrete such that no contamination, segregation or loss of its constituent materials or ingress of foreign material or water takes place.

2. 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.

3. Choose appropriate methods of placing concrete so as to preclude segregation.

4. 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.

5. Compact before the initial setting but not later than 30 minutes of its discharge from the mixer

A 4 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. Where concrete is to be deposited at or near freezing temperatures, heat the mixing water to a temperature below 65^0C and if necessary heat the aggregates as well, before mixing.

4. When concrete is to be deposited in hot weather, ensure that the temperature of green concrete does not exceed 40^0C 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.

A 5 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, 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 50 mm below the surface of the concrete and close the holes with cement mortar.

A 6 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 upto 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. Apply a 10 mm thick layer of cement mortar and resume concrete. Keep the proportion of cement and sand in cement mortar equal to that in concrete mix proportion.

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.

B. Quality Control Requirements

1 Materials

(i) Cement

Use any of the following types of cement given in Table 800.2 for Structural Concrete

TABLE 800.2: TYPES OF CEMENT

Type	IS Code
Ordinary Portland Cement 33 Grade	IS:269
Ordinary Portland Cement 43 Grade	IS:8112
Rapid Hardening Portland Cement	IS:8041
Portland Pozzolana Cement	IS:1489 (Part 1)
Portland Blast Furnace Slag Cement	IS:455
Sulphate Resistance Portland Cement	IS:12330

Obtain samples of cement once for each source of supply and occasionally when called for determine various properties given in Table 800.3

TABLE 800.3: REQUIREMENTS OF CEMENT

Property	Permissible Value		Tested as per
Fineness	Specific surface not less than 225 m^2 / kg		IS: 4031 (Part 1,2 & 15)
Setting Time	Initial set > 30 minutes Final Set < 600 minutes		IS: 4031 (Part 1)
Soundness	Not to exceed 10 mm in Lechatelier mould		IS:4031 (Part 3)
Compressive Strength At 3 days At 7 days At 14 days	33 Grade 16 Mpa 22 Mpa 33 Mpa	43 Grade 23 Mpa 33 Mpa 43 Mpa	(IS:4031:Part 6)

** The initial setting of test blocks shall not differ by ± 30 minutes from the initial setting of control test blocks prepared with the same cement and distilled water.*

(ii) **Coarse aggregates**

The gradation of coarse aggregate shall satisfy the requirements given in Table 800.4

TABLE 800.4: GRADATION OF COARSE AGGREGATE

	Percent by weight passing the sieve for Nominal size of		
IS Sieve Size	40 mm	20 mm	12.5 mm
63 mm	100	-	-
40 mm	95-100	100	-
20 mm	30-70	95-100	100
12.5 mm	-	-	90-100
10.0 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

(iii) **Fine Aggregates**

The gradation of fine aggregates shall satisfy the requirements given in Table 800.5

TABLE 800.5: GRADATION OF FINE AGGREGATES

	Percent by weight passing the sieve		
IS Sieve Size	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 Micron	15-34	35-59	60-79
300 Micron	5-20	8-30	12-40
150 Micron	0-10	0-10	0-10

(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 are got tested in an approved laboratory as directed by Engineer as given in Table 800.6

TABLE 800.6: LIMITS FOR SOLIDS IN WATER

	Maximum permissible limit
Organic	200 mg / litre
Inorganic	3000 mg / litre
Sulphates (as SO_4)	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 (using 43 Grade cement) are given in Table 800.7

TABLE 800.7: NOMINAL MIXES OF CONCRETE

Grade of Concrete	Nominal Mix
M 10	1 :3 :6
M 15	1:2 ½: 5
M 20	1:2:4
M 25	1: 1½ :3

● Add approved quality of plasticizer @ 300 ml per 50 kg of cement to M 25 grade concrete as per Manufacturers specifications

a. The workability of fresh concrete by slump test is determined as per IS:1199 @ one test per 3m^3 of concrete at the place of mixing and / or at worksite.

b. Samples of concrete cubes for making three test cubes shall be taken from a batch of concrete at the point of discharge from the mixer as per the procedure laid down in IS: 1199. Only 150 mm cubes shall be made cured and tested at 28-day age, to determine compressive strength as per IS:516.

(vi) Frequency of Sampling

The minimum frequency of sampling of concrete of each grade is given in Table 800.8

TABLE 800.8: FREQUENCY OF SAMPLING

Quantity of concrete in work (m^3)	No. of samples
1-5	1
6-15	2
16-30	3
31-50	4

Acceptance Criteria

a. Take decision for acceptance based on sample tests lot by lot.

b. The mean strength of any group of four consecutive samples shall exceed the specified characteristic compressive strength by 3 Mpa.

c. The strength of any sample shall not be less than the specified compressive strength minus 3 MPa.

d. The quality of concrete represented by test results shall include the batches from which the first and last samples were taken, together with all intervening batches.

(vii) Sulphate and Chloride Content

The total water soluble sulphate and chloride contents in concrete shall not exceed the values given in Table 800.9

TABLE 800.9: SULPHATE AND CHLORIDE CONTENTS

Details	Content
Sulphate content as (SO_3)	4 percent
Chloride content	0.3 percent by mass of cement (Moderate condition)
(As Chloride ion)	0.20 percent by mass of cement (Severe condition)

(viii) Use of plums in ordinary concrete

Stone plums shall not be used in RCC or Concrete laid in water. The general requirements for the usage of plums are given in Table 800.10

TABLE 800.10 REQUIREMENT FOR USAGE OF PLUMS

Size	160-300 mm (Maximum dimension not to exceed 1/3 least dimension of member)
Quantity of Plums in works	Not to exceed 15 percent by volume

(ix). Storage of Materials (Cement, Fine and Coarse Aggregates)

a. The requirements of storage for cement and fine aggregates are as per Sub-section 600.

b. Store different sizes of coarse aggregates in separate stock piles sufficiently away from each other to prevent intermixing. Keep the height of individual stockpile below 120 mm, unless otherwise permitted. When placed directly on hard ground, do not remove them from stockpile within 300 mm of the ground. Use the bottom 300 mm of stockpile only after thorough cleaning of the material.

2. Tolerances

The accuracy of the measuring devices used for different ingredients shall fall within the limits given in Table 800.11

TABLE 800.11: ACCURACY OF MEASURING DEVICES

Measurement	Quantity in each batch
Cement	± 3% of cement quantity
Water	± 3% of water
Aggregate	± 3% of aggregate
Admixture	± 5% of admixture

3. Mechanical Vibrators

The capacity / size of the vibrators for compaction of concrete is given in Table 800.12

TABLE 800.12: CAPACITY/SIZE OF VIBRATORS

Type of Vibrator	Conforming to	Capacity/size
Internal Vibrators	IS: 2505	25-70 mm
Form Vibrators	IS: 4656	Minimum 500 Watts
Screed Vibrators	IS: 2506	Full width of carriageway (upto two lanes)

4. Quality Control Tests / Checks

4.1 Tests prior to construction

The tests and checks to be carried out prior to construction are indicated in Table 800.13

TABLE 800.13: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1.	Cement	a) Setting Time (IS:4031 Part 5) b) Soundness (IS:4031 Part 3) c) Compressive strength of mortar cube (IS:4031 Part 6) (Table 800.3)	One test for 10 tonnes of cement (same brand & grade) - do – 3 specimens for each lot
2.	Coarse Aggregates	a) Gradation for PCC or RCC works (Table 800.4) b) Flakiness index (IS:2386 part 1) c) Deleterious constituents (IS:2386 part 2) d) Water absorption / content (IS:2386 part 3) e) Aggregate Impact value (IS:2386 part 4) f) Soundness (IS:2386 part 5) [if water absorption exceeds 2%] g) Alkali Silica reactivity (IS:2386 part 7)	3 samples for each quarry source -do - If in doubt Once for each source of supply One test per source of supply - do - If in doubt one test at approved test house
3.	Fine Aggregates	a) Gradation (IS:2386 part 1) (Table 800.5) b) Deleterious Constituents (IS:2386 part 2) c) Alkali silicate reactivity (IS:2386 part 7)	3 samples for each source of supply If in doubt, one test If in doubt, one test
4.	Water	Normally potable water is good enough for making concreteDetermination of Impurities - Suspended matterIS:3025 (Part 17) - OrganicIS:3025 (Part 16) - Inorganic IS:3025 (Part 19) - Sulphates (as SO_3)IS:3025 (Part 24) - Chlorides (as Cl)IS:3025(Part 32) (Table 800.6 for limits)	For large works If the quality is in doubt Samples taken from each source and tested at an approved test house
5.	Concrete	Mix Design (for each work)	To be approved by EE for cement content, W / C ratio and use of plasticizers, if any.

4.2 Tests / checks during construction

The tests required to be carried out during construction are indicated in Table 800.14

TABLE 800.14: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1.	Fine and coarse aggregate	Moisture content (IS:2386 part 3)	Once before commencement of work – each day
2.	Cement (consumption)	Minimum quantity (Kg / m^3)	Daily
3.	Concrete	a) Workability – slump cone test (IS:1199) b) Cube Strength (IS:516)	2 tests / day Minimum of 6 cubes (3 each to determine 7 days and 28 days strength) to be cast every day)
4.	Construction Joints	Fixing location before concreting and resumption of work	As and when work demands
5.	Formwork	For stability, leakage of slurry, bulging etc.	Throughout concreting
6.	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
7.	Curing of concrete	Regular (till 28 days after casting) inspection	Daily

4.3 Quality Control Checks by AE / EE

Quality checks to be exercised by AE / EE are indicated in Table 800.15

TABLE 800.15: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material / Work	Test / Check	Frequency	Designation of Inspecting Officer
1.	All concrete components	a) Soundness of concrete - Sounding Test by strikingwith a ½ Kg hammer - Schimdt's Rebound hammer test (if quality is in doubt)	After hardening of concrete	AE
		b) Honey Combing and Finishing	Before acceptance of work	AE
		c) Tolerances	As per drawings	AE
		d) Workmanship	As and when inspected	EE
2.	Cube Strength	Review of Cube strength test results	Random	EE

C. Do's and Don'ts

Do's	Don'ts
1. Use cement of the same grade and same source for a single work.	1. Do not mix different types of cement or mix Blast Furnace Slag with Ordinary Portland Cement at site.
2. Use 20 mm (nominal) size aggregate for RCC.	2. Do not use fine aggregates having positive alkali-silica reaction.
3. Use potable water with pH value between 6 and 8 for producing concrete.	3. Do not use sea water for mixing and curing of concrete.
4. Determine moisture content in both fine and coarse aggregates as frequently as possible to adjust.	4. Do not increase water content in concrete mix to 'enhance' its workability
5. Remix concrete, if there is segregation after unloading from the mixer.	5. Do not use of aggregates or wooden pieces to provide cover to reinforcements instead of concrete briquettes.
6. Compact before initial setting of concrete but not later than 30 minutes of its discharge from the mixer.	6. Do not drop concrete into place freely from a height exceeding 1.5 m.
	7. Do not change or increase the number of construction joints from those shown in drawings.
	8. Do not club different lots for the purpose of acceptance.

SECTION 900

FORMWORK AND SURFACE FINISH FOR STRUCTURES

900 FORMWORK AND SURFACE FINISH FOR STRUCTURES

A Methodology

A 1 Design and Erection

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.

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 reshoring, 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 falsework system are centrally placed on the member.

11. Make the forms tight and sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between the supports.

A 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.

A 3 Removal of Formwork

1. Plan removal of formwork (deshuttering and decentering) in advance. Give due consideration to the local conditions viz. character of structure, weather and materials used in mix.

2. Lower centering 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. Fill the holes left out with cement mortar (1:3)

4. The time of removal of formwork when OPC is used without any admixtures is given in Table 900.1 Otherwise it may be taken as 14 days for Superstructure.

TABLE 900.1: TIME FOR REMOVAL OF FORMWORK

Member	No. of days
• Walls, piers, abutments, columns and vertical faces of structural members	0.5 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

A 4 Reuse of Formwork

1. After dismantling examine individual components for damage and remove damaged pieces for rectification.

2. Straighten all bent steel propos before reuse, the maximum deviation from straightness being 1 / 600th of its length. Reduce permissible axle loads on props by a minimum of 10 percent after each reuse, depending on their condition.

B. Quality Control Requirements

1 Tolerances in Formwork

(a)	Deviations form 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 of the footings in the direction of deviation but not more than 50 mm	- 12 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 900.2

TABLE 900.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Test	Frequency
1.	Thickness of Steel tubes	Before usage / 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 AE
5.	Design of formwork	To be approved by EE

2.2 Tests during construction

The quality control tests to be carried out during construction are indicated in Table 900.3

TABLE 900.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

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 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

2.3 Quality Control Checks by AE / EE

The Quality Control checks to be carried out by AE / EE are indicated in Table 900.4.

TABLE 900.4: QUALITY CONTROL CHECKS BY AE/EE

S. No.	Test / Check	Designation of Inspecting Officer
1.	Time for removal of formwork	AE
2.	Damages to concrete members due to settlement of support system	AE
3.	Deviations from specified dimensions of concrete members	AE
4.	Shutter finish of members (Smoothness / Sharpness / honey combing)	AE

C. Do's and Don'ts

Do's	Don'ts
1. Use large size panels to keep the number of joints to a minimum.	1. Do not use form panels of height less than 1.0 m for abutments, piers and return walls.
2. Use clamps of adequate strength to hold the forms together.	2. Do not permit deflection of unsupported areas more than 3 mm or 0.003 of span whichever is less.
3. Avoid sharp corners by providing fillets of 25 x 25 mm (minimum) size at all angles of formwork.	3. Do not allow releasing agent come into contact with reinforcement.
4. Use screwjacks or hardwood wedges to make up for any settlement of formwork before and after concreting.	4. Do not keep centering and shuttering on soft or filled up earth.
5. Provide suitable camber of 1/500 of span in horizontal members to counter the effects of any deflection.	5. Do not allow stagnation of water near the base plate supporting the staging.
6. Use angle iron (not steel bars) bracings for column supports.	6. Do not use more than one plank/timber block at the base of a prop to plug the gap, if any.

SECTION 1000

STEEL REINFORCEMENT

1000 STEEL REINFORCEMENT

A. Methodology

A 1 Bending and Placing

1. Use new steel of the same type and grade for main reinforcement in construction. Use of different type of same grade steel as secondary reinforcement may be allowed exceptionally.

2. Straighten the bars which get bent during transportation or handling. Bend rebars cold to the specified shape and dimensions using a proper bar bender operated by hand or power to obtain correct radii of bands and shape.

3. 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.

4. Position the bars on industrially produced polymer cover blocks or concrete cover blocks of required thickness, to provide cover to reinforcement.

5. 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.

6. Separate layers of reinforcement by spacer bars at a maximum length of 1m, keeping the minimum dia of spacer bar as next higher size of main reinforcement

7. 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.

A 2 Splicing, Welding and Substitution of bar sizes

1. Stagger the lapped splices as per the provisions in IRC:21 and at located 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 dia from a bend.

6. 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.

A 3 Storage and Protection

1. Store reinforcement bars on blocks, racks or platforms or other supports about 300-450 mm above the surface of the ground, in a clean and dry condition.

B. Quality Control Requirements

1. Material:-

(i) The Steel reinforcement used and works executed shall conform to the requirements given in Table 1000.1

TABLE 1000.1: REQUIREMENTS OF REBARS

Grade Designation	Bar type conforming to governing BIS Specification	Characteristic strength (f_y) MPa	Elastic Modulus GPa
Fe 240	IS:432 Part I Mild Steel	240	200
Fe 415	IS:1786 High Strength Deformed Bars (HYSD) or Thermotechnically Treated (TMT) bars	415	200

(ii) The workmanship for welding of steel reinforcements shall conform to the specifications given in Table 1000.2

TABLE 1000.2: 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 1000.3

TABLE 1000.3: TOLERANCES FOR COVER

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 1000.4

TABLE 1000.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

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 (Clause 1002 of MoRD Specifications)	Random checking
3.	Protection of Steel (Clause 1003 of MoRD Specifications)	Regularly
4.	Substitution of bar sizes	Approval by AE/EE before execution of work
5.	Detailing of reinforcement cages	Approval by AE/EE before execution of work

** For Major Works frequency of testing may be increased*

3.2 Tests during construction

The Quality Control tests to be carried out during construction are indicated in Table 1000.5

TABLE 1000.5: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Test	Frequency
1.	Bending and placing of reinforcement (Clauses 1004, 1005 of MoRD Specifications or IS:2502)	Daily / Regularly
2.	Splicing and welding (Clause 1006 and 1007 of MoRD Specifications)	As and when such work is taken up
3.	Tolerances (Spacing and cover)	Before concreting

3.3 Quality Control Checks by AE / EE

The quality control checks to be carried out by AE / EE are indicated in Table 1000.6

Table 1000.6: QUALITY CONTROL CHECKS BY AE/EE

S. No.	Test/Check	Frequency
1.	Quality of Steel if in doubt	AE
2.	Tolerances and General Workmanship of Fabrication	AE

C. Do's and Don'ts

Do's	Don'ts
1. Use new steel for works.	1. Do not use scaled of re-rolled steel in works.
2. Use noncorrodible (material) devices for positioning of reinforcements.	2. Do not allow rough handling, dropping or shock loading of reinforcement prior to embedment.
3. Get the welded lengths of reinforcement tested for strength.	3. Do not tack weld cross bars for assembly of reinforcement.
4. Adopt splicing of reinforcement at non critical sections, the percentage not to exceed 33.	4. Do not weld reinforcement at site welding unless adequate facilities, equipment etc to maintain quality is attainable.
5. Protect reinforcement steel from rusting or chloride contamination, by thorough cleaning using suitable method before use.	5. Do not prolong gap between assembling of reinforcement and casting of concrete.
6. Follow the working drawings and bar bending schedules and match detailing and construction.	6. Do not heat the bars to facilitate straightening.
	6. Do not rebend or straighten an already bent HYSD bar to a dia less than 6 times the dia of bar.

SECTION 1100

PIPE CULVERTS

1100: PIPE CULVERTS

A. Methodology

A 1 Excavation 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.

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. 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.

4. Where rock or bouldery strata is met with, take down excavation to alleast 200 mm below the bottom level of pipe, remove all loose material and fill the space with approved earth.

A 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.

A 3 Laying of Pipes

1. Preload the areas to induce major portion of settlement before the pipe is installed.

2. Provide a bedding surface of firm foundation of uniform density, throughout the length of culvert with specified bedding material depending on dia of pipe and height of fill above pipe.

3. 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.

4. 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 450 mm.

5. When pipes are laid in two layers, keep the centers of pipes such that when joined shall form equilateral triangles.

6. Lay the pipes as specified in IS:783, for different conditions such as positive projecting condition, trench condition etc.

7. Lay the pipes on the prepared foundation, commencing from outlet and proceed towards the inlet. In case of pipes with bell mouth, keep the belled end facing the upstream. Keep the invert of pipe minimum 150 mm below average bed level. However, if the invert level is more than 300 mm, a catch pit of size 1500 x 1000 mm upto ground level should be constructed.

8. Install the culvert with a camber, so that the settlement due to the load of the embankment will in time lower the culvert to the desired grade approximately.

A 4 Jointing

1. Join the pipes either by collar joint or by flush joint. Place the collar such that its center 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 with 1:2 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.

A 5 Back Filling

1. Back fill trenches after the pipes have been laid and after jointing material has hardened. On top of pipe upto 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. When minimum specified cushion cannot be provided over the pipe, encase the pipe in M 10 concrete of specified thickness.

B. Quality Control Requirements

1 Materials

(i) Use NP-3 or NP-4 type reinforced concrete pipes, conforming to IS:458. The internal diameter shall not be less than 600 mm except in exceptional situations.

(ii) Conform brick masonry work for pipe culverts to section 600.

(iii) Conform stone masonry work for pipe culverts to Section 700.

(iv) Conform concrete work for pipe culverts to Section 800.

(v) Conform reinforcement for concrete work for pipe culverts to Section 900.

2 Bedding for pipe

(i) Provide Type A bedding for pipes of internal dia 900 mm or more and when height of fill is more than 4 m above the pipe. Make a cradle bedding constructed of plain concrete not leaner than M 15.

(ii) Provide Type B bedding, (I class bedding) 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 5.6 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.

(iii) For expansive soils, provide a layer of sand / moorum on non-expansive material of minimum 450 mm thickness under the bedding.

3 Back filling

(i) The back fill of soil shall be clean from borders, large roots, clay lumps retained on 75 mm sieve, stones retained on 26.5 mm sieve and excessive amounts of sods and other vegetable matter.

4 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	
	80-95 mm	+ 5 mm -2.5 mm
	Over 95 mm	+7 mm -3.5 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 1100.1.

TABLE 1100.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1.	Bricks	As in Table 600.6	As in Table 600.6
2.	Stones	As in Table 700.6	As in Table 700.6
3.	Concrete Pipe	- Dimensions - Manufacturing defects - Tolerances (IS:458) - Three edge bearing test (IS:3597)	At factory before delivery Manufacturer's certificate

5.2 Tests / Checks during construction

The Quality Control Tests / checks to be carried out during construction are indicated in Table 1100.2.

TABLE 1100.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

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	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	Clause No 600.7 or Clause 700.7	As per Clause No. 600.7 or 700.7
6.	Side slopes on Head walls	- Slope - Stone pitching	Before construction of guard stones

5.3 Quality control checks by AE / EE

The quality control checks by AE / EE are indicated in Table 1100.3.

TABLE 1100.3: QUALITY CONTROL CHECKS BY AE / EE

S. No.	Item / Stage	Test / Check	Designation of Inspecting Officer
1.	Head walls / Return walls	Plumbness	AE
2.	Roadway	Camber, width, tolerance in level	AE
3.	Weep holes	Size and Spacing	AE
4.	Protection works	- Material used - Thickness & length of apron	AE
5.	Cushion over pipes	Thickness of earthwork over pipes	EE
6.	General Workmanship	- Inlet and outlet gradient of pipes - Clear spacing between rows of pipes - Roadway alignment / camber	EE

C. Do's and Don'ts

Do's	Don'ts
1. Carry pavement crust, over pipe culverts 2. Keep the trenches free from water until the pipes are installed and joints hardened. 3. Keep the trench in embankment on either side of pipe to about one-fourth dia of pipe subject to a minimum of 150 mm but not more than one-third dia of pipe or 300 mm. 4. Maintain a longitudinal slope of pipe not flatter than bed slope to ensure self cleaning (suggested minimum value 1 / 100).	1. Do not allow humps or dips in the vertical profile of the road at the location of pipe culverts. 2. Do not use defective pipes or those found damaged during laying. 3. Do not permit traffic unless the depth of earth filling above the top of pipe line is at least 600 mm.

SECTION 1200

RCC SLAB CULVERTS AND MINOR BRIDGES

1200: RCC SLAB CULVERTS AND MINOR BRIDGES

General

A culvert is a cross drainage structure having a total length of 6 m or less between the inner faces of dirt walls or extreme ventway boundaries measured at right angles. A minor bridge is a bridge having a total length upto 60 m. A small bridge is a bridge where the overall length of bridge between the inner faces of dirt walls is upto 30 m and where individual span is not more than 10 m. In rural roads, individual span lengths upto 15 m are used exceptionally.

In this section different items of RCC solid slabs, box culverts, and composite bridges have been dealt with. The cross sections of foundations, substructures such as abutments, return walls besides design of superstructure, drainage spouts, railings, parapets etc. and all other details shall be strictly in accordance with contract documents.

For minor bridges having overall length of 30 m and above, a method statement for construction indicating items (a) to (j) as per clause 1201 (xi) of MoRD Specifications for Rural Roads, shall be submitted.

A. Methodology

A1 Foundations

1. Take the minimum depth of foundation upto the stratum having specified bearing capacity shown on drawing but not less than 2 m below the scour level where no bed protection is provided or 1.5 m below the protected bed level.

2. In case of rocky bed, ensure embedment of foundation into the rock below, the minimum depth being 500 mm for hard rocks and 1200 mm for soft erodible rocks.

3. Provide 300 mm thick plain concrete M15 grade footing, unless otherwise specified on the drawings. Provide a minimum offset of 150 mm for the base of substructure.

4. Set out plan dimension of the foundation at the bottom of foundation trench and check with respect to original reference line and axis.

5. Before laying foundation concrete, clean the earth surface of all loose material and sprinkle water to wet. Provide side formwork as per required dimensions and height.

6. Lay foundation concrete continuously to the required thickness upto the level of construction joint proposed.

7. Finish the concrete surface smooth with a trowel and ensure curing as specified in Section 800.

8. Carryout dewatering where necessary for laying of concrete so as to keep the water level below foundation level with adequate provisions/ precautions.

9. Remove loose sand laid on foundation before commencement of back filling. Refill all spaces excavated and not occupied by permanent work with earth upto surface of surrounding ground. In case of excavation in rock, fill the circular space with M15 concrete.

A2 Substructures

This item covers piers, abutments, wing walls, return walls, pier and abutment caps and RCC dirt walls.

1. Adopt either Brick Masonry or Coursed Rubble (CR) Stone masonry or Plain or Reinforced Concrete for piers, abutments and wing / return walls. For wing and return walls upto 3m height use Random Rubble (RR) masonry.
2. Before commencing the masonry / concrete work, scrub the foundation with wire brush and remove all loose material and wet the surface.
3. Make provision for weep holes in solid (non spill through) abutments and provide back fill.
4. Provide vertical expansion gaps of 20mm width between abutments and wing walls.
5. Provide coping for wing / return walls in plain concrete.
6. Provide dirt wall as per specification.
7. Provide RCC pier and abutment caps as shown on the drawings. For Slab bridges, cast surface of pier and abutment caps and pedestals horizontal.
8. Provide RCC dirt wall with specifications of formwork, reinforcement and concrete as per Sections 800, 900 and1000.

A3 Superstructures

(a) Reinforced Concrete Solid Slabs

1. Set out dimension, lines and level and check with respect to permanent reference lines and permanent bench marks.
2. Carry out RCC work conforming to the provision of formwork steel reinforcement and structural concrete given in sections 900, 1000 and 800 respectively.
3. Where adjacent span of slab has already been cast in place, expansion joint and filler board abutting the already cast span shall form the shutter for the adjacent span.
4. Cast whole of the slab with reinforcement embedded for road kerb and railings.
5. Use vibrators as per Table 800.12 for compaction of concrete.
6. Provide wearing coat after the deck slab has been cast true to lines and levels.

(b) RCC Box Cell

Choose box culvert when safe bearing capacity of soil is less than 150 kN / m^2 and when angle of friction is less than 15^o.

1. Prepare M10 Grade cement concrete bearing surface as shown in drawings or clause 1203.4 of MORD Specifications before construction of box cell.
2. Keep the top of the raft in bottom of box cell 300 mm below the lowest bed level.
3. Place the reinforcement cages in the shuttering as per drawings.

4. Construct box section in M25 concrete or as specified, with a maximum of one construction joint located in the web below the fillet between deck slab and web.

5. Carryout concreting operation continuously upto the construction joint.

6. Ensure proper compaction of concrete using screed or form vibrator for concrete in top slab of box. Use needle vibrators to ensure compaction of concrete in webs.

7. Provide pressure relief pipes of 100 mm dia. Mark an area of 500 mm x 500 mm below the pressure relief pipe in the form of inverted filter as per clause 1302 of MoRD Specifications.

8. Provide cut off walls and protective apron as shown in drawing.

9. Provide earth cushion and / or pavement on the top slabs (carriageway) after specified period of curing of all the box cells.

10. Provide 400 mm thick plain cement concrete parapet as per Clause 1208.4 of MoRD Specifications.

(c) Composite type (RCC deck slab on steel girders)

Choose Composite type bridges in hill areas or where problems of centering are foreseen for casting of superstructure

1. Provide simply supported spans for composite type superstructure consisting of longitudinal steel girders with RCC solid slab decking.

2. Provide shear connectors of appropriate size and spacing as shown in drawings between the Steel girder and RCC deck to ensure composite action.

3. Ensure the composite section of steel beams and RCC slab and shear connectors conforming to IRC:22 and IRC:24 and carry out welding works as per Table 1000.2.

4. Cast the RCC deck slab with steel reinforcements in place as per Sections 800, 900 and 1000.

5. Carryout painting and protective coating on Structural steel components in accordance with IS:1477, with a minimum of three coats of paints or a metal coating followed by two coats of paint.

A4 Appurtenances

(a) Wearing Coat

Both bituminous and concrete pavements used in the adjacent road works, are carried over culverts and minor bridges as wearing surface. However, separate bituminous or cement concrete wearing coats are to be laid on RCC slab bridges, as shown in drawings.

1. Use 20 mm thick premix carpet with seal coat as bituminous wearing coat on culverts having earth cushions and pavement carried over such culverts.

2. On minor bridges and culverts without earth cushion, provide 40 mm thick Bituminous Macadam (BM) covered with 20 mm thick premix carpet and seal coat.

3. Where cement concrete pavement is being built for the road, carry the same over box culverts with earth cushion or slab culverts.

4. Provide 75 mm cement concrete wearing coat of M30 grade for isolated RCC slab bridges or submersible structures where specified.

5. Keep a cross slope of 2.5 percent for deck slab level in longitudinal profile for drainage and ensure curing earlier to prevent formation of shrinkage cracks.

(b) Bearings and Expansion Joints

1. Provide only elastomeric bearings for RCC slab bridges of span length more than 10m conforming to IRC:83 part II.

2. Make provision for robust, durable, watertight and replaceable expansion joints, if needed. Such joints shall be designed site specific or adopted as shown in drawings.

3. Install deck joints in accordance with manufacturer's recommendation.

4. For the specifications of filler joints, buried joints, compression seal joints and slab seal expansion joints refer to section 1200.7 of the MoRD Specifications for Rural Roads.

(c) Railings/Parapets

Bridge railings include portion of the structure erected on and above the kerb for the protection of pedestrians and traffic and constructed after the centering for falsework released. Adopt either metal or cast-in-situ concrete railings for RCC slab culverts and minor bridges as specified in the drawings.

1. Adopt all pipe sections and steel elements of railings, conforming to IS:1239 after galvanizing.

2. Adjust railings carefully prior to fixing in place, to ensure proper matching at abutting joints and correct alignment and camber throughout their length.

3. Protect all steel rail elements, pipe terminal sections, posts, nuts and both hardware and other steel fittings against corrosion, by galvanizing or painting.

4. Construct portion of the railing or parapet to be cast in place in accordance with the requirements for structural concrete as per Section 800 and reinforcement as per Section 1000.

5. For RCC slab culverts and minor bridges having overall length not exceeding 30 m, provide parapets of 400 mm thickness (minimum) in PCC of M15 or brick or stone masonry as shown in drawings.

6. Use forms of either single width board or line with suitable material duly approved.

7. Construct all mouldings, panel work and bevel strips as per drawings and finish all corners, true, sharp and clean cut.

(d) Approach slabs

1. Approach slabs are not needed on culverts / or minor bridges having overall length not exceeding 30 m bridges and road pavement is continued in the full formation width between wing walls / Returns.

2. When specified, adopt a minimum length of 3.5 m and minimum thickness of 300 mm for approach slab. Provide a 150 mm thick base in M10 concrete for approach slab.

3. Provide 12 mm dia steel bars at 150 mm c/c in both directions at both top and bottom of approach slab and execute concreting work as per Section 800.

(e) Drainage spouts

1. Fix rigid drainage spouts of 100 mm dia, at a spacing not exceeding 10 m.
2. Use corrosion resistant material for drainage spouts.
3. Ensure suitable camber in the carriageway surface for transverse drainage.
4. Seal the shrinkage cracks around drainage assembly with polysulphide or bituminous sealant, after setting of deck slab concrete.

(f) Filling

Filling around culverts and bridges should be done with non-cohesive soils.

(g) Sectional Details

1. For plain concrete structures, provide a minimum skin reinforcement of 2.5 kg/m^2 on all exposed surfaces in horizontal and vertical directions keeping a spacing not more than 200 mm in each direction.
2. For RCC approach slabs provide a reinforcement of 12 mm dia @ 150 mm c/c at both top and bottom side, in both the directions.
3. For structural steel RCC slab composite superstructures, provide haunches of 150 mm x 150 mm between top of steel girder and soffit of slab. Locate the sides of haunches 45^o from the outside edge of the base of the connections.

B. Quality Control Requirements

(1) Materials	Table/Clause
Bricks	Table 600.4
Stones	Tables 700.1 & 700.2
Cement	Clause 602.2 / 702.2 / 802.2
Coarse aggregate	Clause 802.3
Sand	Clause 602.5 / 802.4
Water	Clause 802.5
Steel Reinforcement	Clause 1002
Structural Steel	Clause 505 of IRC:24
Structural Concrete	Table 800.2 to 800.12
Tolerance in Formwork	As per B of Section 900
Polysulphide Sealant or Bituminous Sealant	IS:1834

(2) Tolerances

1200.1: Tolerances for different items in Tables 1200.1 to 1200.3

(i) Construction of Foundations

(a) No point of the bearing surface on which concrete footing is to be laid shall be higher than the founding level.

(b)	Variation in Dimensions	:	+50 mm
		:	-10 mm
(c)	Misplacement from specified position in plan	:	15 mm
(d)	Surface irregularities measured with 3 m straight edge	:	5 mm
(e)	Variation of levels at top	:	±25 mm

1200.2: Tolerances in Sub-structures

(ii) Sub-Structure

(a)	Variation in cross sectional dimensions	:	+10 mm
		:	-5 mm
(b)	Misplacement from specified position in Plan	:	10 mm
(c)	Variation of levels at the top	:	±10 mm
(d)	Surface irregularities measured with 3 m straight edge	:	5 mm
(e)	Bearing areas	:	3 mm

(iii) Superstructure

(a)	Variations in overall depth or width	:	±5 mm
(b)	Variations in overall length and length between bearings	:	Shall not exceed ± 10 mm or ± 0.1 percent of span length whichever is less.
(c)	Surface irregularities when measured with 3 m straight edge or template	:	5 mm

3 Quality control tests

3.1 Tests prior to construction

(a) Material / Work

TABLE 1200.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test	Frequency
1.	Cement Fine / Coarse Aggregates and water and Concrete for Structures	Tests as in Table 800.13	As in Table 800.13
2.	Steel Reinforcement (For culverts and minor bridges)	Tests as in Table 1000.4	As in Table 1000.4
3.	Plant & Equipment and other arrangements for concrete production	a) Working condition of concrete mixers including stand by arrangement b) Measuring boxes / scales for cement, fine and coarse aggregates c) Standard measuring cans ($^1/_2$, 1, 2, 5 litre capacity) for water d) Needle, plate and screed vibrators e) Arrangements for protection of concrete in hot, cold and rainy weather f) Tools and equipment for finishing and curing. g) Formwork (As per Table 900.2)	Check by AE before commencement of concreting

The tests and checks to be carried out prior to construction are listed in Table 1200.1

(b) Manufactured items:

Other checks to be done on 'Manufactured items' prior to construction indicated in Table 1200.2.

TABLE 1200.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1.	Elastomeric bearings (IRC-83 part II)For Spans > 10m	Approved Test house report obtained by Manufacturer.	To be approved by AE/EE before procurement
2.	Expansion Joints (IRC:SP:70)	Performance report (To be furnished by manufacturer)	-do-
3.	Shear connectors (For composite bridges)	Dia, length and yield strength	-do-
4.	Plasticizer (If used to improve workability of concrete)	As per Manufacturer's test reports.	- do -

3.2 Tests / checks during construction.

The Tests / Checks to be carried out during construction are indicated in Table 1200.3

TABLE 1200.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency / Stage
1.	Concrete for Structures	For constituentsAs in Table 800.14	As in Table 800.14
2.	Concreting - For Foundation - For Substructure	 Dewatering, before laying of foundation concrete Form panel size and jointing to prevent bleeding	 For each foundation work For each work
3.	Cube Strength Results	Analysis of Test results (Clause No 815 of MoRD Specifications)	During construction of substructures / super-structures separately
4.	Formwork	Tests as in Table 900.3	As in Table 900.3
5.	Reinforcement cage	a) Dia and spacing of Reinforcements in cage as per drawing b) Size and placement of briquettes for supporting the reinforcements i.e. to provide bottom and side covers c) Cleaning rust on reinforcements with wire brushing d) Other checks as per Table 1000.5	Before ommencement of cconcreting - do - Before placement and compaction of concrete
6.	- All concrete** works	a) Temperature Control & Control of W/C ratio (As per time & season of work) of mix b) Workability (IS:1199) c) Compaction d) Curing	Regularly Twice in a day. Ensure compaction by needle vibrator To commence 24 h after casting.
7.	Expansion Joint assemblies	Installation as per Manufacturer's specification	At each Joint location
8.	Sealants	To be installed as per Manufacturer's specification.	After hardening of concrete
9.	Kerbs, Drain pipes, Railings / Parapets	- Separate formwork - Spacing - Dimensions	As and when work is taken up
10.	Elastomeric bearings	Correct positioning on pedestals	Before concreting

** *Refer to Table 800.14 also*

3.3 Quality Control checks by AE / EE

The quality control checks to be carried out by the AE / EE are indicated in Table 1200.4

TABLE 1200.4: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material / Work	Test / Check	Frequency	Designation of Inspecting Officer
1.	Foundations	- Dimension and levels	For each foundation	AE
2.	Substructures	-do-	Each supporting member	AE
3.	Deck Slab	- Depth, width of carriageway - Overall length / Length between bearings - Camber	Each span	AE
4	Wearing Coat	- Thickness - Camber - Surface Texture	-do-	AE
5	Railings / Kerbs / Parapets	- Irregularity in alignment - Dimensions	-do-	AE
6	Drainage spouts	- Spacing-Finishing-Sealants	After hardening	AE / EE
7	Protective works	Size of boulders in wire crates, length / thickness	-do-	AE / EE
8	General workmanship	-	-do-	AE / EE
9	All concrete components	- Soundness of concrete - Honey combing, finishing - Tolerances - Workmanship - Cube strength(Review of test results)*	As per Table 800.15 Random	AE / EE

C. Do's and Don'ts

Do's	Don'ts
1. For gravity type masonry or concrete return / wing wall prepare the surface of foundation similar to that of abutments.	1. Do not allow any point of the bearing surface on which concrete footing is to be laid to be higher than the founding level.
2. In case of concrete piers, keep the number of horizontal construction joints minimum.	2. Do not provide any construction joint in the concrete footing.
3. Cast the top surface of pedestal for placing the bearings horizontal.	3. Do not resort to layered construction of thick RCC solid slabs, to avoid cold joints.
4. Cast the portions of deck slab (near expansion joints) along with reinforcements.	4. Do not provide any construction joint at the junction of web and fillet between web and deck slab for T-beam and slab bridges.
5 Rough finish the surface of deck slab before hardening, to ensure bonding of wearing coat later.	5. Do not allow any irregularity in the alignment of the deck for railings.
6. Protect structural steel components of the composite type superstructure against corrosion.	6. Do not provide expansion joints for multi-cell box culverts with earth cushion.
7. For box culverts, strictly follow the sequence of construction and location of construction joints.	7. Do not permit traffic on superstructure prior to 28 days of curing of the deck concrete.
8. Complete the protection works before the flood season to prevent damage of foundation by flooding..	8. Do not provide overlays on wearing coats (thereby increasing dead load on deck).

SECTION 1300

PROTECTION WORKS AND DRAINAGE

1300: PROTECTION WORKS AND DRAINAGE

A. Methodology

General

In this section, 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.

A-1 Apron

1. Keep the length of apron not less than twice the depth of curtain wall.
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. Provide flexible apron beyond curtain walls for a minimum distance of 3 m on upstream side and 6 m on downstream side unless specified otherwise.
4. 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 at 30 m intervals all along the length. Hand pack stone within these walls.
5. Use wire crates of galvanized steel wire of 4 mm dia with apertures not less than 150 mm.
6. Use insitu built wire-crates of size 2 m x 1 m x 0.3 m to 7.5 m x 3 m x 0.6 m and securely stay at 1.5 m intervals or less.
7. Place the crates in position before filling in boulders.

A-2 Pitching on Slopes

1. Use quarry stone of minimum 225 mm thickness or 30 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 and provide before laying the pitching. Fill the depressions and thoroughly compact before hand.
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 the adjacent layers by means of sufficient number of pin headers extending from one layer to the other.

A-3 Toe Protection

The toe wall shall be in dry RR matting conforming to the Clause 1302.5 of MORD Specifications for Rural Roads or as per 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.

1. Use dry rubble or brick masonry for toe walls.
2. While using bamboo walling, examine the ballies of 65mm to 75mm dia from a distance of 1.2m from wider end. Paint the entire length in coal tar.
3. Choose lengths between 1.2m and 3m and drive the ballies into the ground at close intervals of 150 mm c / c. Use atleast three half split runner / stays at equal spacing for horizontal stiffness and fix them with nails.
4. Line the exposed surface of bamboo walling with sheets made of cut drums and fix with nails.

A-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 M10 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 mortar.
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.
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 CD 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.

A-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 atleast 1.5 m on u / s side and 2 m on d / s side below the floor level.

A-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 nallah or CD work.

2. Locate the open drain at the toe of embankment far away from at imaginary slope of 4 (horizontal) : 1 (vertical).

3. Construct hill side drains as per clause 1606.1 of the MORD Specifications for Rural Roads.

4. 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.

5. Refer to IRC:SP:42 'Guidelines on Road Drainage' for more details and design of section.

A-7 Protection of Vented Causeways and Submersible Bridges

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.

1. 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.

2. 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.

3. Provide face walls to protect the edges of the structure and to prevent erosion of core material. 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.

4. 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.

5. In case of submersible bridges, provide bed protection for the whole bed-width of water course plus 3 m on both sides.

6. Provide a minimum foundation depth of 1.5 m on u/s side and 2.5 m on downstream side for cut off wall.

7. In the case of submersible bridge, anchor the deck slabs of span length (<15m) with piers, to counter the water current forces.

8. Provide RCC guard stones at 1.2 m c/c for both vented and non-vented causeways.

9. Provide debris arresters on upstream side to prevent damage to submersible bridges, due to floating trees and branches.

10. Provide aprons for submersible bridges on both u/s and d/s sides as per IRC:89.

B. Quality Control Requirements

1. Stones and Apron

The size and weight of stones for laying boulder apron shall conform to the requirement given in Table 1300.1

TABLE 1300.1: 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	184
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 1300.2

TABLE 1300.2: 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)
Upto 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, CC blocks in M15 grade weighing not less than 25 kg may be used.

3. Coatings on Wires

The galvanizing coating shall conform to IS: 4826 and that of annealed steel wire for wire crates shall conform to IS: 280

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 1300.3

TABLE 1300.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Test / Check	Frequency
1.	Size and weight of stones in apron / slope / flooring etc. (Table 1300.1 and 1300.2)	At quarry site before procurement
2.	Wire crates (Size and mesh size)	Before procurement
3.	Cement concrete blocks (Weight and Size)	Before procurement
4.	Gradation of Filter media	

4.2 Tests during construction

The quality control tests to be carried out during construction are indicated in Table 1300.4

TABLE 1300.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

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) Consistency and water retentivity (IS:2250) c) Compressive strength(IS:2250)	 Each batch As required 3 samples of cubes where specified
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

4.3 Quality Control Checks by AE / EE

The Quality control checks to be carried out by AE / EE are indicated in Table 1300.5.

TABLE 1300.5: QUALITY CONTROL CHECKS BY AE/EE

S. No.	Test / Check	Designation of Inspecting Officer
1.	Fastening of wire crates and size of boulders in apron and pitching	AE / EE
2.	Bonding of brick / stone masonry	AE / EE
3.	Cross section and gradients of all drains	AE / EE
4.	General workmanship of protection works	EE

C. Do's and Don'ts

Do's	Don'ts
1. Complete floor protection well before the onset of monsoon.	1. Do not use stone subject to marked deterioration by water or weather.
2. The minimum of weight of stone in apron shall be 25 kg.	2. Do not adopt length of apron which is less than two times the depth of curtain wall.
3. The stone shall be sound, hard and regular in shape.	3. Do not use round boulders in stone pitching.
4. When stones of required size are not available, use cement concrete block equivalent weight of M15 grade.	4. Do not excavate the completed road works for construction of road side drains.

SECTION 1400

CEMENT CONCRETE CAUSEWAYS

1400 : CEMENT CONCRETE CAUSEWAYS

Under this section quality aspects of different submersible structures viz., Irish / Flush Causeway, Vented Causeway and Submersible Bridges for rural roads are dealt with:

A. Methodology

A1 Flush Causeway

1. Choose flush causeway (Paved dip) to cross a shallow water course by adopting general guidelines given in clause 1401.0 of MORD Specifications for Rural Roads.

2. Keep top level of floor of causeway same as that of bed of water-course.

3. Build cut-off walls in brick masonry on stone masonry or plain cement concrete with suitable formwork as per provisions given in sections 600, 700, 800 and 900 respectively of this Manual.

4. Excavate for laying of foundation of u/s and d/s cut-off walls. Keep it sufficiently deep to avoid exposure due to scouring. Adopt a PCC footing of 150 mm thickness in M15 grade, laid on a layer of 100 mm thick lean concrete (M10)

5. Adopt a plain cement concrete slab of minimum thickness 200 mm in a minimum grade of M30 as paved dip. Provide construction joints 4-6m apart and seal them with polysulphide.

6. Provide u/s and d/s protection works, apron, pitching as per requirement.

7. Provide guide posts/stones at required spacing.

A2 Vented Pipe Causeways

1. Choose vented pipe causeway to cater to low flows through circular vents which overtop during monsoon. Usually RCC pipes (NP3 or NP4) are used for providing circular vents.

2. Follow the same methodology as detailed in section 1100 of this Manual for laying of RCC Pipes.

3. For headwalls or other ancillary works, adopt the requirements given in Section 1300.

4. Take foundation and head walls sufficiently deep to avoid exposure to scouring in erosive strata. Batter the d/s side headwall on the outside and round the corners.

5. Adopt rectangular or arch on type vents instead of circular pipe as per local practice.

6. Raise end portion of face walls and protect entire top of causeway by well desirable non-erodible wearing coat.

A3 Submersible Bridges

For design and construction of submersible bridges, adopt prevailing practice in the State or Guidelines given in IRC:SP:20.

1. Make the deck slabs heavy to withstand drag, uplift and lateral force due to overflow and upstream pressure.

2. Fix the location and levels of pier cap, abutment cap, pedestals and anchorage arrangements to ensure proper alignment.

3. Give streamline slope to pier cap, abutment cap and pedestals.

4. Carryout foundation works as per section 1200 .

5. The works in brick or stone masonry or in RCC are carried out as per the sections 600, 700 and 1200 respectively.

6. Provide chamfers of 40 mm x 40 mm for corners of all submerged elements if they are not streamlined.

7. Provide vent holes of 100 mm dia (with PVC pipes) to reduce the uplift pressure on superstructure during submergence, their minimum number being, three per span in both directions.

A4 Ancillary Items (Wearing coat, Railing, Kerbs, Warning signs, Flood gauges)

1. Provide 75 mm thick C.C. wearing coat in M30 grade with a cross slope of 2.5 per cent towards d/s side of deck slab in submergible bridge. For vented causeways adopt 200 mm thick RCC Slab.

2. Discontinue wearing coat at expansion joint locations. Extend joint fillers upto the top of wearing coat.

3. For CC wearing coat, provide 8 mm dia bars @ 200 mm c/c reducing to 100 mm c/c in both directions over a strip length of 300 mm near expansion joint.

4. Use open type or filler joint with appropriate nose protection.

5. Use metal railing of collapsible or removable or tubular type for submersible bridges.

6. 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.

7. Locate advance warning/cautionary signs at about 200 m from the beginning of submerged portion of causeways and submersible bridges, to indicate speed limit, depth of submergence etc.

8. Install flood gauges at 15 m intervals on submerged section of approaches and submersible bridges, regarding depth of flow above road level bridge deck.

B. Quality Control Requirements

Various components of flush and vented causeways besides submersible bridges shall conform to relevant provisions of the MORD Specifications and IS Codes listed below:

1. Material

(i)	Bricks	Section 600
(ii)	Stones	Section 700
(iii)	Cement	Section 800
(iv)	Sand	Section 800
(v)	Coarse Aggregates	Section 800

(vi)	Water for construction	Section 800
(vii)	Steel	Section 1000

2. Components/ Works

(i)	Earthwork	Section 300
(ii)	RCC Pipe	Section 1100, 1400
(iii)	Vented Box	Section 1200
(iv)	Drainage Spout	Section 1200
(v)	CC Pavement	Section 1500
(vi)	Flood gauges	IRC:67
(vii)	Stainless steel bars (rust, acid and heat resistant)	IS:6603
viii)	Painting of RCC posts / stones	IS:164

3 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.

3.1 Tests prior to construction

The quality control tests to be carried out prior to construction are indicated in Table 1400.1

TABLE 1400.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material	Test / Check	Frequency
1.	Bricks	As in Table 600.6	Table 600.6
2.	Stones	As in Table 700.6	Table 700.6
3.	Concrete Materials	As in Table 800.13	Table 800.13
4.	Stainless Steel bars (For submersible bridges)	Rust, acid and heat resistance (IS:6603)	Before procurement
5.	Steel reinforcement	As in Table 1000.4	Table 1000.4
6.	Cement pipes (If used)	As in Table 1100.1	Table 1100.1
7.	Plant equipment for production of concrete	As in Table 1200.1	Table 1200.1
8.	Pavement Materials	a) Sub-base (Table 401.2) b) WBM (Table 405.6) c) Cement concrete (Table 800.13)	Table 401.2 Table 405.6 Table 800.13

2. Tests during construction

The Quality Control Tests /checks to be carried out during construction are indicated in Table 1400.2

TABLE 1400.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

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 1200.3
2.	Concrete for foundation substructure, super-structure (For submersible bridges)	a) Dewatering b) Form panels, c) Jointing, d) Cover to reinforcements	As per Table 1200.3
3.	Formwork	Design, Erection, Camber, etc.	As per Table 900.3
4.	Reinforcement cage	Dia, spacing, cover as per drawings	- do -
5.	Kerbs, drain pipes railings / parapets	As indicated in drawings	- do -
6.	Bearings & Expansion Joints	Manufacturer's Specification	- do -
7.	Jointing of pipes & bedding	As per Table 1100.2	During construction
8.	Cement Concrete Pavement (Additional tests)	As per Table 1501.3 (Items 5,6,7 & 8)	Table 1501.3 (Items 5,6,7 & 8)
9.	Equipment for handling pipes (prior to lowering)	- Adequacy of chain pulley block - Stability of Tripod arrangement etc.	Check by AE

3. Quality Control checks by AE / EE

The quality control checks by AE / EE are indicated in Table 1400.3.

TABLE 1400.3: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material / Work	Test / Check	Frequency	Designation of Inspecting Officer
1.	All plain and RCC components	a) Compressive (cube) Strength (IS: 516) b) Honey combing and finishing c) Workmanship	At the end of work (Analysis of Test Results) Before acceptance of work As and when inspected	AE / EE AE / EE AE / EE AE / EE
2.	Wearing coat	Camber / tolerances / levels	At the end of work	AE
3.	Approaches	a) Gradient b) Pavement Surface	One check on each side of approach along centre line	AE / EE
4.	Protection works	a) Pitching of Slopes b) Thickness & Length of Apron c) Head, Face and Cut off walls	Before onset of monsoon	EE
5.	CC Pavement	Item 2 of Table 1501.4	Before acceptance of work	AE/EE

C. Do's and Don'ts

Do's	Don'ts
1. Locate Causeways and Submersible bridges far away from the confluence of streams.	1. Do not choose submersible bridge if the mean velocity of stream is high (exceeding 6m / sec).
2. Adapt submersible bridges which blend aesthetically in the environment.	2. Do not use composite type superstructure of steel girder with CC solid slab decking for submersible bridges.
3. Adopt guide post / stone of 250 mm dia of specified height embedded full depth in concrete pavement and in approach portion of causeway. Paint them with alternative black and white bands with ordinary paint.	3. Do not use fixed type railings for submersible bridges.
4. Permit traffic on causeways and submersible bridges after sealing of construction joints and 28 days curing period of concrete.	4. Do not adopt masonry substructure if the depth of foundation is more than 7 m.
5 Protect the stream bed on upstream and downstream of causeway by providing aprons and other protective works.	5. Do not use dry rubble masonry in retaining walls / breast walls and if necessary in approaches of submersible bridges.
6. Anchor the superstructure of submersible bridges with piers and abutments by using stainless steel anchor rods.	6. Do not use metallic bearings for submersible bridges.
7. At submersible bridges / causeways, follow the same profile as the flanking road section without any break in grade line. Provide properly designed vertical curves to avoid jerks.	7. Do not provide gradients steeper than 1 in 20 on both ends of causeways.

SECTION 1500

CEMENT CONCRETE PAVEMENT

1501 : PLAIN CEMENT CONCRETE PAVEMENT

A. Methodology

1. Approval of materials, plant, equipment and construction method.

(i) A trial length of at least 30 m will be constructed off road to demonstrate the proposed materials, plant, equipment and construction methodology before constructing the concrete pavement. 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 Contractor.

(ii) The trial length will be constructed in 2 days with a minimum 15 m length on each day.

(iii) Before taking up the trial length, 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), and 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 of trial length.

(iv) The mix design shall be based on the compressive strength of concrete as specified in the Contract.

The cement content should not be more than 425 kg nor less than 310 kg per cum of concrete unless specified otherwise. If flyash is used to replace a part of cement in the concrete mix, the cement content should not be less than 250 kg/cum.

All batching of materials shall be by weight. Volume batching may be allowed for small jobs with the approval of the Engineer.

Minimum M 30 grade concrete is recommended. Water cement ratio should not be more than 0.5.

Admixtures may be used to achieve the desired workability.

(v) Semi-mechanised and labour oriented construction techniques will be permitted. Plant, equipment and tools required for preparation and laying of concrete are listed in Clause 1501.11.2 of MoRD Specifications.

(vi) Approval of materials, plant, equipment and construction method will be given when the trial length complies with the specifications

2 Prepare the Sub-grade to the specified grades and cross-sections 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 stabilise any loose material.

3 Lay granular or WBM grading 3 or lime treated 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 (125 micron thick plastic sheet) between sub-base and concrete slab. It should be laid without creases.

5 Mark location and type of the joints on either side of the surface of the sub-base, with red paint.

(i) Contraction joints shall be mechanically sawn joints spaced 2.5 m to 3.75 m. Length of panel in the direction of traffic shall not be less than the width of the pavement. 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.

(ii) Construction joints shall be butt joints and placed after a day's work is over or when work is suspended for more than 30 minutes.

(iii) Expansion joints shall be provided near bridges and slab culverts and consist of a bitumen impregnated joint / premoulded synthetic joint filler board, about 20 mm thick, and dowel bars.

(iv) Longitudinal joints shall be provided for a two-lane road and shall be saw-cut.

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 in Clause 1501.11.2 of Specifications for Rural Roads.

7 Pavement concrete shall be produced near the site, using approved concrete mixers of at least 0.2 cum capacity. Readymade 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 mm

9 Concrete shall be placed between the side forms and shall be levelled with rakes and shovels. In concrete panels having acute angles, a bar mat of 10 mm dia ribbed steel bars at 150 mm center to center in both directions shall be provided at 50 mm below the top of slab, in the entire panel.

10 Around man-holes or other openings in pavement, place 12 mm thick pre-moulded board as per IS:1838 and bar mats before concreting.

11 Compact concrete by a vibrating screed supplemented by two internal vibrators.

12 As soon as practicable after compaction of concrete, smoothen the surface with a longitudinal float operated from the work bridge. Just before the concrete becomes non-plastic, it shall be textured with a long handled steel or fibre brush.

13 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.

14 After completion of the finalizing operations, the surface of the pavement shall be covered with wet Hessian cloth, burlap or jute mats. They shall be maintained fully wetted and in position for 24 hours.

Upon the removal of the wet covering out the end of 24 hours, the slab shall be thoroughly wetted and then cured by ponding or sprinklers.

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.

15 After minimum of 28 days after casting the concrete pavement, joint groove at contraction joint shall be widened to 10 mm width and to a depth 18 to 20 mm and shall be sealed.

B. Quality Control Requirements

1. Material

(i) Cement

Cement shall be capable of achieving the design strength and may be

(a) Ordinary Portland Cement, 33 Grade IS:269

(b) Ordinary Portland Cement, 43 Grade IS:8112

(c) Ordinary Portland Pozzalana cement, IS:1489

(d) Portland Blast Furnace Slag cement, IS:455

(e) Ordinary Portland Cement (OPC), 53 Grade IS:12269, (to be used only when a part of cement is replaced by fly-ash.)

(f) If the soil around has soluble salts like sulphates in excess of 0.5%, by weight of soil, cement used shall be sulphate resistant and shall conform to IS:12330.

(ii) Admixture

Chemical admixture conforming to IS:6925 and IS:9103 may be used to improve workability of concrete. Mineral admixture like fly-ash shall conform to IS: 3812.

(iii) Aggregate

(a) Aggregate for pavement concrete shall conform to IS:383 but with a Los Angeles Abrasion test value not more than 35% or Wet Aggregate Impact Value not exceeding 30%. The limits and deleterious material shall not exceed the requirements set out in IS 383.

(b) The total chloride content expressed as chloride ion content shall not exceed 0.06% by weight.

(c) Total sulphate content expressed as sulphuric anhydride (SO_3) shall not exceed 0.25% by weight.

(d) 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 25 mm. It shall not have a flakiness index more than 35% and water absorption exceeding 5%.

(e) Fine aggregate shall be clean natural sand or crushed stone sand or a mixture of both. It shall not contain deleterious material beyond the following limits:

- Clay : 4%
- Coal and lignite : 1%
- Material passing Sieve No. 75 micron: 4% in natural sand and 15% in crushed sand.

(f) Coarse and fine aggregates, after blending shall conform to the gradation requirements mentioned in Table 1501.1

TABLE 1501.1: AGGREGATE GRADATION FOR CONCRETE PAVEMENTS

IS Sieve designation	Percentage passing by weight
26.5 mm	100
19.0 mm	80-100
9.5 mm	55-80
4.75 mm	35-60
600 micron	10-35
75 micron	0-8

(iv) Water

Water used for mixing and curing concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter and shall meet the requirements set out in Section 800 B (IV).

(v) Dowel Bars

Plain mild steel bars 25 mm dia conforming to IS:432 (Part 1) having minimum yield strength 240 N/mm^2 shall be used as dowel bars. These shall be free from oil, dirt, loose rust, scale, irregularities and burring. Dowel bars shall be positioned at mid depth of the slab within a tolerance of (±) 20 mm.

All bars in a joint shall be within (±) 5 mm in length of bar. Normally 500 mm long and spaced 250 mm c/c or as specified. They shall be parallel to the longitudinal axis of the pavement.

(vi) Premoulded Joint Filler

Bitumen impregnated filler board / premoulded 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.

2. Horizontal Alignment

± 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 upto (–) 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

1501: Plain concrete pavement

6.1 Tests prior to construction

The Quality Control Tests to be carried out prior to construction are indicated in Table 1501.2

TABLE 1501.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Type of Test	Frequency
1.	Cement	As in Table 800.13
2.	Fine Aggregates	As in Table 800.13
3.	Coarse Aggregates	As in Table 800.13
4.	Water	Once for each source, subsequently in case of doubt.
5.	Admixture - Chemical (For workability) (IS:6925 & IS:9103) - Mineral (Flyash) (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.	- Premoulded 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 for cement content, w / c ratio and dosage of plasticizers for the specified design strength.	To be approved by EE
10.	Granular Sub base	Table 401.2
11.	Trial length	To be approved by EE before regular work.

6.2 Tests during construction.

The tests required to be carried out during construction are indicated in Table 1501.3

TABLE 1501.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Tests / Check	Frequency
1.	Subgrade & Subbase	As in Tables 301.5 & 401.3
2.	Gradation and moisture content of aggregate for CC pavement	Minimum once per day.
3.	Concrete workability (Slump cone tests IS:1199)	One test per 3 cum of concrete at paving site.
4.	Strength of Concrete (IS:516)	Minimum 6 cubes and 6 beams (3 each for 7 day & 28 day strength) per day.
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
8.	Hot / Cold weather concreting including compaction	Checks Regularly
9.	Compaction equipment (Needle, Screed and Plate vibrators)	For continuous working and stand by arrangement
10.	Separation membrane (thickness and laying)	Prior to laying of pavement concrete
11.	Levels and Alignment	
	(i) Level tolerance	Clause 1802.3; to be checked for each day's work
	(ii) Surface Regularity (Transverse and Longitudinal including camber / cross slope)	Regularly
	(iii) Width of pavement and position of paving edges work Regularly at grid points	Clause 1802.2; to be checked for each day's
	(iv) Pavement thickness	To be checked for each day's work
	(v) Alignment of joints	-do-
	(vi) Depth of Dowel Bars	-do-
	(vii) Texturing and Edging	-do

6.3 Quality Control Checks By AE / EE

The quality control checks to be carried out be AE / EE are indicated in Table 1501.4

TABLE 1501.4: QUALITY CONTROL CHECKS BY AE/EE

S. No.	Tests	Frequency	Designation of Inspecting Officer
1.	Review of cube and beam test data	Regularly	AE
2.	Quality Checks by AE / EE		
	- Width thickness of pavement	At random	AE
	- Surface levels	-do-	AE
	- Surface regularity	-do-	AE
	- Surface texture	-do-	AE
	- Transverse joints	Every Joint	AE
3.	Joints (Expansion / Contraction)		
	- Joint alignment, dimensions & filling of joints	Every joint	AE / EE
	- Cracking of slabs	Cracked slabs	AE / EE
4.	Paving near culverts and bridges	At each site	AE / EE
5.	Performance of 30 m Trial length	For each work	EE

C. Do's and Don'ts

Do's	Don'ts
1. Back fill properly, surface trenches and soft spots in the sub-grade and compact the same. Remove all organic and extraneous material from sub grade. 2. Saw cutting of joints should be done when concrete is neither too soft nor too hard. 3. Ensure that side forms are sufficiently robust and rigid to support the weight and pressure caused by paving equipment. 4. Do make provisions to maintain sufficient supply of tarpaulin or other water proof cloth during placement of concrete when rain is expected. 5 The Coarse aggregate shall be free from dirt, flint, chalecedony or other silica. 6. Use fine aggregate free from soft particles of clay, shale, loam cemented particles, mica and other foreign matter. 7. Ensure sufficiency and accuracy of material, plant and equipment and methods of construction by laying a trial length of at least 30 m. 8. Measure workability of the concrete at the time of placing with slump cone Test. 9. Provide proper construction joint if concreting is suspended for more than 30 minutes. Use bulk head to retain the concrete.	1. Do not lay sub-base on a sub grade softened by rain 2. Do not expose concrete slab for a period of more than half an hour for saw cutting of joints. 3. Do not provide any vertical step between the adjacent side forms greater than 3 mm 4. Do not carry out concreting work when concrete emperature is more than 30^0C or less than 5^0C at the point of placing and ambient temperature is greater than 35^0C 5. Do not use disintegrated, soft, flaky, elongated, highly angular or splintery coarse aggregate. 6. Do not vibrate concrete excessively to prevent flow of mortar to the top. 7. Do not allow normal working until the trial length has been approved. 8. Do not walk on freshly laid concrete to place covering for curing. 9. Do not allow any traffic, including construction vehicles on the finished surface of concrete pavement till the joints are permanently sealed.

1502: ROLLER COMPACTED CONCRETE PAVEMENT

A. Methodology

1. Lay a trial length of minimum 30 m length as detailed in sub-section 1501 A (i) To (iii). Roll the trial length as per rolling sequence in Table No. 1502.1. If waves appear on top of the rolled surface in front of roller during construction of trial length, the moisture content shall be varied and strength redetermined. Determine natural moisture content on day to day basis, before production of the mix.

TABLE 1502.1: ROLLING SEQUENCE FOR ROLLER COMPACTED CONCRETE PAVEMENT

Sl. No.	Type of Roller	No. of Static passes	No. of vibrating passes	Remarks
1	Double drum tandem roller	2 Nil 1-2	Nil 4-6 Nil	Breakdown rolling Vibratory rolling with amplitude 0.8-0.4 mm Smoothening
		or		
2	Single front drum steel roller with rear tyres of rubber	1 Nil 1-2	Nil 4-5 Nil	Breakdown rolling Vibratory rolling with amplitude descending from 0.8 to 0.4mm Smoothening

2. Check the in-situ density of freshly laid Roller Compacted Concrete Pavement (RCCP), after rolling, with sand replacement method with 200 mm dia density hole. Three density holes shall be made along a diagonal which bisects the trial length with no holes within 0.5 m of edge from either side. Average density of these three holes shall be taken as 100%. Later on the field density of regular work shall not be less than 97% of this density.

3. The trial length shall be cut over one metre length and reversed to inspect the bottom surface to check any segregation of the mix. Relay the trial length if the same does not comply with specifications.

4. Take core density of RCCP after 28 days. A minimum of three cores shall be taken for each day's work and average of these shall be the core density for the day's work. Strength of cores shall be determined as per sub-section 1501.23.5 of MoRD Specifications. Check the homogeneity of RCCP from these cores.

5. Mix design for RCCP, based on weighed proportion of all ingredients, shall be prepared and got approved from Engineer 30 days prior to laying of trial length. Mix design shall be based on the flexural strength of concrete as per IRC:44.

6. Use flyash in RCCP as 15-35 percent replacement of cement and shall have a zero slump.

7. The water content may be kept within 5 to 7 % of the weight of cement, aggregates and other dry material. Determine the optimum moisture content by making mixes at 0.5% increments. If concrete is transported by tippers, water content may be kept 2% higher than the optimum moisture content.

8. The cement content of concrete shall be within 310 kg and 425 kg per cum of concrete unless specified otherwise in the contract. If fly-ash is used to replace a part of cement, cement in concrete shall not be less than 250 kg per cum. Flexural strength of concrete shall not be less than 3.5 MPa. The design mix shall be minimum M30 grade also.

9. Produce concrete near the site, using approved concrete mixers of at least 0.2 cum capacity.

10. Fix the side forms as detailed in sub-section 1501 A6 these shall conform to IRC:43.

11. Place the concrete between the side forms separated by a distance equal to the width of carriageway in a continuous manner without any breakage/stoppage. Carry the concrete to the placement location in wheel barrows.

12. For placing of concrete by semi-mechanised tools, ascertain actual prodding during field trials. Place the mix with wheel barrow / steel pans with rotary motion and spread uniformly with shovels and rakes. Use a wooden screed 3 m by 125 mm by 50 mm in a sawing motion to level the mix before rolling.

13. For placing concrete with a paver, the equipment shall be capable of laying material in one layer in full width without segregation to the specified thickness. The paver shall have high amplitude temping bars to give good initial compaction. When paving is done by a paver, pavement width shall be 300 mm extra on both sides

14. The rolling shall be carried out in sequence indicated in Table No. 1502.1. At the end of rolling, no roller marks shall be visible. If thickness of concrete is less or there are high spots as checked with

a 3 m straight edge, rake open the area and add extra material or remove extra material. Check the in-situ density by sand replacement method and if field density is less than 97% of the trial length, use additional passes of roller to achieve at least 97% of density of trial length.

15. The final time of rolling shall not exceed 100 minutes from the time of mixing water when the temperature is between 25^{0}C and 30^{0}C, and 120 minutes when the same is less than or equal to 25^{0}C. No concreting is to be done when the temperature is less than 4^{0}C or more than 40^{0}C. Chilled water should be used to bring the temperature of concrete to 30^{0}C. Take precautions indicated in IRC:15 when ambient temperature is below 5^{0}C or more than 40^{0}C.

16. Carry RCCP over hume pipe culverts. In case of existing or new bridges/ culverts, RCCP shall abut the deck/ approach slab and a construction joint should be provided.

17. No longitudinal joint shall be provided if the width of carriageway is less than 4 m. RCCP shall have only transverse contraction joints at 5 m center. These shall be saw-cut after 6-12 hours of laying or initial hardening. The width of joints shall be 6-8 mm and depth one-fourth of RCCP slab. These shall be filled with hot pouring sealing compound in accordance with sub-section 1501.22.4 of MORD Specifications and in accordance with IS:1834.

18. Cover RCCP, within one to two hours after compaction, by laying wet hessian in two-three layers for first 24 hours. After the first day's curing, small earthen rectangles/ dykes about 50 mm high transversely and longitudinally shall be made and filled with water for at least 14 days. In case of flyash concrete, the period shall be 16 days.

19. Freshly laid RCCP shall be protected by not allowing traffic for a minimum period of 28 days.

B. Quality Control Requirements

1. Material

Cement, Water, Coarse and Fine aggregates for roller compacted concrete shall meet the requirement of material indicated in Section 1501 B, except that the grading of blended coarse and fine aggregates shall be in conformity with the requirements indicated in Table No. 1502.2.

TABLE 1502.2: AGGREGATE GRADATION FOR RCCP

IS Sieve designation	Percentage passing by weight
26.5 mm	100
19.0 mm	80-100
9.5 mm	55-75
4.75 mm	35-60
600 micron	10-35
75 micron	0-8

Fly-ash may be from anthracitic coal or lignite collected by electro-static precipitator. Bottom ash or pool ash shall not be used as a replacement of cement. Flyash shall conform to the physical requirements indicated in Table No. 1502.3.

TABLE NO. 1502.3: PHYSICAL REQUIREMENT OF FLY-ASH AS CONCRETE ADMIXTURE (IS: 3812)

Sl. No.	Characteristics	Requirement of grade 1 fly-ash
1	Fineness, specific surface area in m^2/kg by Blaine's permeability test,	320 m^2/kg minimum
2	Particles retained on 45 micron IS sieve	34% maximum
3	Lime reactivity average compressive strength	4.5 N/mm^2
4	Soundness by autoclave test expansion of specimen	0.8% maximum
5	Drying shrinkage	0.15% maximum

Quality Control requirements for Horizontal Alignment, Surface Level, Surface Regularity, and Acceptance Criteria for cracked concrete slabs and strength of concrete as described in subsection 1501 C shall apply.

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 1502.4

TABLE 1502.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Tests	Frequency
1.	Materials for concrete	As in Table 1501.2
2.	Concrete Mix design (With and without flyash)	Approval by EE for cement content w/c ratio and use of plasticizers
3.	Plants, Equipment and tools	As per contract
4.	Trial length before commencement of regular work	Approval by EE
5.	Granular Sub base	As in Table 401.3
6.	Design Parameters (Grade of concrete, width, thickness and details of joints)	As per construction drawings.

2.2 Tests during construction

The quality control tests to be carried out during construction are indicated in Table 1502.5

TABLE 1502.5: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Tests/ Check	Frequency
1.	Gradation and moisture content of aggregates	As in Table 1501.3
2.	Batching and mixing of materials	Check for measurements and proper mixing
3.	Workability, zero slump and insitu density of RCCP	One test for 3 cum of concrete
4.	Insitu density of trial length by sand replacement method IS:2720)	Three tests for each 2000 sq m or part thereof.
5.	Subgrade and Subbase	As in Table 301.5 and 401.3
6.	Strength of Concrete (IS:516)	As in Table 1501.3
7.	Side forms	As in Table 1501.3
8.	Transverse Contraction Joints (width and depth)	18-24 hours after laying

2.3 Quality Control Checks by AE / EE

The Quality Control checks to be carried out by AE / EE are indicted in Table 1502.6

TABLE 1502.6: QUALITY CONTROL CHECKS BY AE/EE

S. No.	Tests/ Check	Frequency	Designation of Inspecting Officer
1.	Thickness, levels and strength	Three sections at the end of work At random	AE / EE
2.	Cumulative length of cracks	One check for every 100 m length.	AE / EE
3.	Core density of RCCP and homogeneity (Average of three cores)	At the end of 28 days	AE/EE
4.	Performance of 30 m Trial length	For each work	AE/EE

C. Do's and Don'ts

Do's	Don'ts
1. Determine optimum moisture content requirement after making field trial construction.	1. Do not lay sub-base on a sub-grade softened by rain.
2. Do ensure uniform spreading of concrete to ensure uniform density, proper compaction and achievement of designed thickness.	2. Do not allow normal working till the trial length has been approved.
3. Do taper concrete in half a metre length at the end of day's work. Before commencement of work on the next day, this half metre width should be cut straight and fresh concrete abutting the old concrete is laid.	3. Do not provide any vertical step between the adjacent side forms greater than 3 mm.
4. Commence rolling from lower edges to center / super-elevated edges.	4. Do not make up depressions, while placing RCCP, by depositing fine material.
5 Ensure sufficiency and accuracy of material, plant and equipment and methods of construction by laying a trial length.	5. Do not use flyash as replacement of cement if Portland Pozzolana flyash based or any other blended cement is used.
6. Use flexible synthetic or jute rope to avoid infiltration of foreign particles / dust in empty joints.	6. Do not allow any traffic, including construction vehicles on the finished surface of concrete pavement till the joints are permanently sealed.

1503: RECTANGULAR CONCRETE BLOCK PAVEMENT

A. Methodology

1. The rectangular concrete blocks should preferably be cast using block manufacturing machine or semi mechanized means as per clause 1503.6 of MoRD specifications.

2. Ensure a trial length of 30 m is laid for demonstrating the procedure and equipment for laying the main pavement.

3. Prepare the subgrade to the specified grades, lines and cross-sections and uniformly compact to the design strength. Subgrade shall have a camber of 3 percent and the soaked CBR not less than 4 percent.

4. Lay cement concrete pavement over a 75 mm thick WBM (Gr.2 or 3) base layer, extended by at least 150 mm beyond the edge blocks. The subbase layer below the WBM base shall be a GSB layer or WBM Gr.1 100 mm compacted thickness.

5. Lay 25 mm thick (compacted) bedding sand conforming to grading requirements indicated in Table No. 1503.1 uniformly over the base course. The bedding sand shall have about 6 percent moisture content to facilitate its spreading and compaction and shall be compacted with a hand rammer, preferably plate compactor and the surface levelled using a screed.

6. The pattern for paving blocks shall be herringbone or stretcher. The joints between stretcher bond shall be staggered by about half the length of stretcher.

7. The concrete blocks for pavement shall be 450 mm x 300 mm x 150 mm size and Restraint blocks shall be of 300 mm x 300 mm x 200 mm size. The cement content shall be between 310 and 425 kg / cum unless specified otherwise in the contract. Extra blocks to the extent of 5 percent should be manufactured and properly stored for subsequent use for maintenance purposes.

8. The width of joint shall be between 2 mm and 4 mm. On curves non-uniform joint width may have to be resorted to. When space does not permit the use of cut piece of blocks, the use of premixed or dry packed concrete is recommended.

9. After a section has been paved, start compaction with a suitable vibratory plate compactor in the following sequence of operations.

   (i) Apply three passes of a standard vibrating plate compactor of weight 0.9 kN, with plate area not less than 0.3 m^2

   (ii) Spread a thin layer of joint filling sand on the top of paved blocks and sweep into joints using suitable brooms. The sand shall be vibrated into the joints by moving the vibrating plate compactor and more sand shall be applied till the joints are well packed.

   (iii) Clean excess sand from the top of block pavement.

B. Quality Control Requirements

1. Material

(i) Cement Concrete paving Blocks

Cement, coarse and fine aggregates and their grading, for cement concrete, Gradation of aggregates, Admixture and Water for cement concrete shall meet the requirements indicated in sub-section 1501.

(ii) Bedding and joint filling sand

Grading for bedding and joint filling sand shall conform to the requirements indicated in Table no.1503.1

TABLE 1503.1: RECOMMENDED GRADING FOR BEDDING AND JOINT FILLING SAND

IS Sieve Size (mm)	Per cent passing	
	Bedding Sand	Joint Filling Sand
10.00	100	100
4.75	90-100	95-100
2.36	75-100	95-100
1.18	55-90	90-100
0.60	35-59	80-100
0.30	8-30	15-50
0.15	0-10	0-15
0.075	0-3	0-5

(iii) Sub-base and base course

Granular sub-base shall conform to sub-section 401.

Coarse aggregate, screenings, binding material for WBM shall conform to sub-section 405.

2. Cube Strength and Tolerances

i) A minimum of six cubes (3 each for 7-day and 28-day strength) shall be cast, cured and tested as per IS: 516. the compressive strength shall not be less than the design characteristic compressive strength.

(ii) The tolerance in surface levels shall be not more than $\pm$ 15 mm.

(iii) The maximum allowable difference between the road surface and underside of a 3 m straight edge when placed parallel or at right angles to the centre-line the road shall be not more than 12 mm for longitudinal profile and 10 mm for cross profile

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 1503.2

TABLE 1503.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Tests/ Check	Frequency
1.	Materials for concrete	As in Table 1501.2
2.	Concrete Mix Design	For approval by EE
3.	Grading for bedding and Joint filling sand	As in Table 1503.1
4.	Size and Compressive Strength of Paving blocks	As per drawings
5.	Subgrade and Subbase	As in Table 301.5 & 401.3
6.	Trial length before commencement of regular work	Approval by EE
7.	Design parameters(Joints Details, Pattern of laying and End restraints)	As per drawing
8.	Manufacturing machine or Semi mechanized method for blocks and Vibrating plate compactor	As per contract

3.2 Tests during construction

The Quality Control Tests to be carried out during construction are indicated in Table 1503.3

Table 1503.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Tests/ Check	Frequency
1.	Subgrade and Subbase	As in Table 301.5 and 401.3
2.	Compressive Strength of concrete (IS:516)	As in Table 1501.3
3.	Pattern of laying of blocks and End restraints (As per drawings)	At random
4.	Earthen shoulders(Width and camber)	At random
5.	Width of Joints between blocks	At random
6.	Tolerances (Level tolerance & Surface Regularity)	At random

3.3 Quality Control Checks by AE/EE

The Quality Control Checks to be carried out by AE / EE are indicated in Table 1503.4

TABLE 1503.4: QUALITY CONTROL CHECKS BY AE / EE

S. No.	Tests/ Check	Frequency	Designation of Inspecting Officer
1.	Level and surface regularity	Once for every work	AE / EE
2.	Dimensions of blocks (Size and thickness)	- do -	-do-
3.	Performance of 30 m Trial length	For Each Work	AE/EE
4.	General Workmanship	-do-	-do-

C. Do 's and Don'ts

Do's	Don'ts
1. Use only mechanised or semi-mechanised methods for manufacturing blocks and ensure that blocks are properly cured. 2. Ensure proper bedding and filling of joints using vibratory compactor.	1. Do not use cement concrete with a characteristic compressive strength less than 30 MPa.

1504: INTERLOCKING CONCRETE BLOCK PAVEMENT

A. Methodology

1. Concrete Paving Blocks shall conform to the relevant IS Standard.

2. Ensure a trial length of 30 m is laid for demonstrating the procedure and equipment for laying the main pavement.

3. Prepare the sub-grade to the specified grades and cross-sections and uniformly compact to the design strength. Sub-grade shall have a camber of 3% and of soaked CBR not less than 4 %.

4. Lay a minimum 100 mm thick granular / stabilized base course conforming to sub-section 402. The base course shall be extended at least 300 mm beyond the edge restraints.

5. Lay interlocking concrete block pavement over a 100 mm thick granular sub-base layer conforming to sub-section 401 or over a 100 mm thick WBM Gr. 1 conforming to sub-section 405.

6. Lay 25 mm thick (compacted) bedding sand conforming to grading requirements indicated in Table No. 1503.1 uniformly over the base course. The bedding sand shall have about 6% moisture content to facilitate its spreading and compaction. Compact with a hand rammer; preferably plate compactor and readjust the level using a screed.

7. The pattern for paving blocks shall be herringbone or stretcher. The joints between stretcher bond shall be staggered by about half the length of stretcher.

8. The minimum thickness of paving blocks shall be 80 mm for projected traffic upto 100 vehicles per day and 100 mm for projected traffic from 100 to 250 vehicles per day. The dimensions and tolerances for paving blocks shall meet the requirements of Table 1504.1.

9. The average 28 days compressive strength of 8 blocks shall not be less than 30 MPa and strength of individual block shall not be less than 26 MPa. The edge blocks shall have equivalent cube compressive strength not less than 30 MPa.

1. Compression testing machine of adequate capacity shall be used for testing the blocks. The blocks shall be stored for 24 $\pm$ 4 hours in water maintained at a temperature of 20 $\pm$ 5^{O}C before testing. The load shall be applied without shock and increased continuously @ 15 + 3N / mm^2 / minute and the maximum load that can be applied to a specimen shall be noted. Apparent compressive strength shall be calculated by dividing the maximum load by the plan area. This shall then be multiplied with a correction factor, as indicated in Table 1504.2 to obtain the corrective compressive strength.

2. The width of joint shall be between 2 mm and 4 mm. On curves non-uniform joint width may have to be resorted to. When space does not permit the use of cut piece of blocks, the use of premixed or dry packed concrete is recommended. After a section has been paved, compaction with a vibratory plate compactor shall be done in the following sequence of operations.

   (i) The blocks shall be vibrated with three passes of a standard vibrating plate compactor of adequate capacity.

   (ii) A thin layer of joint filling sand as per clause 1503.2.6 shall be spread on the top of paved blocks and swept into joints using suitable brooms.

(iii) The sand shall be vibrated into the joints by making three passes of the compactor.

(iv) Excess sand from the top of block pavement shall be swept clean.

B. Quality Control Requirements

1. Material

(i) Concrete paving blocks shall conform to the relevant IS Standard.

(ii) Grading for bedding and joint filling sand for interlocking concrete block pavement shall meet the requirements indicated in Table 1503.1

2. The tolerance in surface levels in transverse profile shall not be more than ± 10 mm.

3. The maximum allowable difference between the road surface and underside of a 3 m straight edge when measured in the longitudinal profile shall not be more than 12 mm.

4. The dimensions and tolerances of paving blocks shall conform to the requirements indicated in Table 1504.1. Aspect ratio is the ratio of length to thickness of blocks. Chamfer is the beveled edge, provided on the top surface of a block. Plan area is the horizontal area bounded by the vertical faces. Wearing surface area is the horizontal area bounded by the vertical faces, minus the area reduced due to the presence of chamfer.

TABLE 1504.1: DIMENSIONS AND TOLERANCES FOR PAVING BLOCKS

S. No.	Dimension	Recommended Values	Tolerance Limit
1	Width W	To be specified by Manufacturer	± 2 mm
2	Length L	To be specified by Manufacturer	± 2 mm
3	Thickness T	60 to 80 mm	± 3 mm
4	Aspect Ratio L / T	Maximum: 4.0	+ 0.2
5	Chamfer (Arris)	Minimum: 5 mmMaximum: 7 mm	± 1 mm
6	Plan Area	Maximum 0.03 sqm	+ 0.001 sqm
7	Wearing Face Area	Minimum 75% of plan area	- 1 %
8	Squareness	NIL	± 2 mm

TABLE 1504.2: CORRECTION FACTORS FOR THICKNESS AND CHAMFER OF PAVING BLOCK FOR CALCULATION OF COMPRESSIVE STRENGTH.

Paving Block Thickness (mm)	Correction Factor for	
	Plain Block	Chamfered Block
60	1.00	1.06
80	1.12	1.18

2. Quality Control Tests

2.1 Test Prior to Construction

The Quality Control Tests to be carried out prior to construction are indicated in Table 1504.3.

TABLE 1504.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Tests/ Check	Frequency
1.	Concrete materials	As in Table 1501.2
2.	Grading for bedding and Joint filling sand	As in Table 1503.1
3.	Mix Design for concrete	For approval by EE
4.	Base Course	As in Table 301.5 and 401.3
5.	Trial length of 30 m before commencement of work	For Approval by EE
6.	Block size and thickness	5 samples selected at random for every 1000 specimens. For approval by AE.
7.	Water absorption and compressive strength of blocks	5 blocks selected at random for every 500 blocks. For approval by AE.

2.2 Tests during Construction

Quality Control Tests to be carried out during construction indicated in Table 1504.4.

TABLE 1504.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Tests/ Check	Frequency
1.	Subgrade and subbase	As in Table 301.5 and 401.3
2.	Dimensions and Tolerances of paving blocks	As specified. At random
3.	Paving pattern	Approval by EE before commencement of work
4.	Paving and compaction of blocks	Regularly
5.	Surface Regularity a) Tolerances for lines, levels and grades b) Longitudinal and Transverse profile	Random check
6.	Compressive Strength of concrete of blocks	As specified

2.3 Quality Control Checks by AE / EE

The Quality Control Checks to be carried out by AE / EE are indicated in Table 1504.5

TABLE 1504.5: QUALITY CONTROL CHECKS BY AE / EE

S. No.	Tests/ Check	Frequency	Designation of Inspecting Officer
1.	Tolerance for lines, levels and grades	Random check	AE / EE
2.	Performance of 30 m trial length	For each work	AE/EE
3.	Water absorption and Compressive Strength (5 out of 500 blocks selected at random)	-do-	-do-
4.	General workmanship	-do-	-do-

C. Do 's and Don'ts

Do's	Don'ts
1. Lay a trial length of 30 m and get the same approved from Engineer. 2. Maintain a buffer of specified quantity of paving blocks required for maintenance.	1. Do not use blocks with water absorption (for an average of 5 blocks) greater than 6% by mass.

SECTION 1600

HILL ROAD CONSTRUCTION

1600 : HILL ROAD CONSTRUCTION

Most of the quality aspects related to site clearance, setting out of the works, earthworks, including rock cutting and blasting operations; construction of subgrade, subbase, base, bituminous surfacing; construction of drainage and cross-drainage works; protection measures and retaining structures; stone masonry, brick masonry and cement concrete are already covered under the respective sections of this Book. The methodology and quality requirements and quality tests specified therein are relevant to hill road construction as well and may be followed. The Specifications already covered under various sections are not repeated in this Section. This Section therefore, brings out only those of the construction aspects and related quality requirements for hill roads which have not been covered in previous sections.

Hill Road Construction should be taken up after carrying out necessary Geo-technical investigations.

A. Methodology

1. Site Clearances

Carry out the site clearance to the requirements of Section 200.

2. Setting Out

Set out the work carefully with reference to the Reference pillars fixed at the Project preparation stage. For details refer to Sub-section 108.

(i) Mark the hill side edge of roadway (back-cutting line) on the hill face accounting for the specified slope of hill cutting. Ensure its accuracy by measuring distance from each reference peg so as to match with the drawing.

(ii) Where the road is in filling, ensure that the outside edge of the retaining wall is accurately fixed as measured from the Reference Pillar.

(iii) Ensure that the roadway demarcation lines between consecutive reference pillars follow the curvature shown on the drawings.

(iv) In case any discrepancy in length (measured parallel to road grade), direction and grade is found between two reference pillars beyond the specified tolerances, review and take corrective measures.

(v) Ensure that the level pillars are fixed as per the final longitudinal gradient.

3. Rock Cutting

(i) Carry out rock cutting to the specified lines, grades, side slopes, width and cross-slope conforming to the drawings.

(ii) Ensure that hill cutting is carried out in a manner to minimize the deforestation to the extent possible, following the Environmental Management Plan (EMP). Necessary mitigation measures shall be ensured before start of hill cutting work.

(iii) Take care to restrict the rock cutting to the required width. For steep slopes (say more than 30 degrees depending upon the type of rock) initial 3 m bends may be cut manually for movement of machinery.

The prescribed roadway width for hilly terrain is inclusive of parapet and hillside drains. Extra widening on curves and in snow bound areas should be done as per Drawings.

(iv) Resort to slope benching to improve sight distance.

(v) Make provision for 2 to 3 passing places per kilometre length.

(vi) Where hairpin bends are to be provided, ensure that the hill slopes are stable and gentle. The hairpin bend will be provided as a circular curve with transitions at either end.

(vii) Follow procedure and safety precautions for rock cutting as per Sub-section 304.

(viii) Ensure that excavation work starts along back cutting line. Also ensure that completion plan and verification of curve radii and longitudinal gradients is carried out at site. Defects if any shall be corrected immediately.

4. Preparation of cut formation for Subgrade

Prepare as per the requirements of Sub-section 302.

5. Retaining Walls, Breast Walls and Gabion structures

(i) Construct retaining / breast walls, and Gabion structures, conforming to the Drawings.

(ii) The foundation bed should be sloped towards the hillside.

(iii) Resort to stepping up of the foundation bed of retaining walls in stable rocks.

(iv) The masonry for retaining / breast walls should conform to Sub-section 700.

(v) Ensure that the top level of the retaining wall matches the adjoining shoulder edge.

(vi) Ensure that full section is constructed as per the drawings.

(vii) Ensure that approved filter material is provided behind the wall before back filling. Also ensure that back filling is done only after the masonry work is approved by the Engineer.

6. Pavement Construction

Prepare subgrade to the requirements of Subsection 303 and construct subbase, base and bituminous surfacing in accordance with the requirements of the respective subsections.

7. Drainage

Carry out excavation for drains alongwith hillside cutting conforming to the shape, size and grades as shown on the drawings.

(i) Provide lining as specified.

(ii) Locate catchwater drains over stable slopes outside the periphery of the slide area.

8. Cross Drainage Works

(i) Use locally available stone for construction of Scuppers with dry stone masonry. Ensure a minimum cushion of 600 mm over corbelling, conforming to Clause 1606.5 of MORD Specification.

(ii) Cement Concrete Causeways: Construct causeways as per drawings and conforming to the requirements of Section 1400

(iii) Pipe Culverts: Construct pipe culverts conforming to requirement of Section 1100.

9. Protection Works

Ensure that protection works are constructed conforming to the Drawings and Section 1300.

10. Safety Measures

(i) Provide traffic signs, guide posts, railings / parapets in accordance with the requirements of Section 1700.

(ii) Security manpower should be deployed for ensuring that any person including labourers are removed from the flagged area at least 10 minutes before the firing.

B. Quality Control Requirements

1. **Materials**

(i)	Masonry Work	:	Conforming to Section 700
(ii)	Sub-Base, Base, Bituminous Works	:	Conforming to Sections 400 & 500
(iii)	Cement Concrete	:	Conforming to Section 800
(iv)	Pitching / Apron	:	Conforming to Section 1300
(v)	Steel	:	Conforming to Section 1000

2. **The tolerances for width of formation, longitudinal grade, grade compensation and super-elevation shall be as follows:**

a)	Width of formation	(+) 5% (-) 1%
b)	Longitudinal profile	(±) 5% of the specified grade
c)	Grade compensation	(±) 5% of the specified gradient
d)	Super-elevation	(±) 5% of the specified super-elevation

3. **The tolerances for layout of hairpin bends shall be as follows:**

a)	Length	(+) 0.5%
b)	Direction	(±) 20 minutes
c)	Grade	(±) 0.2%

4. The tolerances in the various courses of pavement should conform to the provisions given in the relevant Sub-sections of this Handbook.

C. Do's and Don'ts

Do's	Don'ts
1. Take precautions for safe guarding the environment (Clause 110 of MoRD Specifications)	1. Do not throw debris from excavation / blasting haphazardly down the hill slope.
2. Take appropriate measures to ensure stability of slopes during construction. Provide the necessary protective measure for safety against erosion, subsidence and recurrent slips and slides. Provide apron below the outlet point of culvert where height of waterfall is liable to cause erosion.	2. Do not carry out blasting operation indiscriminately.
3. Ensure that safety measures including traffic signs, guideposts, railings, parapets are provided at appropriate places.	3. Do not provide Hair Pin bends at inner curves. Locate them at stable places having gentle hill slope requiring lesser height of retaining walls and lesser height of back cutting
4. Safeguard the Reference Pillars till the completion of work	4. Do not stack serviceable stones over Roadway so as to allow free flow of traffic.
5 Identify areas for proper disposal of debris and waste materials before commencement of the work	5. Do not allow debris lying along the road.
6. At hairpin bends, pave the entire roadway width to avoid erosion.	6. Do not allow bumps or steep grades or reverse grades in longitudinal section of hill roads.
7. Provide one cross drain on upper arm of hair pin bend just before the bend to minimize flow of water along the surface of the road.	7. Do not construct retaining walls, which are having outer curve in plan, specially at hairpin bends. These are weaker in regard to stability and are easily liable to collapse. Better break such as walls into segments to avoid their bulging tendency.
8. If hill cutting is done by manual labour, then start from back cutting line proceeding outwards to valley face otherwise it will be difficult to rectify the defects left in back-cutting.	8. Do not allow gradient defects to continue. These must be got rectified otherwise these will remain for the whole life of the road.
9. Always prepare completion plans of completed lengths and compare it with original drawings enclosed with the agreement in regard to widths, curves, camber, super elevation and the longitudinal gradient as per Para 1603.8.1 of " Specifications for Rural Roads".	9. Do not spread the aggregate in very very small stretches. This may adversely affect the riding quality of the surface.
10. Carry out the backfill behind retaining wall / breast wall only after the masonry work of wall has been approved by the Engineer.	10. Do not allow construction of Retaining walls until proper road geometrics has been achieved in hill-cutting otherwise this may lead to excessive heights and quantities of R wall masonary creating unnecessary cost escalation.
11. Ensure proper longitudinal gradient as per drawings and all vertical bumps in grades have been removed.	11. Do not allow any pilferage of reference level pillars & back reference pillars. Keep a watch and ward on reference pillars. If a few level pillars are raised by about one metre in a continuous stretch, same geometrics can be achieved. But this will adversely affect the adjoining jobs where steeper gradient will occur. Similarly if back-cutting line is shifted to 1.0 m in front, it will be difficult to judge its correctness but its overall effects will be less height of cutting and much more quantity of retaining walls may cause huge cost escalation.
12. Excavate the hill side drain along with hill side cutting work as per Para 1606.1.3 of MORD Specifications. Keep the bed level of side Drain at least 300 mm below the Subbase or drainage layer or as per desired specifications.	12. Do not allow gradient steeper than permissible at hairpin bends. Flatter gradients are always preferable to steeper gradients at such locations.
13. Construct the cross drainage works like scuppers or small culverts alongwith the formation cutting work. Excavation for catch pit should also be done simultaneously.	13. Do not consider the hill road as complete until it has been properly compared with the contract drawings in regard to curve radius & gradient.
14. Salvage serviceable materials and stack at the earmarked location.	

SECTION 1700

TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES

1700. TRAFFIC SIGNS AND MARKINGS

A. Methodology

I Traffic Signs

1. The colour, configuration, size, location and dimensions of different road signs shall be in conformity with the Code of Practice for Road Signs IRC: 67. The language of inscription and font for informatory signs shall also be in conformity with the Code of Practice for Road Signs IRC: 67.

2. Signs shall be semi-reflective, fixed over mild steel sheeting duly stove enameled in white colour in front and grey colour on the back, red engineering grade tape on borders and required message in non-reflective black sheeting of Engineering grade tape.

3. Road signs, in particular, the cautionary / warning and mandatory / regulatory signs in the approaches to level crossings or narrow bridges may be reflectroised using luminous paints or other similar reflective material.

4. 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.

5. The informatory signs on PMGSY roads shall have prescribed diamond type logo (600 mm x 600 mm) of Pradhan Mantri Gram Sadak Yojana on top of sign board.

6. 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 conform to IS:2062.

7. Sign posts, their foundations and sign mountings should be so constructed as to hold them in a proper position against normal wind loads or displacement by vandalism.

8. Normally signs with an area upto 0.90 sqm can be mounted on a single post and for greater area two or more supports shall be provided.

9. 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.

10. The signs and supports, except the reflectorised portion and GI posts, shall be thoroughly de-scaled, 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.

11. 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.

12. The extreme edge of the Road Sign adjacent to the highway should be at a distance of atleast 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.

13. The lowest edge of Road Sign shall not be less than 2.0 m above the crown of pavement.

II. Road Markings

1. The road markings should be in conformity with the Code of Practice for Road Markings with paints IRC: 35.

2. Paining may be done by machine or by hand, preferably by machine.

3. The finished road markings should 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 should be free from streaks.

B. 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 Section 801 of these Specifications.

(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 to IS:2062 or any other relevant IS Specifications.

(v) **Reflectorised paint:** Reflectorised paint shall conform to IS:5 or the manufacturer's specifications in case of proprietary product and as approved by the Engineer.

(vi) **Non reflectorised paint**: Non-reflectorised paint shall conform to 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 1700.1.

When totally wet, the sheeting shall not show less than 90 per cent of the values, of retro-reflection indicated in Table 1700.1. At the end of 5 years, the sheeting shall retain at least 50 per cent of its original retro-reflectance.

TABLE 1700.1: ACCEPTABLE MINIMUM COEFFICIENT OF RETROREFLECTION 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	9.0	14.5	4.0
0.2	+ 30	30	22	7.0	3.5	6.0	1.7
0.5	- 4	30	25	13.5	4.5	7.5	2.0
0.5	+ 30	15	13	4.0	2.2	3.0	0.8

(viii) Signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick. All others shall be at least 2 mm thick. The thickness of the sheet shall be related to the size of the sign 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 IRC:67, 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 IS:164. These shall have a wear resistance of at least 4 hours under accelerated laboratory test. Yellow colour (conforming to IS colour No. 356) as given in IS:164, white and black colours are the standard colours used for markings.

C. Do's and Don'ts

Do's	Don'ts
1. Insist on a minimum three year warranty for the MS or GI sheets being purchased from the supplier.	1. Do not keep the lowest edge of Road Sign less than 2.0 m above the crown of the road
2. Ensure that the edge of the Road Sign adjacent to the road is at least 2.0 m away from the edge of the carriageway.	2. Do not cause inconvenience to traffic while painting operations are in progress.

SECTION 1900

MAINTENANCE

1901, 1902, 1903, 1907 & 1914: maintenance of earthworks & DRAINS

The maintenance of Earthworks in this Sub-section includes restoration of rain cuts, maintenance of earthen shoulders, embankment slopes and drains.

A. Methodology

I. Restoration of Rain Cuts

1. Clear the area affected by rain cuts of all loose soil and then provide benching. The width of benches should be at least 300 mm and should extend continuously for a sufficient length, the height of benches being in the range of 150-300 mm.

2. Lay fresh material, meeting the requirements of a suitable fill material (as per Sub-section 301) in layers not exceeding 250 mm loose thickness and compact at a moisture content equal to optimum ± 2%. Carryout compaction using plate compactors / rammers or by suitable implements handled manually.

3. Ensure that the finished work conforms to the specified alignment, levels and slopes.

II. Maintenance of Earthen Shoulders

1. For making up of an earthen shoulder where extra soil is required to be added, loosen the existing earthen shoulder to receive fresh soil. Make up the deficiency in layers of loose thickness not exceeding 250 mm. After ensuring the placement moisture in the loose soil layer at optimum ± 2%, compact the layer to obtain 97% to 100% of maximum dry density in accordance with IS:2720 (Part 7). For compaction, an 80 to 100 kN smooth wheel roller, plate vibrator, hand-held roller or even a hand rammer can be used, provided the specified dry density is achieved.

2. Where earth is required to be excavated from the shoulder, remove high spots / excess earth either using equipment like grader or by manual means using hand tools. The resulting surface should be uniform and have a field density of atleast 97% of maximum dry density as per IS:2720 (Part 7), otherwise excavate / loosen the surface to a depth of 150 mm and compact to 97% to 100% of maximum dry density as per IS:2720 (Part 7), making sure that the moisture content prior to compaction is at OMC± 2%. The compacted layer should be finished to the required cross fall.

3. All obstructions like tree branches, heaps of soil, debris etc. must be removed, and disposed of to an off-road dumping place. This task should be performed alongwith other tasks like patching shoulders, grass cutting, cleaning ditches etc.

4. Carry out weed cutting and bush clearing at least once a year after the rainy season or more often where climatic conditions so warrant. Where long stretches of shoulder vegetation is to be cut and the work cannot be done by hand tools, use an agricultural tractor towed mower / ripper.

III. Maintenance of Slopes and Drains

1. Together with clearing unwanted vegetation on shoulders, clearing of slopes and drains / ditches should also be carried out.

2. Carry out reshaping, re-grading and deepening of ditches / drains preferably by tractor-towed grader, wherever possible, otherwise by manual methods. Alignment should be set by stringline and the materials within the stringline should be cut and removed. Cross-section, grading and depth should be checked and corrected. Excess material must be removed from the site and should never be spread over the road.

3. Any objects which can interfere with water flow must be removed.

4. Repair drain erosion by replacing and backfilling the lost soil. In case of recurring problems of erosion, permanent measures like masonry lining should be considered.

5. Check for any settled or damaged precast drain sections or loose stone, which should be removed and underlying soil compacted. After addition of fresh soils, the levels should be corrected and then only fresh stones or precast drain should be laid.

6. For vegetation control, tractor-towed mower can be employed where available and as an alternative hand-guided mower can also be used.

7. For erosion control, turfing (grass sodding) is suitable when climate and soil conditions are favourable. Seek advice of local agriculture department on topsoil required, seed type and rate of spread, fertilizer types and rate of spread and most favourable season and weather for seeding. Suitable mulch like jute netting can be provided for preventing the seeds from getting washed away before the seeds sprout.

B. Quality control requirements

1. Materials

All soils and other materials used for maintenance should satisfy all quality requirements for use in shoulders, along slopes and in roadside ditches / drains, as laid down for original construction.

2. Surface Finish

All maintenance works must be carried out to the finished surface standards laid down in original designs.

3. Camber/Cross Fall/Side Slopes

Check that the maintenance work has been carried out to the specified camber / cross-section and side slopes.

C. Do's and Don'ts

Do's	Don'ts
1. Do carry out suitable benching of the rain cuts to be restored, as per the specified procedure.	1. Do not use any soil for restoring rain cuts, which does not meet the requirements for suitability as a fill material.
2. The deficiency in shoulder thickness should be made up in layers, ensuring the optimum moisture for compaction and achieving the specified density.	2. Do not allow any obstructions to remain on the shoulders
3. The compacted layers on the shoulder should be finished to the required cross-fall.	3. Do not spread the excess material over the road surface while reshaping, regarding and deepening of ditches.
4. Do make provisions to maintain sufficient supply of tarpaulin or other water proof cloth during placement of concrete when rain is expected.	4. Do not attempt turfing or seeding on soil type, which will not sustain plant growth, without providing topsoil.
5 While reshaping / regrading and deepening of ditches / drains, carefully check and correct the invert level and grading.	5. Do not use any chemical methods or resort to burning to control roadside vegetation.
6. Before turfing or grass-seeding, get the needed advice from the local agriculture department.	

1904 : MAINTENANCE OF BITUMINOUS SURFACE ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the road be inspected atleast once a year and that the past record of performance, maintenance and traffic data is available with the Maintenance Engineer.

A. Methodology

1. After a field inspection, determine the areas for

   (i) **Surface defects** like fatty surfaces, smooth surfaces, streaking and hungry surfaces

   (ii) **Cracks**-hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks and reflection cracks.

   (iii) **Deformation**- slippage, rutting, corrugation, shoving, shallow depressions, settlements and upheavals; and

   (iv) **Disintegration** – stripping, loss of aggregates, ravelling, pot-holes and edge breaking.

2. Surface Defects

2.1 Fatty surfaces

(i) If the bleeding is fairly uniform and the surface is free from irregularities, application of cover aggregates or sand (sand blotting or sand-blinding) would be successful. The aggregate or sand used shall be of small size, clean and regular, and may be heated, if necessary.

(ii) An open-graded premix surfacing with a low bitumen content can absorb the excess binder.

(iii) A liquid seal coat, with special care taken to select the rate of application of the binder and the quantity and size of cover aggregates, can also be effective.

(iv) Special methods such as the burning of the excess binder.

(v) In case of large areas of fatty surface having irregularities, removal of the affected layer in the area and replacing it with layer having a properly designed mix, may be necessary.

2.2 Streaking

Repair for longitudinal and transverse streaking is to remove the streaked surface and apply a new surface treatment. It is always desirable to prevent longitudinal and transverse streaking than to correct it. Whenever mechanical equipment is used for spraying of bitumen, manufacturer's recommendations of the bitumen distributor should be carefully adhered to.

2.3 Hungry Surface

A slurry seal may be used as a repair measure. It is applied in an average thickness of 2-5 mm.

As an emergency repair, a fog seal may be used.

3. Cracks

The treatment for cracks would depend on whether the pavement remains structurally sound or has become distorted or unsound.

In case the pavement remains structurally sound, then the cracks should be filled with a bituminous binder having a low viscosity so that it can be poured and worked into the cracks. Cut back bitumen and emulsions are generally suitable. All loose materials are removed from the cracks with brooms and if necessary, with compressed air jetting. The binder is poured with a pouring can and a hand squeegee is used to assist the penetration of the binder into the cracks. Light sanding of the cracks is then done to prevent traffic picking up the binder.

If the cracks are wide enough a slurry seal or sand bituminous premix, or sand bituminous premix patching can be used to fill the cracks.

If the cracks are fine (crazing) and extend over large areas, a light-cut-back or an emulsified bitumen (fog seal) can be broomed into the cracks and lightly sounded to prevent the picking up of the binder by the traffic.

4 Deformation

4.1 Slippage

Remove the surface layer around the area affected upto the point where good bond between the surfacing and the layer underneath exists and patching the area with premix material after a tack coat.

4.2 Rutting

Fill the depression or groove in the wheel tracks with premix open-graded or dense-graded patching materials and compact to the desired levels. The limits of the depression are first determined with a string line and marked on the surface. After applying a suitable tack coat, the premix is spread and compacted.

Situations indicative of shear failure or subgrade movement generally require excavation. The job should be carefully assessed. The area to be opened up should as far as possible be limited to that which can be completed and made safe in a day's working.

4.3 Corrugations

If the surface is thin, the same is scarified, including some portions of the underlying water-bound macadam base, and the scarified material is recompacted. A new surfacing layer is then laid.

Cutting of high spots with a blade with or without heating and addition of levelling course materials can also be resorted to.

Spreading of sand bituminous premix with a drag spreader with its blade adjusted to just clear the high spots can also be an effective way of making up the corrugations. The area is then thoroughly rolled.

4.4 Shoving

Remove the material in the affected area down to a firm base and lay a stable premix patch.

4.5 Shallow depression

Fill up the depression with premix materials, open-graded or dense-graded and compact to the desired profile as the surrounding pavement.

4.6 Settlement and Upheaval

If settlements and upheavals indicate an inherent weakness in the fill or subgrade, it may be necessary to excavate the defective fill and upto bottom of subgrade and do the embankment afresh under properly controlled conditions. Material having good drainage qualities should be preferred. Under-drains may become necessary in locations where lack of drainage has been identified as the cause of failure. Where the cause of deformation is inadequate pavement thickness, then properly designed pavement shall be provided. Frost-affected regions may need thorough investigations and a complete reconstruction of the pavement.

5. Disintegration

5.1 Stripping

In the case of surface dressing, hot coarse sand heated to at least 150^0C and spread over the affected areas, may be used to replace the lost aggregates. After spreading, it should be rolled immediately so that it will be seated into the bitumen. If aggregates are only partially whipped off, a liquid seal may be the solution.

In other cases the existing bituminous mix should be removed and a fresh one laid. As a precautionary measure, a suitable anti-stripping agent should be added to the bitumen, at the time of construction.

5.2 Loss of Aggregate

If the loss of aggregates is due to ageing and hardening of the binder, the condition may be rectified by applying liquid seal, fog seal or slurry seal.

If the loss of aggregates has occurred over large isolated areas, the best thing to do would be to provide another surface dressing layer, after carefully cleaning the surface.

If the loss of aggregates has taken place in small isolated patches, a liquid seal would be sufficient.

5.3 Ravelling

Ravelled surface is corrected by adding more quantity of binder, the rate of application depending upon the condition of existing surface and degree of hardening occurred to the binder. If the ravelling has not developed too far, the condition may be corrected by a simple application of a cut-back bitumen covered with coarse sand, or a slurry seal can be applied. Where the ravelling has progressed far, a renewal coat with premix material would be necessary.

5.4 Pot-hole

Fill pot holes with premix open-graded or dense-graded patching or penetration patching as per clause 501.2.3.1 of MoRD Specifications.

5.5 Edge-breaking (Frayed edges)

The shoulder and the pavement material in the affected area should be fully removed to a regular section with vertical sides. The pavement and the shoulders should be built up simultaneously with thorough compaction. A bituminous surface similar to that in the adjacent reach should be laid. The shoulder should have an adequate slope to drain away the water. A slope one per cent steeper than the camber of the bituminous surface should be found generally necessary for earthen

shoulders. In order to prevent the edges from getting broken again, the maintenance operations should include periodic inspection of the shoulder condition and replacement of worn out shoulder material with adequate compaction. In sandy areas where the soil is likely to be eroded by wind and rain, it may be advantageous to have brick paving at least for some width to protect the edges. Surface and subsurface drainage, wherever deficient, should be improved.

II Periodic Surface Renewal

When the condition survey data reveals the need for surface renewal, provide 20 mm thick Premix Carpet as per Sub-section 508 and seal coat as per Sub-section 510. Prior to laying a surface renewal, clean the existing surface of all dust and cake mud by wire brushes and brooms.

1905: MAINTENANCE OF GRAVEL ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the Gravel road can be inspected atleast once a year and that the past record of performance, maintenance and traffic is available with the Maintenance Engineer.

A. Methodology

I. Routine Maintenance Measures

1. Where loss of profile is observed on a gravel road, drag the accumulated material from the roadsides / shoulders to the center, using an approved tractor-towed grader and compact by roller. If a suitable mechanical grader is not available, adopt manual methods. Prior to roller compaction, ensure that the gravel is at optimum moisture content ± 2%

2. Where the surface is corrugated, rectify it by grading with a mechanical grader or by using a tractor-towed drag of approved design. The scrapped material should be spread over the surface and roller compacted. Prior to compaction, ensure that the material is at optimum moisture content ± 2%

3. Repair all local depressions, ruts, potholes and erosion gullies, replacing or adding new surface material of specified properties as per Sub-section 402 and then compact the replaced / new surface material by road roller. Before undetaking repairs, the affected area should first be cleaned of all loose material, bringing it to a regular rectangular shape with the help of spades and pick axes and hand ramming the bottom surface. The prepared area should be filled up with gravel of specified properties and roller compacted, ensuring that prior to compaction, the moisture content is at the optimum ± 2%.

II. Periodic Surface Renewal

Prior to regravelling, scarify the old surface and provide additional gravel 50 mm to 75 mm in loose thickness meeting specified requirements (as per Sub-section 402) over the scarified surface. After bringing the moisture content of the addititional gravel to optimum ± 2%, compact the loose gravel layer to the maximum dry density as per IS:2720 (Part 7).

B. Quality Control Requirements

1. Materials

Any gravel used for routine maintenance repairs and for periodic regravelling should conform to the requirements as per Sub-section 402.

2. Surface Finish

The surface finish after the routine maintenance repairs and periodic regravelling should conform to the requirements laid down in Sub-section 402.

3. Camber/Cross-fall

Check that the final surface conforms to the specified camber / cross fall.

C. Do's and Don'ts

Do's	Don'ts
1. Do ensure that any gravel used for repairs, whether as salvaged material or as fresh material meets the specified requirements for use in the layer in question.	1. Do not allow heavy grading, without the provision of additional surface material if the remaining thickness of gravel is less than 75 mm
2. The grader should start from the edges of the road and work towards the center.	2. Do not use any scrapped gravel for repairs, if it does not meet the specified requirements.
3. The surface of a gravel road should be improved by dragging with the use of an approved drag.	3. Do not spread additional gravel for re-gravelling on the old surface without scarifying the old surface.
4. Do make sure that prior to filling up local depressions, ruts, potholes and erosion gullies, the affected area is first cleaned of all loose material, brought to a regular shape and the bottom surface hand-rammed.	4. Do not start roller compaction unless the material to be compacted is at a moisture content equal to OMC ± 2%.
	5. Do not use manual methods for making up the loss of profile without the approval of the Engineer.

1906: MAINTENANCE OF WBM ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the WBM road be inspected once a year and that the past record of performance, maintenance and traffic data is available with the Maintenance Engineer.

A. Methodology

I. Routine Maintenance

1. After a field inspection, determine the areas for (a) filling up potholes (b) filling up ruts, (c) rectifying corrugated surface, (d) repairing damaged edges and (e) rectifying ravelled surface.

2. Before filling up a pothole, remove all loose material from the pothole upto the firm base, cut the affected area made into a regular rectangular shape with sides of the hole kept vertical. Fill the prepared pothole space with aggregate of the same size and type as used in the original layer and apply screenings and binding material of the same type (if found suitable) as used in original construction over the aggregate and compact by hand rammer. After watering, compact the layer again by hand rammer first and then by a road roller.

3. Clean the rutted potion of all loose material and sprinkle with water and shape the rutted portion into a rectangular portion with flat bottom. Fill the prepared rut portion with salvaged material, if found suitable and / or fresh suitable aggregates and roll after addition of screenings, binding material and watering following the standard procedure as per Sub-section 405. After rolling, provide a 6 mm sand layer over the finished surface and lightly sprinkle with water.

4. Remove any damaged portions at the edges, replace by fresh material and roll.

5. Any corrugated surface formed by excess blindage material should be rectified by removing all excess blindage material by dragging or brooming. Where corrugations develop in WBM course itself, a renewal layer of WBM will be required.

6. Fine hair cracks on the surface are usually indicative of ravelling taking place later. This tendency for ravelling can be remedied by blending with good binding material and watering the surface. Where ravelling has developed prominently, resurfacing should be carried out.

II. Periodic Surface Renewal

Where the condition survey data reveals the need for surface renewal, provide a 75 mm thick layer of WBM grading 3 as per Sub-section 405. Prior to laying a surface renewal, clean the existing surface of all dust and caked mud by wire brushes and brooms. After light sprinkling of water, scarify the surface and screen the salvaged materials to be used later, if found suitable. The salvaged material together with fresh additional material should be spread and dry rolled followed by application of screenings and binding material, and wet rolling as per Sub-section 405.

B. Quality Control Requirements

1. Materials

The quality of stone aggregates, screenings and binding material used for routine maintenance as well as periodic surface renewal should conform to the requirements laid down in Subsection 405 for WBM construction.

2. **Surface Finish**

The surface finish requirements after carrying out various maintenance measures should also conform to the surface finish requirements laid down in Subsection 405.

3. **Camber/Crossfall**

Camber / Crossfall should be checked for ensuring conformance with the specified requirements.

C. Do's and Don'ts

Do's	Don'ts
1. Make sure that all materials used in maintenance repairs i.e., coarse aggregates screenings and binding material meet the quality requirements laid down in Subsection 405. 2. While filling potholes, keep the surface slightly proud of the surrounding area. 3. While repairing damaged portions of edges, rolling of the edge and shoulder should be carried out simultaneously and the cross profile of the shoulder remedied by grading. 4. After providing surface renewal, a 6 mm layer of coarse sand should be provided and lightly sprinkled with water.	1. Do not use the salvaged material for repairs, if these do not meet all the quality requirements. 2. Do not ignore the presence of fine hairline cracks on WBM surface as these are indicative of serious ravelling to occur later. 3. Do not provide resurfacing unless the old surface has been scarified. 4. Do not allow traffic immediately after laying the WBM surface renewal.

1908 : MAINTENANCE OF CULVERTS AND SMALL BRIDGES

General: Under this Section the maintenance aspects of all the culverts and small bridges are covered.

A. Methodology

1. Inspect approaches of CD works for possible erosion and settlement, besides any damage due to movement of cattle between stream and roadway.
2. Examine floor protection to assess extent of cracking / damage to the floor condition and cut off walls, aprons etc.
3. Observe any abnormal change of channel flow and movement of debris, floating material, sand / silt and boulders.
4. Examine the general condition of foundation, pier, abutment, wing, return walls, springing of arches, headwalls, cut off walls for any damages due to scouring / earth pressure.
5. Check for growth of vegetation in all structural components for cracking in concrete, loosening of brick / stone masonry work, opening of joints at crown section, separation of arch rings / spandrel walls, settlement / tilt of foundation etc.
6. Check for condition of inlets, outlets and catch pits of pipe culverts / arches / boxes from inside and on outerfaces for growth of vegetation, erosion and choking of culverts.
7. For concrete members examine for signs of distress such as cracking, spalling / corrosion of embedded steel etc.
8. Examine drainage spouts, guide posts, railings, parapets guard stones, kerbs and wearing coat for durability and for safety of pedestrians and animals.

B. Quality Control Requirements

1. Clear and clean debris of sand and silt from culvert opening and catch water pit including growth of vegetation at inlet and outlet. Remove and dump the same far away from water channel.
2. Undertake repairs for damages caused due to erosion, cracks and spalls and to substructures and protection works.
3. Inspect general condition of foundation and for separation of arch rings and spandrel walls and carry out repairs.

C. Materials

1. Carry out repairs on cement based components / parts with cement mortar.
2. Inject epoxy grout for sealing of cracks and filling of voids in concrete, under pressure, following Manufacturer's specification.
3. Carry out repairs on concrete deck slabs with Methyl Methacrylate (MMA) or Trimethyl Propane, Trimethacrylate as per Manufacturer's specification.
4. Carry out repairs to approaches and banks periodically with local soil.
5. Use brick or stone masonry for repair of components made of the same materials.

1909: MAINTENANCE OF CAUSEWAYS

A. Methodology

1. Check for adequacy of waterway and any abnormal change in flow pattern of channel on u/s and d/s side after each flood season, including out flanking.
2. Examine major damages caused by outflanking or cavitation, causing collapse of head walls, damages to paved surface and fill material that holds multiple pipes/openings.
3. Check the condition of vents for accumulation of sand/debris etc. and check for accumulation of debris on the surface of causeway after each submergence and clean.
4. Check the approaches for erosion/wash out and face walls and head walls for loosening of material.
5. Check the condition of guideposts/guardstones/kerbs including slopes of approaches.
6. Check any damages to d/s protection works like CC blocks, stone pitching and wire crates.
7. Check the functioning of flood gauge of causeways and submersible bridges before onset of monsoon.

B. Quality Control Requirements

1. Carryout repairs to the submerged portions of the structure with the same parent material.
2. Remove growth of vegetation in different components debris/floating material on both u/s and d/s side of causeway as well as roadway.
3. Carryout repairs to guide posts/guard stones/kerbs, debris arresters and roadway.
4. Undertake minor repairs to flood gauges and other ancillaries.
5. Undertake repairs to the damages caused by out flanking, collapse of head walls and to paved roadway surface.

C. Materials

1. Carry out repairs to concrete components on cement plaster with the same material.
2. Use stones / bricks for replacement of parts or to repair local damages
3. Use local soil if suitable, for repairs to embankments approaches etc.

1910: MAINTENANCE OF ROAD SIGNS

A. Methodology

1. All road signs should be inspected at least four times a year both in day and night.
2. All signs alongwith the posts shall be maintained in proper position and kept clean and legible at all times.
3. Damaged signs shall be replaced immediately. All road signs alongwith the posts should be maintained in proper position and kept clean and legible at all times

4. A schedule of painting of the posts and signs periodically shall be maintained. Painting the signs may be undertaken after every two years.

5. Tree branches, plantations, weeds, shrubbery and mud etc. shall not be allowed to obscure the sign.

B. Quality Control Requirements

1. Materials

The material for repair / fabrication of signs shall conform to subsection 1701 and IRC:67.

1911, 1912, 1913 & 1915 MAINTENANCE OF MARKINGS & APPURTENANCES

A. Methodology

1. All road markings shall be maintained so as to be clearly visible to the driver. An yearly schedule of re-painting the markings should be maintained to ensure proper maintenance of the markings.

2. The material for maintenance of road markings shall be in conformity with subsection 1702.

3. Repainting and lettering on kilometre and 200-m stones shall be as per guidelines indicated in IRC:8 & IRC:26. The stones shall be maintained in proper position and kept clean and legible at all times. Damaged as well as tilted stones shall be fixed, repaired / replaced immediately.

4. Plantation, weeds, shrubbery and mud etc. shall not be allowed to obscure the stones / signs.

5. Iron, wooden or concrete posts for road delineators shall be repainted regularly, especially after the rains to keep them clean and visible. The ground around the delineators, hazard markers, roadway indicators and object markers should be kept clean by cutting grass / weeds and bushes etc. periodically to maintain the visibility of the delineators.

6. The material for repair / replacement of road delineators, hazard markers, roadway indicators and object markers shall conform to the guidelines included in IRC:79.

7. All branches of trees extending above the roadway shall be cut or trimmed so as to provide a clear height of 5 m above the road surface and shoulders.

8. All shrubs, grass and weeds in the roadway land shall be trimmed and debris removed to a suitable location as directed by Engineer to ensure unobstructed sight distance of adequate length.

9. The parapet walls of culverts, minor bridges and tree trunks shall be cleaned of all scales, dirt or loose material and applied two coats of white wash using good unslaked lime.

CHAPTER 4
QUALITY MONITORING

1. General

1.1. As part of an overall Quality Management System, the aspect of 'Quality Control' is to be treated as distinctly different from 'Quality Monitoring', both at the State and Central levels. The aspect of Quality Control of Works has been dealt with in detail in Chapter 3 of this Hand Book. This Chapter deals with Quality Monitoring which essentially involves only expeditious random checking by specially appointed Quality Monitors both at the State and Central levels to ensure that the works are indeed being carried out as per the prescribed standards.

1.2. In the three-tier system of Quality Management being adopted for rural roads constructed under the Pradhan Mantri Gram Sadak Yojana (PMGSY), while the first tier is an in-house quality control by the executing agency, the second tier is an independent quality check and monitoring by State-level Quality Monitors (SQMs) operationalized by the State. In the third tier of quality management, the National Rural Roads Development Agency (NRRDA) arranges for Quality Monitoring through independent monitors, termed as National Quality Monitors (NQMs). The main objective of quality monitoring at the second and third tiers is to verify whether the quality of road works executed by the States under the PMGSY conforms to the specified standards and to see if the system of quality management in the State is indeed effective.

2. Role of The Quality Monitors

2.1. The role of the quality monitors is more of providing guidance to the State implementation authority than to pinpoint specific faults. Accordingly, the Quality Monitors are required to bring out the weaknesses or shortcomings in the quality control system being adopted by the State and to provide a feed back for improvement. This role can be fulfilled by the field inspections of the PMGSY works by Quality Monitors during different stages of construction and also through inspection of completed works.

2.2. It may be pointed out here that at the State level, there has to be a more rigorous and involved role of State Quality Monitors requiring more frequent visits of SQMs compared to the National-level Quality Monitors.

3. Field Inspections by Quality Monitors

3.1. The field inspections by Quality Monitors need to be so organised that every Quality Monitor is able to inspect the rural road works during different stages of construction like Setting Out, Earthwork, Subgrade, Sub-base, Base, Surfacing and Drainage system, including culverts and bridges, besides completed works. Since the duration of such field inspections will be short, the Quality Monitors will have to depend largely on visual inspection, simple hand-feel tests, use of simple gadgets like Camber Board and Straight Edges etc. available in the Field Laboratory. It is

only in exceptional suspect cases that detailed laboratory tests may be necessary. The Quality Monitors need to bear in mind that all the checks made by them should be in accordance with the provisions made in the approved Plans and Bill of Quantities forming part of the Contract.

3.2. 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 insitu 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 needed tests. The longitudinal profile should be tested by a 3 m straight edge in a stretch of atleast 9 m length and the transverse profile at two or three locations at each 100 m length.

4. ITEMS TO BE CHECKED BY QUALITY MONITORS

The various items to be checked by the Quality Monitors are given below, with respect to the MORD Specifications for Rural Roads.

1. Section 100 : General

1.1 Quality Arrangements

1.2 Attention to Quality

1.3 Setting out and Geometrics

2. Section 300 : Earthwork

2.1 Earthwork and Subgrade / Improved Subgrade in Embankment / Cutting

3 Section 400 : Granular Sub-bases, Bases and Surfacings

3.1 Granular Sub-base / Stabilized Soil Sub-base

3.2 Base Course : Water Bound Macadam

3.3 Shoulders

4 Section 500 : Bituminous Construction

4.1 Prime Coat

4.2 Tack Coat

4.3 Bituminous Layer-Surface Dressing

4.4 Bituminous Layer-Premix Carpet

5 Section 1100 : Pipe Culverts, Section 1200 : R.C.C Slab Culverts and Minor Bridges and Section 1400: Cement Concrete Causeways and Submersible Bridges

5.1 Cross-Drainage Works

6 Section 1300 : Protection Works and Drainage

6.1 Side Drains and Catch Water Drains

7 Section 1500 : Cement Concrete Pavement

7.1 Cement Concrete / Semi-Rigid Pavements

8 **Section 1700 : Traffic Signs, Markings and Other Road Appurtenances**

8.1 Road Furniture and Markings

1. SECTION 100: GENERAL

1.1: Quality Arrangements

On-going

At any particular stage of construction e.g, Setting Out, Earthwork / Subgrade, Sub-base, Base, Surfacing, and Cross-Drainage works, it is necessary to check the following:-

(a) Check, if the field laboratory has been set up at an appropriate location and has the basic facilities to carry out the needed quality control tests.

(b) Check, if out of the specified List of Essential Equipment pertaining to that stage of construction, any items are missing.

(c) Check whether all the items needed are indeed in working order and that, wherever needed, the necessary calibrations have been done. For example, standard sand used in the insitu density test by Sand Replacement method and calibration of Rapid Moisture Meter or any other equipment.

(d) Check, if the Laboratory Technician / Junior Engineer carrying out the quality control tests is adequately trained and is competent to carry out all the needed field and laboratory tests reliably.

1.2 ATTENTION TO QUALITY

1. Verification of Quality Control Registers

- Check the dates for which the test results have been entered for different stages of construction in the Quality Control Registers. Ascertain if the Registers are uptodate and for each day, the type and number of tests carried out are as specified and that all calculations have been done properly. Spot checking of the Abstract of tests with the filled-in proformae of various tests is also necessary.

2. Verification of Test Results on the basis of Field Tests

- Check on the criterion adopted for acceptance, rejection or conditional acceptance of the work in progress. For example, adequacy of the level of compaction in a finished layer, based on a minimum of 3 insitu density tests carried out on the finished layer (Table 301.5). Where the acceptance criterion was not satisfied, check if a Non-Conformance Report was filled up or any other action was taken.
- Check, whether adequate action was taken on each of the Non-Conformance Reports to rectify the defects.
- Check, the compliance of observations made earlier by Quality Monitors.

1.3: SETTING OUT AND GEOMETRICS

1. Setting Out

(a) Check the Reference Bench Mark and the Working Bench Marks.

(b) Check, if the centre line of the carriageway is accurately established and referenced every 50 m intervals in plain and rolling terrain and 20 m intervals in hilly terrain with a closer spacing of 10 m on sharp curves, 5 m on hairpin bends with marker pegs and chainage boards.

2. Width of Roadway

(a) Take atleast 3 measurements of the Roadway width per km length, or part thereof. Measuring Tapes (available in the Field Laboratory) can be used for the purpose. The three locations for measurements per km length or part thereof may be selected at random.

(b) Determine the mean of the 3 measurements per km length and compare with the specified width of roadway. Permissible tolerances are as under:

±30 mm in plain and rolling terrains

±50 mm in hilly terrain

3. Carriageway Width

(a) Take atleast 3 measurements of the carriageway width per km length or part thereof. Measuring Tapes (available in the Field Laboratory) can be used for the purpose. The three locations for measurements per km length or part thereof may be selected at random.

(b) Determine the mean of the 3 measurements per km length and compare with the specified width of carriageway. Permissible tolerances are as under:

±20 mm in plain and rolling terrains

±30 mm in hilly terrain

4. Camber

Take atleast 3 measurements of camber, using a Camber Board (available in the Field Laboratory) per km length, or part thereof, following the procedure as shown in Annex 100.1. Note the discrepancies between the specified camber and the camber actually provided. Two designs of the commonly used Camber Board are shown in Annex 100.2.

5. Superelevation and Extra Widening at Curves

(a) Along the circular curve portion of the road, measure the carriageway width at three selected chainages, using a measuring tape. The mean of the three observations will give the width of the carriageway provided along the circular curve. The difference between the mean carriageway width along the curve and the carriageway width along the straight reaches gives the extra widening provided along the curve, which should be compared with the design value of extra widening.

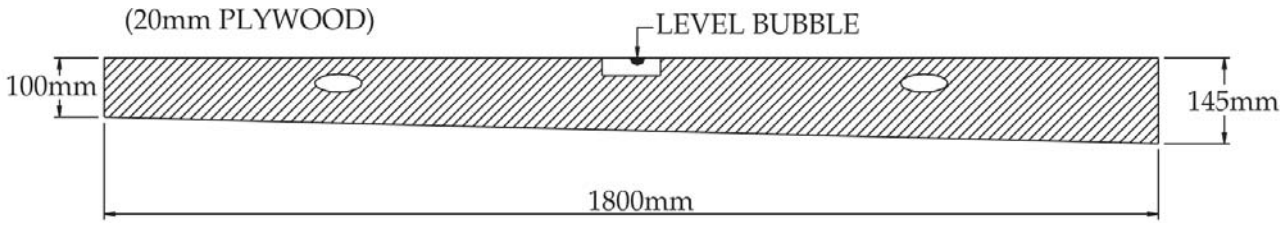
(b) The widening should be effected by increasing the width at an approximately uniform rate along the transition curve. The extra width should be contained over the full length of the circular curve.

(c) The amount of superelevation provided along a curve can be determined by using a straight edge as shown in Annex 100.3, spririt level and measuring tape. The measured amount of superelevation should be compared with the superelevation designed for the curve.

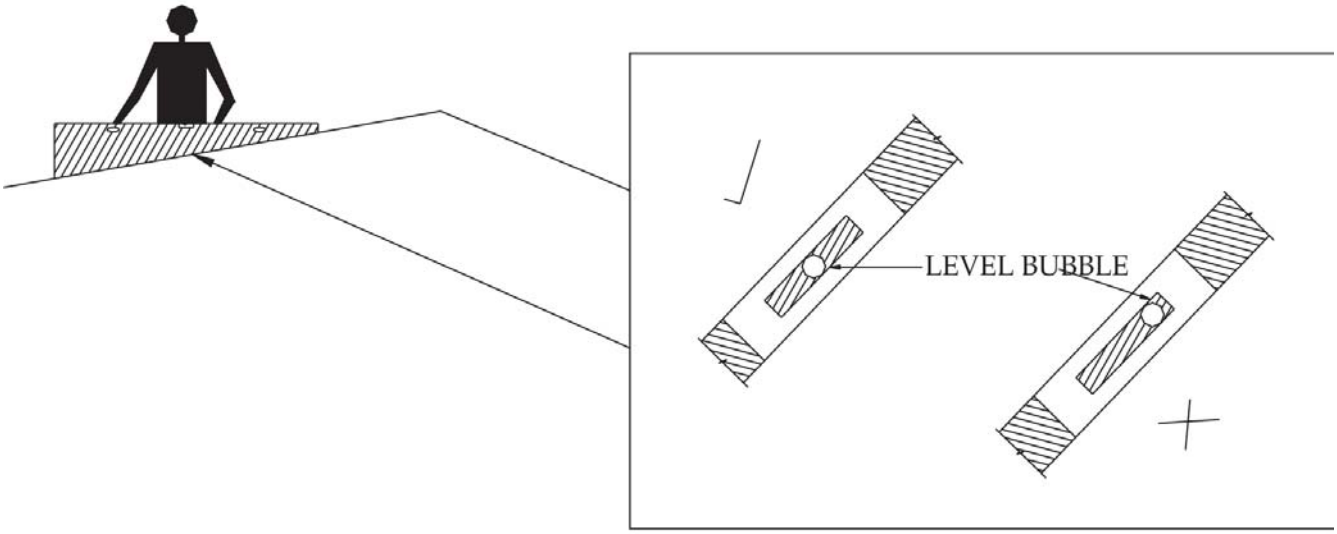
6. Longitudinal Gradient in Case of Road in Hilly/ Rolling Terrain

Longitudinal gradients can be checked expeditiously, using simple Dumpy Level and staff. Reasonably accurate checks on gradient can be considered by using suitable Hand Level or even Calibrated Spirit Levels, depending on availability. These checks should be carried out at 3 critical locations per km length or part thereof and mean of the three observations determined.

ANNEX 100.1



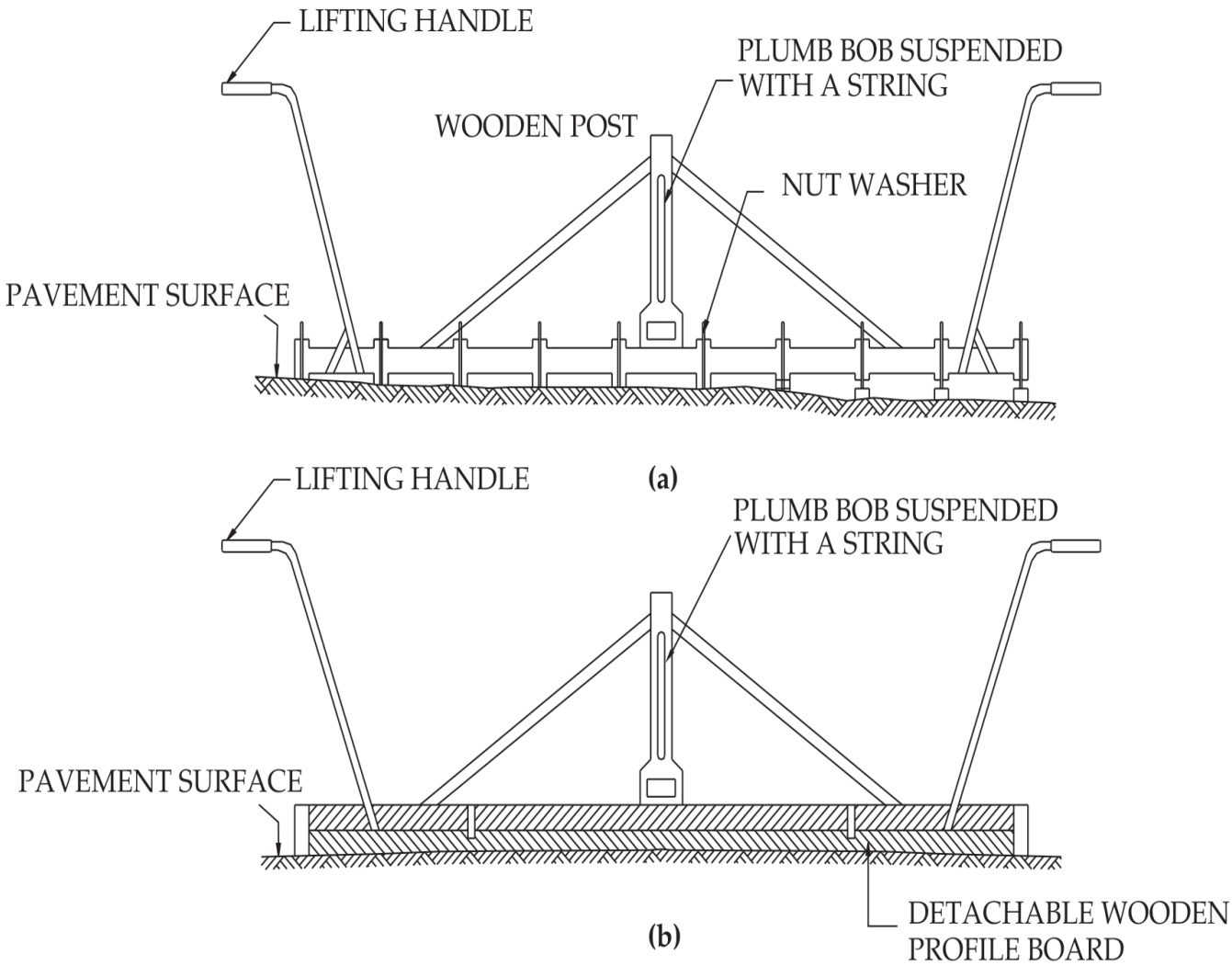
CAMBER BOARD (2.5% CAMBER)



USE OF CAMBER BOARD

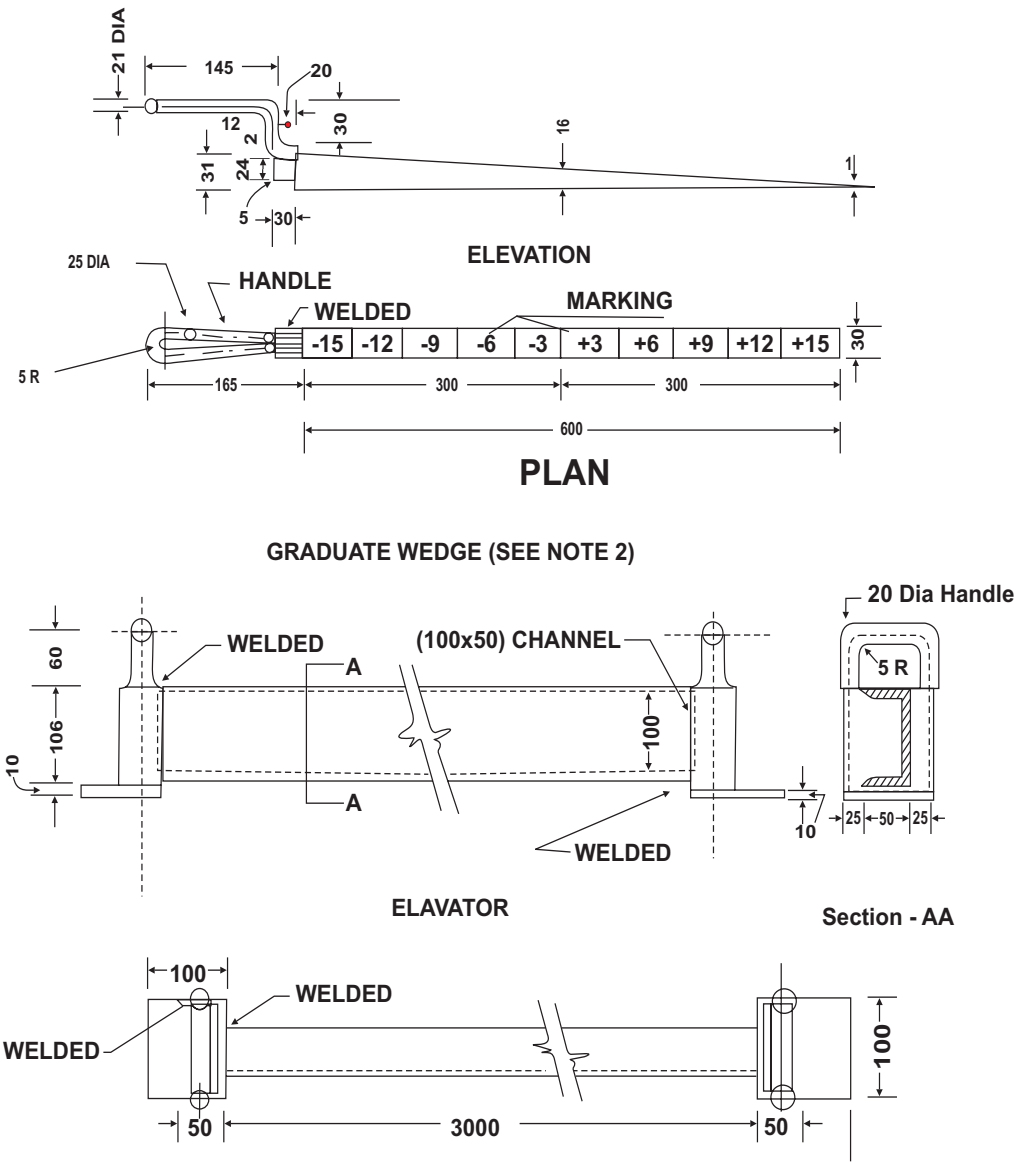
[Source : Overseas Road Note 2 : Maintenance Techniques for District Engineers, 2nd Edition, TRRL (UK) 1985], Adapted Version

ANNEX 100.2



TWO DESIGNS OF CAMBER BOARD

ANNEX 100.3



PLAN
STRAIGHT EDGE

Notes : 1. All dimensions are in millimetres

2. In this design of the wedge, graduations are marked up to 15 mm. for measurements on subgrade and sub-bases, where variations are larger, a modified wedge with graduations up to 25 mm should be employed.

TYPICAL DESIGN OF STRAIGHT EDGE AND WEDGE

2. SECTION 300 : EARTHWORK

2.1 : Earthwork and Subgrade/ Improved Subgrade in Embankment/ Cutting

1. Quality of Material for Embankment/ Subgrade/ Improved Subgrade

(a) For earthwork in embankment, check its suitability by soil type and its soil group. This can be determined by adopting a Visual Soil classification System, using only hand-feel tests, as shown at Annex 1. Details of the three hand-feel tests required for classifying fine-grained soils are given in Appendix-1, paras 1.1, 1.2 and 1.3.

A quick supplementary procedure for determining the presence of clay is performed by cutting a lump of dry or slightly moist soil with a knife. A shining surface imparted to the soil indicates highly plastic clay, while a dull surface silt or clay of slight plasticity.

Using the following the suitability of soil as a fill material can be ascertained:

- Dry Unit Weight estimated from the soil group as per Table (Annex 300.2) on Average Engineering Properties of Soil Groups.
- Wherever suspect, Deleterious Material Content (Appendix 1, Para 4) should be determined.
- Wherever suspect, pH value to be determined using litmus paper strips (if pH>8.5, the soil is sodic in nature and unsuitable for use)

  Check, if the subgrade soil meets all the requirements of fill material as above, has the maximum dry unit weight (Proctor Test) and soaked CBR not less than the specified value.

(b) Where a clayey subgrade soil / black cotton soil with very low CBR value is to be improved by lime treatment, as per the provisions of the Contract, check from records if the purity of lime used for the purpose has been tested. It should be not less than 70% by weight of quicklime (CaO).

(c) Check the lime treated soil for its Plasticity Index (PI).

(d) Check, if prior to mixing of soil with lime, pulverization of soil clods was carried out as per requirements i.e, 100% passing 26.5 mm sieve and 80% passing 5.6 mm sieve.

(e) Check, if the mixing of pulverised soil with lime was carried out thoroughly by using appropriate equipment like tractor-towed disc harrows / tractor-towed Rotavator.

2. Compaction

(a) Check, if the moisture content in the soil during compaction is close to the optimum by taking a handful of the wet soil on the palm of hand and attempting to make a ball out of it (Appendix 1, Para 5). The moisture content at which the ball of wet soil can retain its round shape is approximately the optimum. At moisture contents below the optimum, the ball tends to crumble while at moisture contents wet of optimum, the water will tend to ooze out of surface.

(b) Carry out an insitu density test each at the following two locations:

(i) close to the edge of the roadway

(ii) any location selected at random

(c) If at location (i), the insitu density is lower than the lower specified limit, it goes to show that proper precautions in regard to trimming at the verges were not taken by building the embankment initially wider than the design embankment and then trimming at the edges.

(d) At location (ii), the insitu density test result should not be lower than the lower specified limit. If the actual insitu density obtained at the time of checking is lower than the lower specified limit, check on the action taken to rectify the defect and if any Non-Conformance Report was filled up.

(e) Check, if the improved subgrade was compacted to 100% Proctor density.

(f) Check, if the improved subgrade just after compaction was properly cured for 7 days with wet gunny bags, moist straw or sand, periodically sprinkled with water.

3. Side Slopes and Profile

(a) Simple gadgets for estimating the side slopes from the horizontal distance (horizontality ensured by a spirit level) and vertical height of a T or L frame (Appendix 1, Para 1.8) can be used for monitoring the actual side slopes of a completed embankment.

(b) A set of 3 observations can be expeditiously taken per km length, using such gadgets.

4. Stability and Workmanship of Cut Slopes

(in case of hilly/ rolling terrain)

(a) As per the design requirements of Cut Slopes, check if all the needed measures have been taken for erosion control (by providing suitable species of vegetation), drainage (catch water drains etc) and retaining structures like breast walls / retaining walls etc.

(b) Check on the actual slope(s) provided; extent and type of vegetation provided; the cross-section, lining and gradients of drains provided; dimensions adopted and materials used in retaining structures, to see if they all meet the design requirements.

5. Adequacy of Slope Protection (in case of high embankments/ hilly/ rolling terrain)

(a) Check, using the simple gadgets described earlier, if the actual slopes provided are indeed within permissible tolerances of the design slopes.

(b) In order to avoid any rain cuts along the slopes, check if the type of vegetation provided for erosion control is of the right species and that wherever required, top soil was indeed provided on completed embankment slopes before planting vegetation. If not, the deficiencies should be pointed out.

(c) Check, if any design requirements like provision of stone pitching or gabions etc. are implemented satisfactorily by examining the quality of stone pitching (e.g if the drainage layer underneath has indeed been provided and the size and quality of stones meet the specified requirements) and in case of gabions, the wire mesh of the crate is plastic coated etc.

(d) Check, if the drainage system provided is as per the design requirements. Any deficiencies observed should be brought out.

ANNEX 300.1

VISUAL SOIL CLASSIFICATION*

Field Identification Procedures							Group Symbols[a]
Coarse-grained soils More than half of material is larger than 75 m sieve size	(The 75 m sieve size is about the smallest particle visible to naked eye)	Gravels more than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			GW
				Predominantly one size or a range of sizes with some intermediate sizes missing			GP
			Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see ML below)			GM
				Plastic fines (for identification procedures, see CL below)			GC
		Sands more than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			SW
				Predominantly one size or a range of sizes with some intermediate sizes missing			SP
			Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see ML below)			SM
				Plastic fines (for identification procedures, see CL below)			SC
		Identification Procedures on Fraction Smaller than 380 m Sieve Size					
Fine-grained soils More than half of material is smaller than 75 m sieve size		Silts and clays liquid limit less than 50		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	
				None to slight	Quick to slow	None	ML
				Medium to high	None to very slow	Medium	CL
				Slight to medium	Slow	Slight	OL
		Silts and clays liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	MH
				High to very high	None	High	CH
				Medium to high	None to very slow	Slight to medium	OH
		Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			Pt

From Wagner, 1957

[a] *Boundary Classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder*

[b] *All sieve sizes on this chart are U.S. standard. Corresponding to the US 380 mm sieve size, the equivalent Indian Standard is IS 425 mm sieve size.*

* *Source : Soil Mechanics by T.W. Lambe and R.V. Whitman, John Wiley and Sons, 1979*

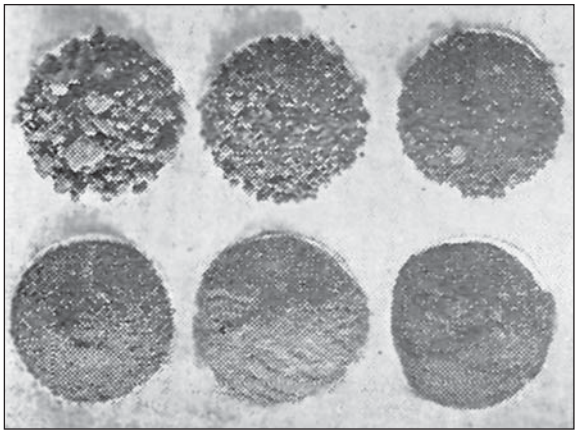


Photo 1. Visual Classification of Soils: (Top, left to right) Gravel, Moorum and Moorum with Excessive Fines. (Bottom, left to right) Sand, Silt and Clay

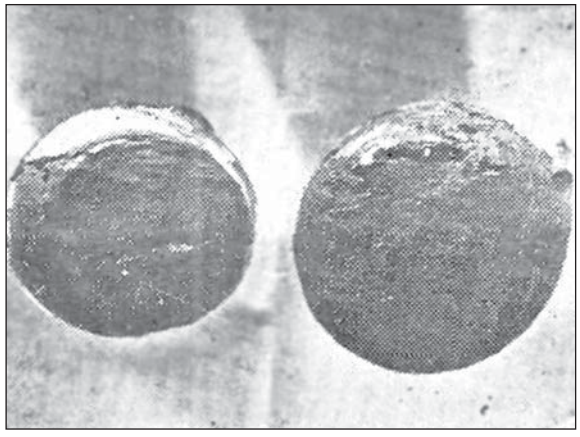


Photo 2. Hand Feel Method for Di-latency Test Shiny surface (left) after tapping in case of silt

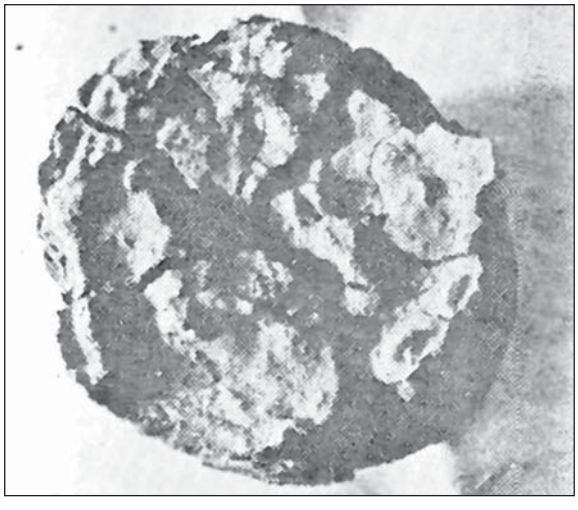


Photo 3. Typical shrinkage cracks in Expansive Clays

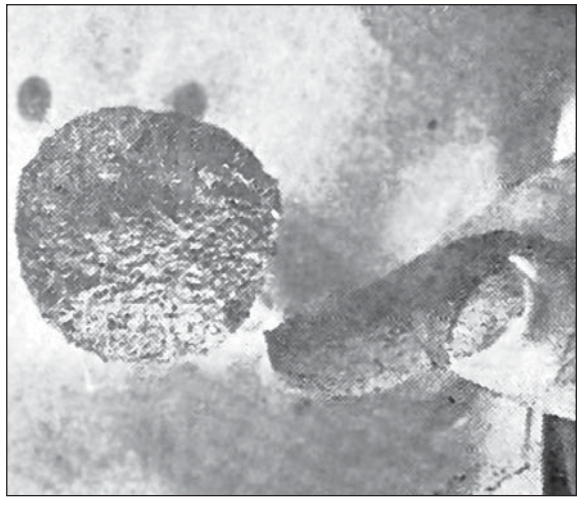


Photo 4. Hand Feel “Stain” Method for testing Clayey soils

ANNEX 300.2

AVERAGE ENGINEERING PROPERTIES OF SOIL GROUPS*

Group Symbol	Proctor Compaction		Permeability (10^{-6} cm/sec)	Typical Design Values[11]	
	Maximum Dry Density (g/cm^3)	Optimum Water Content (%)		CBR (%)	ks (kg/cm^3)
GW	> 1.907	< 13.3	27000 ± 13000	40–80	8.304–13.840
GP	> 1.763	< 12.4	64000 ± 34000	30–60	8.304–13.840
GM	> 1.827	< 14.5	> 0.3	40–60(f)	8.304–13.840(f)
GC	> 1.843	< 14.7	> 0.3	20–40	5.536–13.840
SW	1.907 ± 0.080	13.3 ± 2.5	*	20–40	5.536–11.072
SP	1.763 ± 0.032	12.4 ± 1.0	> 15.0	10–40	4.152–11.072
SM	1.827 ± 0.016	14.5 ± 0.4	7.5 ± 4.8	15–40(f)	4.152–11.072(f)
SM-SC	1.907 ± 0.016	12.8 ± 0.5	0.8 ± 0.6	–	–
SC	1.843 ± 0.016	14.7 ± 0.4	0.3 ± 0.2	5–20	2.768–8.304
ML	1.651 ± 0.016	19.2 ± 0.7	0.59 ± 0.23	15 or less	2.768–8.304
ML-CL	1.747 ± 0.032	16.3 ± 0.7	0.13 ± 0.07	–	–
CL	1.731 ± 0.016	17.3 ± 0.3	0.08 ± 0.03	15 or less	1.384–4.152
OL	*	*	*	5 or less	1.384–2.768
MH	1.314 ± 0.064	36.3 ± 3.2	0.16 ± 0.10	10 or less	1.384–2.768
CH	1.506 ± 0.032	25.5 ± 1.2	0.05 ± 0.05	15 or less	1.384–4.152
OH	*	*	*	5 or less	1.384–2.768

* *Source : Soil Engineering in Theory and Practice Part-1, Third Edition, Fundamentals and General Principles by Alam Singh and G R Chowdhary, CBS Publishers and Distributors, Delhi, 1994.*

3. SECTION 400 : GRANULAR SUB-BASES, BASES AND SURFACINGS

3.1: Granular Sub-Base/ Stabilized Soil Sub-Base

1. Quality of Material

(a) Granular Sub-Base

(i) Check the PI of the fines present in the GSB. This can be quickly done by using one of the following simple hand feel tests.

- Take two or three handfuls of GSB material and take away stone pieces larger than 5 mm. Add enough water to be able to pack the material into a ball. Pick up a handful of the moist material and squeeze it into a ball. For use in GSB, the moist material should not leave a stain on the hand. When dried, the ball may be broken with very slight force.
- For roughly checking the plasticity of fines, take a handful of GSB material passing ISS 425 micron (or just even a window screen) and add the minimum amount of water that will mould the material into a ball. A suitable GSB material will be difficult to roll; in any case not thinner than 7.5 mm in diameter. If the diameter is less than 4 mm, the fines are too plastic for use in GSB.
- By using Uppal's Plasticity Syringe (Appendix 1, Para 1.4).

(ii) If grading is suspect, compare the sieve analysis, using relevant sieve sizes, for material coarser than the prescribed maximum size of material and for the percentage passing 75 micron size sieve.

(b) Stabilized Soil Sub-Base

(i) Where a lime-treated soil sub-base has been provided for in the Contract, check from Quality Control Registers, the purity of lime used, its amount added and Plasticity Index of the mix. Verify from the laboratory test values, recorded in Quality Control Registers, that the strength in terms of UCS / CBR is not less than the minimum specified requirement.

(ii) Where a cement-treated soil sub-base has been provided for in the Contract, check on the type of cement used and the amount added. Verify from the laboratory test values that the laboratory 7-day unconfined compressive strength (UCS) obtained for the mix is not less than the minimum specified requirement of 1.7 MPa.

2. Mixing of Soil with Stabilizer in Stabilized Soil Sub-Base

- Check, from records, if prior to mixing of soil with lime / cement, pulverization of soil clods was carried out as per requirements i.e., 100% passing 26.5 mm sieve and 80% passing 5.6 mm sieve.
- Check, if the mixing of pulverized soil with lime / cement, was carried out thoroughly by using appropriate equipment like tractor-towed disc harrows / tractor-towed Rotavator.

3. Compaction

- Check, if for lime treated soil sub-base, compaction is completed within 3 hours of mixing and for cement treated soil subbase, within 2 hours of mixing or such shorter period as may be found necessary in dry weather.
- Carry out an insitu density test on the compacted subbase layer and compare it with the specified density. If one test result does not meet the specified density requirements, take 2 more samples at random and then apply the criteria as given in Table 301.5.

4. Thickness of Layer

- Determine the thickness of compacted layer at random by digging a pit. If it does not meet the requirement, determine the thickness at two more locations.

5. Curing of Stabilized Subbase

- Check, if curing of the compacted stabilized soil layer is carried out for 7 days by spreading wet gunny bags / moist straw or sand, sprinkling water periodically.
- Check that no ponding of water was resorted to for curing
- Check that no traffic is allowed to ply during curing

6. Surface Regularity

- Using a 3 m Straight Edge, the undulations observed should not exceed 12 mm in the Longitudinal Profile and not more than 10 mm in the Cross Profile.

3.2 BASE COURSE : WATER BOUND MACADAM

1. Quality of Material (for Ongoing Works)

- **Grading of Coarse Aggregates :** Check grading for coarse aggregate on at least one sample from each km length.
- **Flaky and Elongated Aggregates :** Visually observe if the proportion of flaky aggregate exceeds the specified limit.
- **Grading of Screenings :** If softer aggregates like brick ballast are used, screenings may not be required. Where screenings are to be used, a representative sample should be subjected to a grading test. If it does not meet the specified grading requirements, two more samples should be taken and average of the three test results should be taken. Similarly, a sample of screenings passing 425 micron sieve should be checked for Plasticity Index using the Syringe method.
- **Plasticity of Binding Material :** Where the Screenings used are of a crushable type, binding material is not required. The plasticity index of the binding material (on sample passing 425 micron sieve) can be checked using simple syringe test (Appendix 1, Para 8).

2. Completed Section

For random checking of completed WBM layer, the following procedure shall be followed.

(i) Dig a pit 0.5 m x 0.5 m in area into the compacted WBM layer and take out all the WBM material from the pit.

Test 1

Refill the pit with the dug material without compacting. If the pit can be filled by using not more than 65% of the dug material, it is indicative of adequate compaction and use of specified quantity of all materials combined together.

Test 2

(ii) Separate out the portions of the WBM material passing and retained on 11.2 mm size sieve when Type B Screenings have been used. Where Type A Screenings have been used, the proportions of WBM material passing and retained on 13.2 mm size sieve should be determined.

(iii) Measure the loose volumes of the two portions using cylinders of known volume and compare the combined volume with the combined specified quantities of Coarse Aggregate + Screenings + Binding Material.

(iv) The volume of material retained on 11.2 mm size sieve (or 13.2 mm size sieve, as the case may be) shall be compared with the specified quantities of coarse aggregate viz 0.91 to 1.07 cu m per 10 sq m for WBM gradings 2 and 3. Due allowance shall be made for crushing during rolling.

(v) The material passing 11.2 mm size sieve (or 13.2 mm size sieve, as the case may be) shall be compared with the specified quantities of Stone Screenings and Binding Material or Crushable Screenings as the case may be.

(vi) For the Coarse Aggregates, the quality may be checked by conducting an Aggregate Impact Test and determining the presence of any oversize aggregates.

(vii) For the finer fractions passing IS 425 micron size sieve, the Plasticity Index shall be determined to check that it is less than 6.

3.3 SHOULDERS

1. Quality of Material in Shoulders

Check, by visual classification, the type of material used in the shoulders.

2. Degree of Compaction

Check the degree of compaction of the shoulder material by an insitu density test @ atleast one test per km length, or part thereof. If it does not meet the specified requirement of 100% compaction, two more insitu density tests should be conducted and all the 3 test results reported.

3. Cross fall

Determine the cross fall, using appropriate Straight Edge, on the shoulders. Check if the measured cross fall is 1% higher than the camber on the main carriageway. If not, the same should be reported.

4. Provision of Brick/ Stone Block Edging

Check, if the quality of Bricks / Stone Blocks used meet the specified requirements.

5. Provision of Gravel Shoulders

Where there is a provision of gravel shoulders in the Contract, check if the gravel used meets all the quality requirements and has been compacted to the specified density.

4. SECTION 500: BITUMINOUS CONSTRUCTION

4.1 Prime Coat

1. Material

Check that Slow Setting bituminous emulsion with required viscosity and quantity as per Table 502.1 has been used and that where bituminous cutback has been used, it is only in situations of sub-zero temperatures or in emergency applications.

2. Application of Bituminous Primer

(i) Check if the surface to be primed has been properly prepared.

(ii) Check that only self-propelled or towed sprayer is used and that spraying with the use of a perforated canister has not been resorted to.

(iii) Check if the rate of spray of primer has been checked by a tray test at least twice a day.

(iv) Check if the sprayed primer is cured for atleast 24 hours before opening to traffic.

4.2 Tack Coat

1. Material

(i) Check, if the type of binder used for tack coat is a bituminous emulsion of RS-1 grade and not a straight-run bitumen.

(ii) Check, if a bituminous cutback is used, it is only in areas of sub-zero temperature or in emergency applications.

(iii) Check that the rate of application of bituminous emulsion has been selected on the basis of the type of receiving surface as per MORD Specifications.

2. Application of Binder

(i) Check, if the surface receiving the tack coat has been properly prepared.

(ii) Check that only self-propelled or towed sprayer is used and that spraying with the use of a perforated canister has not been resorted to.

(iii) Check, if the rate of spray of binder has been checked by a tray test, atleast twice a day.

(iv) Check that the tack coat has been left to cure until all volatiles have evaporated and that no traffic is allowed to ply on the tack coat.

4.3 Bituminous Wearing Course-Surface Dressing

1. Aggregate

(i) Check, if the size of aggregate in use is appropriate to the surface on which it is being laid and the anticipated traffic on the road.

(ii) Check, visually, if the flaky aggregates do not exceed the permissible limit.

(iii) Check the aggregate for gradation (atleast one test per km length) to see if it meets the specified requirements.

(iv) Check, that the aggregates are not undergoing any amount of crushing.

(v) Check, if the 'Average Least Dimension' of the aggregate has been determined scientifically and rate of spread of aggregate is according to the Design Chart.

(vi) Where pre-coated stone chips are used, check if the mixing of stone chips and paving bitumen was carried out in a suitable mixer and that the stone chips and bitumen were heated to the specified temperatures.

(vii) Check if the pre-coated chips were allowed to cure for atleast one week or until they become non-sticky, before spreading.

2. Bitumen

(i) Check, if the bitumen is of specified penetration / viscosity grade and is heated to the required temperature, using a calibrated thermometer.

(ii) Check, if the surface receiving the surface dressing has been properly prepared and where required, properly primed.

3. Rate of Spread of Aggregate

Check the rate of spread of aggregate as explained earlier.

4. Rate of Spread of Binder

(i) Check, if the rate of spray of bituminous binder has been scientifically determined by using the design chart (considering the climate, the type of receiving surface and type of materials used etc.) and that a tray test is being used to determine the actual rate of spray of bitumen in the field.

(ii) Check if spraying of bituminous binder was carried out by a Pressure Distributor or at least by hand held lance sprayer at proper temperature.

5. Checking Completed Surface

For completed surface dressing, check:-

(i) If the size of aggregate used is appropriate to the type of receiving surface and the anticipated traffic.

(ii) If the proportion of flaky and elongated aggregates is not more than the permissible limits.

(iii) If there is any ravelling / loss of aggregate / streaking.

(iv) If the edges of surface dressing are within a tolerance limit of ±20 mm in plain and rolling terrain and ±30 mm in hilly terrain.

(v) If the surface regularity was measured with a 3 m Straight Edge.

4.4 Bituminous Wearing Course : Premix Carpet/Mix Seal Surfacing

1. Aggregate

(i) Check for the gradation of aggregate at the hot mix plant; also visually check if the proportion of flaky and elongated aggregates is within specified limits.

(ii) Check the temperatures of heated aggregate, heated binder and the mix at the hot mix plant to be within the specified limits, using appropriate thermometers.

(iii) Check the temperature of the mix at the time of laying the mix.

2. Equipment

Check that the hot mix plant used for the preparation of premix has a separate dryer arrangement for aggregate and is of appropriate capacity and type.

3. Checking Completed Project

For completed projects, check:-

(i) The thickness of layer by making test pits at random.

(ii) The binder content from test results.

(iii) The edges to be within ±20 mm in plain and rolling terrain and ±30 mm in hilly terrain.

(iv) Surface regularity at random, using a 3 m straight edge.

(v) The types of visible surface defects, if any.

5. SECTION 1100:PIPE CULVERTS

SECTION 1200: R.C.C SLAB CULVERTS AND MINOR BRIDGES

SECTION 1400: CEMENT CONCRETE CAUSEWAYS AND SUBMERSIBLE BRIDGES

5.1 Cross Drainage Works

1. Quality of Materials

(i) Check from the registers of quality control tests, the results of tests on constituents of cement concrete (coarse and fine aggregates, water and setting time of cement), steel reinforcement, bricks and stones etc.

(ii) Check the test results on 7 day/ 28 day strength as per Specifications of concrete and workability of fresh concrete (Slump test) etc. during construction.

(iii) Check the Manufacturers' Certificates for the physical and chemical test results on cement, test results on concrete/ hume pipes, bearings and plasticizers where used, sealants etc.

2. Quality of Workmanship

(i) In ongoing projects, check on the time for removal of formwork.

(ii) Check for any damage to concrete members due to settlement of support system.

(iii) Check visually for any honeycombing in concrete.

(iv) **For Pipe Culverts:**

- Check the dia of pipes and defects, if any
- Check for inlet and outlet gradients of pipes
- Check clear spacing between rows of pipes
- Check the thickness of earth cushion over pipes
- Check for plumbness in head Walls/ Return Walls.
- Check dimensions for bedding of pipes.

(v) **Slab Culverts/ Minor Bridges**

- Check the deck slab for depth and width of carriageway, overall length/ length between bearings, and camber.
- Where quality of any concrete member is in doubt, check for soundness of concrete after hardening by striking with a 0.5 kg hammer or Schmidt's Rebound Hammer.
- Check the Railings/ Kerbs/ Parapets for the specified dimensions and irregularities in alignment.

(vi) **Protective Works:**

- Check on the size and spacing of weep holes, where applicable.
- Check on the size of boulders, wire crates, length / thickness as may be applicable.
- Check for any signs of soil erosion.
- Check the length of apron.

(vii) **Cement Concrete Causeway**

- Check the provision of guard stones, guide posts, warning signs and flood gauges.
- Check the adequacy of vents (their number and spacing).
- Check that the approaches are in cutting.
- Check whether road crust has been provided in the entire width of the approaches.

(viii) **Submersible Bridges**

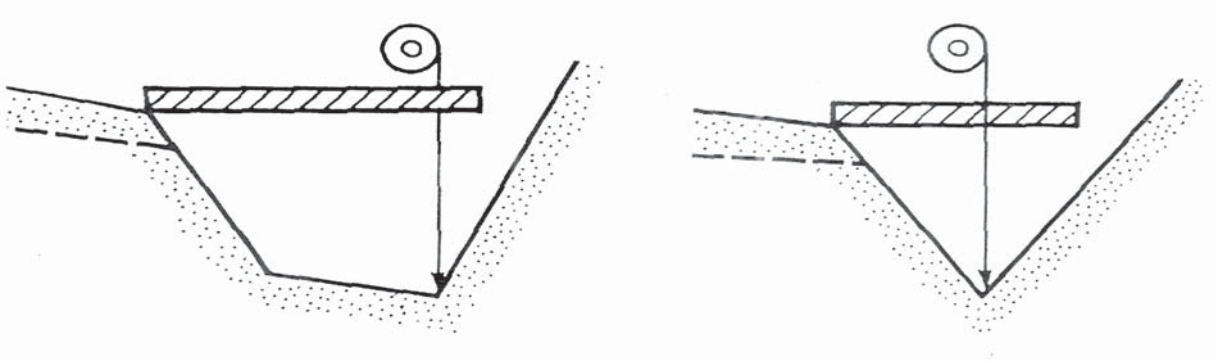
- Check the provision of anchorages to deck slab with piers / abutments.
- Check the provision of rounded / streamlined chamfers to all concrete elements.
- Check provisions of steps in slope pitching for inspection of submersible bridges

6. SECTION 1300: PROTECTION WORKS AND DRAINAGE

6.1 Side Drains and Catch Water Drains

- Check if the side drains and catch water drains are excavated to the design cross-section, measuring depth with straight edge and measuring tape (see Annex 1300.1).
- Check on the quality of lining material used in the side drains / catch water drains, where specified.
- Check on the gradients provided (using the same procedure as for checking the longitudinal gradient of a road) and compare the same with the design gradients, as per the Drainage Plan.
- Check if the outlets have been properly identified as per the approved plan.
- Check if the side drains are so located as to provide drainage from adjoining area / agricultural fields also.
- In case of any adjoining borrow pits, it must be ensured that the bed level of the pits should slope down progressively towards the nearest cross drain, if any, and should not be lower than the bed of the cross drain.

ANNEX 1300.1



Measuring depth of side drains with straight edge and measuring tape

[Source : Overseas Road Note 1 : Maintenance Management for District Engineers, 2nd Edition, TRRL (UK), 1987]

7. SECTION 1500: CEMENT CONCRETE PAVEMENT

7.1 Cement Concrete/ Semi-Rigid Pavements

1. Quality of Materials

(i) Check on the Manufacturer's Certificate on the type / grade of cement in use and results of any tests carried out at site like the setting time.

(ii) Check on the cement storage features and the length of storage.

(iii) Check from the Quality Control Registers, the test results obtained on coarse aggregates, fine aggregates and water used in cement concrete and on concrete blocks where block pavement is to be constructed.

(iv) Check the Manufacturers' Certificate on the admixture where used, pre-moulded joint filler etc.

(v) Check the cement content, water / cement ratio and dosage of plasticizer, where used, in the mix design.

(vi) Check the results on 7 day and 28 day strength of concrete.

(vii) Check the results on concrete workability (Slump cone tests), one test per 4 cu m of concrete at paving site or one test for each dumper laid at plant site.

(viii) Check on the results of aggregate gradation and moisture content.

(ix) Check the adequacy of plant / equipment used for the manufacture and placement of concrete.

(x) Check whether a Trial Length was constructed and approved.

2. Quality of Workmanship

- Check on the following
  - Width of pavement; permissible tolerances on edges of carriageway ±20 mm in plain / rolling terrains, ±30 mm in hills.
  - Surface Levels : Check whether surface levels have been checked or not.
  - Surface Regularity : the max permissible undulations measured with 3 m Straight Edge = 6 mm.
  - Surface texture to be evaluated visually.
  - Adequacy of setting of concrete, quality of joints, the joint sealing compound used, joint alignment and dimensions.
  - Straightness of side forms (steel)
  - Size, spacing, paralleling of dowel bars.

- In case of cracked concrete slabs (one panel), the acceptance criteria would be as under:
  - Slabs with cracks penetrating to more than half the depth of slab should not be accepted.
  - For cracks with depth less than half the depth of slab, no single crack should exceed 750 mm length, cumulative length of such cracks in each slab should not exceed 1250 mm.
- Check on the thickness of the pavement by actual measurements every 100 m length of pavement.

8. SECTION 1700: TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES

8.1 Road Furniture and Markings

1. Traffic Signs

General

Check, if the colour, shape, size and location of all traffic signs is as per the specified requirements.

Ensure that the citizen Information Board is installed and located at the right place with respect to the carriageway.

Check, if all sign boards are clearly visible and not hidden by plantation.

Logo and Informatory Sign Boards

(a) Material

Check on the following from Supplier's Certificate / Warranty Card.

- Concrete for footing should be of minimum M 15 Grade.
- Reinforcing steel should meet the requirement of IS:1786.
- Bolts, nuts, washers: High strength bolts should conform to IS:1367
- MS Sheets, Plates and Supports for the sign posts should conform to IS:2062
- Reflectorised Paint should conform to IS:5 or the Manufacturer's specification in case of proprietary product.
- Non-Reflectorised Paint should conform to IS:1614.
- Engineering grade sheeting should be enclosed lens type. When totally wet, the sheeting should not show les than 90% of the values of raetro-reflection given in Table 1700.1 of MORD Specifications.
- Signs with a maximum side dimension not exceeding 600 mm should not be less than 1.5 mm thick. All others should be atleast 2 mm thick.

(b) Installation

- Sign posts, their foundations and sign mounting should be so constructed as to hold these in a proper and permanent position against normal storm wind loads or displacement by vandalisin.
- All components of signs and supports, other than the reflective portion and GI posts should be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint.
- The signs should be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size in the case of reinforced concrete of GI posts.

2. Road Markings

- Check that there are no centre-line markings on single-lane roads.
- Check if the colour, width and layout of road markings is in accordance with the specified requirements.
- Check if only standard yellow colour (conforming to IS Colour No. 356), white and black colours are used for markings.
- Check, if the finished lines are free from ruggedness on sides and ends and are in true plane with the general alignment of the carriageway.
- Check, if the Contractor maintains traffic control while painting operations are in progress.

3. 200 m/ Kilometre Stones

- These may be made of local stones, concrete or any other locally available material. The stones should be bedded into the ground to a minimum grip of 600 mm with adequate plain cement concrete M 10 grade foundations.
- The dimensions of the stones, size, arrangement of letters and script should be as per IRC:8 and IRC:26.
- Kilometre stones should be located on left side of the direction of travel on the road, and fixed at right angles to the centre-line of carriageway.

APPENDIX - 1

SIMPLE/HANDFEEL TESTS

HAND-FEEL TESTS FOR MATERIALS

1. SOILS

1.1 Dilatancy Test

Remove all particles larger than IS 425 micron sieve size and prepare a pat of moist soil with a volume of about 8000 mm^3. Make the soil soft by adding water if necessary. Place the pat of soil on the open palm of one hand and shake horizontally by striking against the other hand, a number of times. A positive reaction consists of the appearance of water on the surface of the pat rendering the surface glossy, which disappears when the sample is squeezed between the fingers, the pat stiffens and begins to crumble. The rapidity of appearance of water during shaking and its disappearance during squeezing signify the nature of fines in the soil pat. While clean fine sands give the quickest reaction, a plastic clay shows no reaction at all and silts will show a fairly quick reaction by way of a shiny surface.

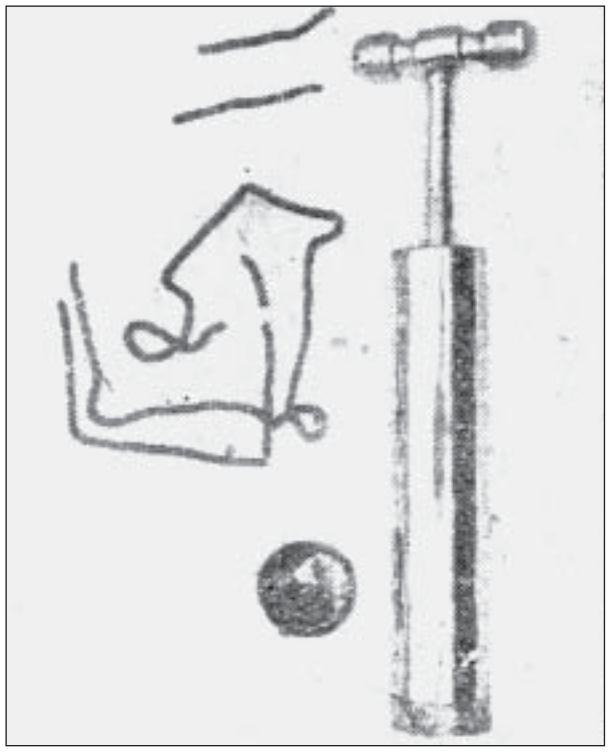
1.2 Dry Strength Test

Remove all particles larger than IS 425 micron sieve size and mould a pat of soil to the consistency of putty by adding water, if necessary. Dry the pat by air drying or under the sun or in an oven and test its strength by breaking and crumbling between fingers. The strength of dried pat of soil is indicative of its plasticity and the nature, as well as quantity of the colloidal fraction. Dry strength increases with increasing plasticity and is of a very high order in highly swelling type Black Cotton soils. While the CH soils exhibit high dry strength, the silts and silty fine sands have only slight dry strength but can be distinguished by the feel when powdering the dried sample: fine sands feel gritty while silts give a smooth feel.

1.3 Toughness Test

Remove all particles larger than the IS 425 micron sieve size and mould a soil specimen of about 12 mm cube in size, at the consistency of putty. If the soil sample is too dry, adequate amount of water should be added to bring it to the consistency of putty; if too sticky, allow it to lose some moisture by evaporation. Roll out the specimen by hand on a smooth surface or between palms into a thread about 3 mm diameter. The thread should then be folded and re-rolled separately. During such a manipulation, the thread stiffens, loses its plasticity and crumbles at a moisture content corresponding to the Plastic Limit. Lump together the pieces of crumbled thread, apply kneading action until the lump crumbles. Tougher the thread near the Plastic Limit and stiffer the lump when it finally crumbles, higher the plasticity and more potent is the colloidal clay fraction in the soil. Weakness of the thread at Plastic Limit and quick loss of cohesion of the lump below the Plastic Limit signify clay of low plasticity or such materials which occur below the “A”-line in the Plasticity Chart.

1.4 Estimating Plasticity Index Using Uppal's Syringe



UPPAL'S SYRINGE

For purposes of estimating the plasticity index for rural road works, the simple Uppal's syringe method comes in quite handy. The Uppal's syringe is shown in the Photo above. The method is extremely simple, briefly given as under:

"Make a paste of soil passing 425 micron IS Sieve, adding sufficient quantity of water so as to bring it close to the plastic limit state. The paste is put in the syringe and pushed through the holes. If the thread coming out of the holes is unbroken and shiny, the plasticity index can be considered to be more than 10. The threads do not come out of the syringe for soils having plasticity index less than 5. For soils with a plasticity index between 5 and 10, the texture of the threads is not smooth".

1.5 Tests for Presence of Deleterious Material

The presence of organic matter and / or harmful salts also need to be determined in areas infested with salts like sulphates and / or organic matter. The presence of organic matter can generally be detected by its smell and dark colour and in some cases by the presence of fibrous materials. The organic content can be determined by burning a weighed quantity of the soil and noting the loss on ignition. The presence of sulphates can be detected by adding a few crystals of barium chloride to the filtrate of soil suspension in water. If a white precipitate is formed, this gives an indication of the presence of sulphates. From the extent of milkiness of the solution, an approximate evaluation of sulphate content can be made, with experience.

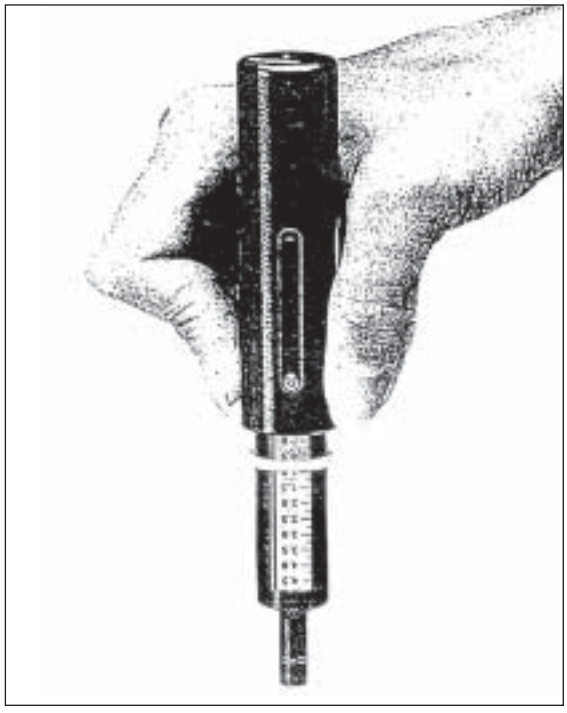
1.6 Estimating Optimum Moisture Content

Take a handful of the wet soil on the palm of hand and attempt to make a ball out of it. The moisture content at which the ball of wet soil can retain its round shape is approximately the optimum moisture content. At moisture contents below the optimum, the ball tends to crumble while at moisture contents wet of optimum, the water will tend to ooze out of the surface.

1.7 Pocket Penetrometer

Purpose

Soil strength depends on dry density and moisture content. Pocket penetrometer is used to measure soil compressive strength.

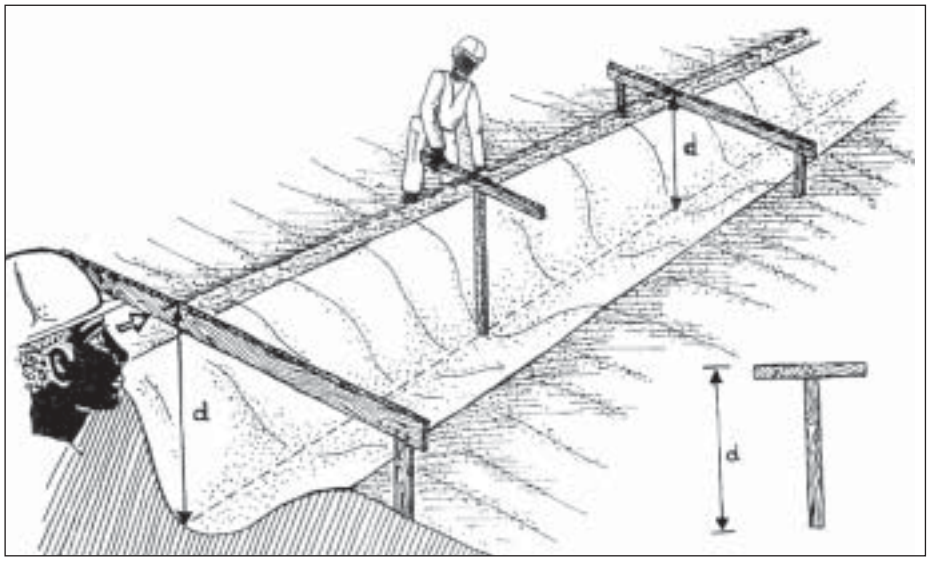


POCKET PENETROMETER

Procedure

1. Select the test location with care to avoid gravel or other particles that would influence reading. Avoid obviously disturbed areas. For saturated cohesive soils, it is important that readings be taken in “fresh” samples or cut surfaces, since rapid drying will greatly influence the reading.
2. Return ring to back position against the penetrometer body.
3. Grip the handle firmly, insert the shaft 6 mm in depth with a smooth constant force into the soil mass or sample until calibration mark is level with soil.
4. Take reading from the top of the indicator ring. Scale measures strength in kg per sq cm or tonne per sq. ft.

1.8 Simple Gadgets for Estimating Side Slopes



[Source : Road Maintenance Hand book, Vol 1, United Nations Economic Commission for Africa]

2. BRICKS

The bricks should be sound, of compact structure (as seen when broken) free from cracks and flaws. They should be regular in shape and of uniform size (dimensional accuracy) with plane faces and sharp edges. The colour should be uniform and of deep red or copper colour. The quality of bricks is generally assessed by compressive strength, efflorescence, dimensional accuracy, water absorption and evenness of baking. Some of the simple tests to fairly assess the quality of bricks are given below:

(i) In efflorescence test, a sample brick is soaked in water for 24 hours and its appearance after removal from water, should be free from white patches, the total area not exceeding 50%. In case the surface area exhibiting, patches exceed 50% of total area both the brick and water samples shall be subjected to further testing for ascertaining suitability.

(ii) In water absorption test, a brick should not absorb more than one-fifth of its dry weight after immersion in water for 24 hours.

(iii) Bricks are considered good when clear ringing sound is heard when two bricks are struck against each other. A sample brick should not break when dropped flat on hard ground from a height of about 1 m.

Correct firing promotes toughness. The bricks should not be under-burnt. A well burnt brick when scratched with a finger nail should leave no impression.

2.1 Cement-Lime (Composite) mortar

Refer to 3.2

3. STONE MASONRY

3.1 Stones

The principle 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 colour.

(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.

3.2 Cement-Lime (Composite) Mortar

Lime is classified as quick and hydraulic lime. The quick lime is obtained by calcination of pure lime stone, chalk or sea shells. It is nearly white and increases in bulk two or three times its original volume when slaked. It does not set but dissolves in water and has no cementing property.

Hydraulic lime is obtained by burning clayey lime stones or kankar and it sets and hardens under water. In Rural Road works only class A and B (hydraulic and semi-hydraulic type) lime mortars conforming to IS:712 are permitted in composite mortar. Use of quick lime is not permitted.

Strict control over mix proportion (Cement:Lime:Sand) shall be exercised to ensure that the mortar mix conforming to the mix proportion specified in the contract. Normally, a proportion of 1:3:9 (Cement:Lime:Sand) is used in masonry works.

Purity of lime shall be determined in accordance with IS:1514.

3.3 Cement Mortar

Refer to 4.4

4. CONCRETE FOR STRUCTURES

4.1 Water

Water should be clean and free from oils, acids, alkalies, vegetable and other organic impurities. Water shall be got tested before the start of works, thereafter each monsoon till completion of works. Some of the simple tests to fairly judge the suitability of water in cement-concrete works are given below:

(i) Presence of acids or alkalies in water can be tested by litmus paper. If blue litmus paper turns red, it indicates acidity; while the red litmus paper turning blue indicates alkalinity. Rapid change in colour of litmus paper indicates significant amounts of acids or alkalies.

(ii) Make two identical pats of 75 mm dia and 12 mm thick of neat cement paste, one with water under test and the other with water of known suitability. Place the pats on a clean non-absorbent surface and leave for 48 hours, and setting and hardening time observed for both the pats. If the quality of water under test is not upto mark, both setting and hardening time of the pat would be different from the one of known quality.

4.2 Cement

Cement more than three (3) months old shall be got tested to ascertain its quality and satisfy the acceptability requirements as per Table 800.11. The quality of cement can be roughly judged by the following:

(i) Thrust a hand into a cement bag. It must give cool feeling. There should be no lump inside.

(ii) Take a pinch of cement and feel between the fingers. It should give a smooth and not a gritty feeling.

(iii) Take a handful of cement and throw it in a bucket full of water. The particles should float for sometime before they sink.

(iv) Take about 100 gm of cement and mix it with water to make a stiff paste. Make a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket, without disturbing the shape of cake. After 24 hours, the cake should retain its original shape and gain some strength.

(v) **Setting time**: Make a stiff paste of neat cement and water, and form it into a pat of about 75 mm dia and 12 to 25 mm thick. The pat should commence to set in 30 to 60 minutes. The commencement of setting can be roughly estimated by pressing the uncut end of a lead pencil into mass. The resistance to piercing increases suddenly when setting commences. In 18 to 24 hours, the pat should have hardened sufficiently so that a scratch can be made with a thumb nail.

(vi) **Soundness**: Boil the set pat (as above) in water for about 5 hours. The pat should remain sound and hard and should not swell, crack or disintegrate, but may show only hair cracks. Reject cement if pat shows radial cracks or curl or crumble.

(vii) **Fineness**: In the sieve test, 100 gm cement is correctly weighed and placed on 90 micron sieve. Air set lumps, if any, are broken down with fingers. The sample is sieved for 15 minutes and the residue left on the sieve is weighed. The amount of residue should not exceed 10% for OPC.

4.3 Sand or Fine Aggregate

The sand should be sharp, clean, chemically inert, coarse and gritty to the touch and free from silt / clay and organic impurities. The general quality of sand can be assessed as below:

(i) **Presence of Silt or Clay**: Rub a sample of sand between damp hands and note the discolouration caused on the palm. If the sand is clear, the palm would be stained slightly. If the hands stay dirty after sand has been thrown away, it indicates too much of silt or clay.

(ii) **Sedimentation:** Place, without drying, a sample of sand in a 200 ml measuring cylinder upto 100 ml mark. Add clean water upto 150 ml mark. Shake the contents vigorously and allow it to settle for 3 hours. The height of the silt visible as a layer above the sand is expressed as a percentage of the sand below.

(iii) **Organic impurities:** Shake the sample with an equal volume of 3% solution of NaOH (Caustic soda) and allow it to settle for 24 hours. Examine the colour of the liquid above the sand. Clear or pale yellow colour shows that the sample is tolerably free from organic impurities. Dark yellow or brown tinge shows that the sand should be washed and tested again. If on retesting, dark yellow colour persists, the sand should be rejected.

4.4 Cement-Mortar

(i) The cement mortar if unused for more than 30 minutes after addition of water shall be rejected and removed from site.

(ii) The mix proportion of cement: sand can be checked as follows:

Take about 200 gm of green cement mortar and add 100 ml of water in a measuring jar and shake the contents well and allow the contents to settle. While the sand gets deposited at the bottom, cement shall settle above. From the volumes of each, the approximate proportion of cement and sand can be determined.

(iii) **Consistency:** Mortar consistency can be checked by the following:

(a) If a small quantity of mortar is dropped from a trowel, the trowel ought to be left perfectly clean.

(b) A little mortar worked gently in the hands should be easily moulded into a ball; on the surface of which water would appear.

(c) When the ball is dropped from a height of half a meter (500 mm) on a hard surface, it must retain its rounded shape.

4.5 Coarse Aggregate

Coarse aggregates shall be hard, strong, non-porous, free from friable, elongated and laminated particles. They shall be clean and free from clay, coal, vegetable and other organic material.

Two simple tests to check the suitability of stone aggregates are given below:

(i) If the aggregates of a known quantity absorb more than 10 percent of their weight after 24 hours immersion in water, they are considered porous and are avoidable.

(ii) If Mica inclusions persist on the surface, the stone aggregates shall be rejected as presence of Mica affects durability of concrete.

However, the detailed tests indicated in Table 800.13 are to be conducted before the use of coarse aggregates in concrete bridge works.

4.6 Cement Concrete

The principal requirements of concrete include workability, strength, durability, impermeability, and volume changes. Some of the simple tests to determine quality of concrete are described below:

(i) **Consistency**: The concrete can be considered to satisfy consistency requirement if an ordinary iron rammer sinks into concrete mixture by its own weight. It shall run-off a showel unless showelled very quickly; and shall spread out and settle to a level surface after wheeling for about 8 m distance in a wheel barrow.

(ii) **Workability**: Take a handful of concrete in left hand and make a round ball with both hands. If a ball can be maintained for a while, it is indicative of a 'workable mix'. Any low or high content of water cannot make a good ball of concrete.

(iii) **Alkali Silica Reaction (ASR)**:

Alkali Silica reactivity is noticed in aggregates crushed with siliceous rock. When aggregates are immersed in water, a slight increase in volume occurs. If alkali content in Portland cement is less than 0.6 percent by weight, no harmful reaction occurs.

The Basalt rocks found in parts of Deccan plateau, Madhya Pradesh, Kathiawar peninsula of Gujarat, Jammu & Kashmir, Jharkhand and West Bengal should be viewed with caution. Similarly, some lime-stones containing chert modules occurring in Madhya Pradesh, Rajasthan, Punjab and Assam are reactive.

Due to ASR, normally damp patches are visible at the junction of cracks, the edges of cracks often appear light in colour, the concrete often has an uncharacteristic pinkish appearance in the affected areas. There will be negligible spalling of concrete but exudation may occur from some of the cracks.

If aggregates are suspect of likely positive ASR on the basis of past performance or any evidence, it is always recommended that the aggregates are tested as per IS:2386 part 7 before they are approved for use in making concrete.

APPENDIX - 2

(Refer Section 105)

GUIDELINES FOR APPROPRIATE TECHNOLOGY FOR RURAL ROAD CONSTRUCTION

In view of the rural road projects being relatively small in size, the sites of work generally scattered and level of accessibility of project site often being poor, there is need for adopting appropriate technology. An appropriate technology is a blend of manual methods and small capacity mechanical equipment generally using agricultural implements towed by tractor, which would attain the desired quality standards at minimum cost.

The Construction Equipment which best meets the quality requirements at minimum cost for various construction operations are mostly tractor-towed, since agricultural tractors are increasingly becoming available in rural areas. Moreover, agricultural tractors are not used for agricultural purposes all the year round and can be utilized for road construction and maintenance works for sufficiently long periods of time during the year. The appropriate technologies which can be adopted for the more common construction operations are as under:

1. **Earthwork and Subgrade Construction**

• For clearing, grubbing and excavation	:	Rippers towed by agricultural tractor
• For hauling of earth	:	Agricultural tractor-trailer
• For spreading of soil in layers	:	Spreading blades attached to agricultural tractor
• For adding water	:	Water Bowser towed by agricultural tractor
• For mixing of soil with water	:	Agricultural tractor-towed disc harrows
• For compaction in earthwork and subgrade construction	:	80-100 kN static smooth-wheeled road roller for compacted hickness of 100 mm.

2. **Mechanical Stabilization**

Besides the appropriate equipment list under 1 above, for the mixing of different locally available materials for mechanical stabilization, an agricultural tractor-towed Rotavator can be used.

3. **Lime/Cement Stabilized Soil Construction**

• Pulverization of soil clods	:	Agricultural tractor-towed disc harrows
• Adding water	:	Agricultural tractor-towed water browser
• Spreading of Lime / Cement stablizer over pulverized soil	:	Placing bags of lime / cement at predetermined distances for spreading the required quantities
• Mixing of soil with stabilizer	:	Agricultural tractor-towed Rotavator
• Compaction	:	80-100 kN smooth-wheeled Roller

- Curing : Covering the compacted stabilized soil surface with wet gunny bags and sprinkling water.

4. **Surface Dressing**

- Applying Prime Coat : Hand-held lance with sprayer operated by Compressor
- Heating Bitumen : Bitumen Boiler of small capacity
- Applying Binder : Hand-held lance with sprayer, operated by Compressor
- Spreading stone chips : Agricultural tractor-towed Spreader Box
- Rolling : 80-100 kN smooth -wheeled roller

5. **Premix Carpet**

- Applying Prime Coat : Hand-held lance provided with sprayer, operated by compressor
- Applying Tack Coat : Hand-held lance provided with sprayer, operated by compressor
- Mixing of aggregates and bitumen in specified quantities : Mini Hot Mix Plant, capacity of with around 6 tonnes / hour
- Transporting from the mixer to site : Tarpaulin- covered tractor-trailer or hand barrows

APPENDIX-3

LIST OF IRC PUBLICATIONS

Sr. No.	Code/ Document No.	Title of the Publication
		1. ROADS
		1.(A). Transport Planning, Traffic Assessment & Policies
1.	IRC:3-1983	Dimensions & Weights of Road Design Vehicles (First Revision)
2.	IRC:9-1972	Traffic Census on Non-Urban Roads(First Revision)
3.	IRC:71-1977	Recommended Practice for Preparation of Notations
4.	IRC:SP:24-1984	Guidelines on the Choice and Planning of Appropriate Technology in Road Construction
		1. (B). Road Geometric & Design Features
1.	IRC:12-1983	Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling and Motor-Fuel Filling-cum-Service Stations (Second Revision)
2.	IRC:32-1969	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
3.	IRC:38-1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
4.	IRC:39-1986	Standards for Road-Rail Level Crossings (First Revision)
5.	IRC:54-1974	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic
6.	IRC:64-1990	Guidelines for Capacity of Roads in Rural Areas (First Revision)
7.	IRC:66-1976	Recommended Practice for Sight Distance on Rural Highways
8.	IRC:70-1977	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas
9.	IRC:73-1980	Geometric Design Standards for Rural (Non-Urban Highways)
10.	IRC:80-1981	Type Designs for Pick-up Bus Stops on Rural (i.e. Non-Urban) Highways
11.	IRC:86-1983	Geometric Design Standards for Urban Roads in Plains
12.	IRC:98-1997	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (First Revision)
13.	IRC:99-1988	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads

Sr. No.	Code/ Document No.	Title of the Publication
14.	IRC:103-1988	Guidelines for Pedestrian Facilities
15.	IRC:106-1990	Guidelines for Capacity of Urban Roads in Plain Areas
16.	IRC:SP:23-1983	Vertical Curves for Highways
17.	IRC:SP:41-1994	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
1.(C). Road Markings		
1.	IRC:30-1968	Standard Letters and Numerals of Different Heights for Use on Highway Signs
2.	IRC:35-1997	Code of Practice for Road Markings(with Paints) (First Revision)
1.(D). Road Furniture & Signage		
1.	IRC:8-1980	Type Designs for Highway Kilometre Stones (Second Revision)
2.	IRC:25-1967	Type Designs for Boundary Stones
3.	IRC:26-1967	Type Design for 200-Metre Stones
4.	IRC:31-1969	Route Marker Signs for State Routes
5.	IRC:67-2001	Code of Practice for Road Signs (First Revision)
6.	IRC:79-1981	Recommended Practice for Road Delineators
7.	IRC:SP:31-1992	New Traffic Signs
1.(E). Road Safety & Traffic Management		
1.	IRC:53-1982	Road Accident Forms A-1 and 4 (First Revision)
2.	IRC:SP:27-1984	Report Containing Recommendations of IRC Regional Workshops on Highway Safety
3.	IRC:SP:32-1988	Road Safety for Children (5-12 Years old)
4.	IRC:SP:44-1994	Highway Safety Code
5.	IRC:SP:55-2001	Guidelines for Safety in Construction Zones
1.(F). Embankment Construction & Erosion Control		
1.	IRC:10-1961	Recommended Practice for Borrow pits for Road Embankments Constructed by Manual Operation
2.	IRC:28-1967	Tentative Specifications for the Construction of Stabilised Soil Roads with Soft Aggregate in Areas of Moderate and High Rainfall

Sr. No.	Code/ Document No.	Title of the Publication
3.	IRC:33-1969	Standard Procedure for Evaluation and Condition Surveys of Stabilised Soil Roads
4.	IRC:36-1970	Recommended Practice for Construction of Earth Embankments for Road Works
5.	IRC:56-1974	Recommended Practice for Treatment of Embankment Slopes for Erosion Control
6.	IRC:75-1979	Guidelines for the Design of High Embankments
7.	IRC:SP:58-2001	Guidelines for Use of Flyash in Road Embankments
1.(G). Non-Bituminous Base and Sub-Base		
1.	IRC:19-2005	Standard Specifications and Code of Practice for Water Bound Macadam (Third Revision)
2.	IRC:49-1973	Recommended Practice for the Pulverization of Black Cotton Soils for Lime Stabilisation
3.	IRC:50-1973	Recommended Design Criteria for the Use of Cement Modified Soil in Road Construction
4.	IRC:51-1992	Guidelines for the Use of Soil-Lime Mixes in Road Construction (First Revision)
5.	IRC:60-1976	Tentative Guidelines for the Use of Lime- Flyash Concrete as Pavement Base or Sub-Base
6.	IRC:63-1976	Tentative Guidelines for the Use of Low Grade Aggregates and Soil Aggregates Mixtures in Road Pavement Construction
7.	IRC:74-1979	Tentative Guidelines for Lean-Cement Concrete and Lean-Cement Flyash Concrete as a Pavement Base or Sub-Base
8.	IRC:88-1984	Recommended Practice for Lime-Flyash Stabilised Soil Base / Sub-Base in Pavement Construction
9.	IRC:109-1997	Guidelines for Wet Mix Macadam
10.	IRC:SP:59-2002	Guidelines for Use of Geotextiles in Road Pavements and Associated Works
1.(H). Design, Construction and Maintenance of Flexible Pavements		
1.	IRC:14-2004	Recommended Practice for Open graded Premix Carpet (Third Revision)
2.	IRC:16-1989	Specification for Priming of Base Course with Bituminous Primers (First Revision)

Sr. No.	Code/ Document No.	Title of the Publication
3.	IRC:19-2005	Standard Specifications and Code of Practice of Water Bound Macadam (Third Revision)
4.	IRC:20-1966	Recommended Practice for Bituminous Penetration Macadam (Full Grout)
5.	IRC:27-1967	Tentative Specifications for Bituminous Macadam (Base & Binder Course)
6.	IRC:34-1970	Recommendations for Road Construction in Waterlogged Areas
7.	IRC:37-2001	Guidelines for the Design of Flexible Pavements (Second Revision)
8.	IRC:47-1972	Tentative Specification for Built-up Spray Grout
9.	IRC:55-1974	Recommended Practice for Sand-Bitumen Base Courses
10.	IRC:82-1982	Code of Practice for Maintenance of Bituminous Surfaces of Highways
11.	IRC:95-1987	Specification for Semi-Dense Bituminous Concrete
12.	IRC:110-2005	Standard Specifications and Code of Practice for Design and Construction of Surface Dressing
13.	IRC:SP:53-2002	Guidelines on Use of Polymer and Rubber Modified Bitumen in Road Construction (First Revision)
1.(I). Design, Construction and Maintenance of Cement Concrete Pavements		
1.	IRC:15-2002	Standard Specifications and Code of Practice for Construction of Concrete Roads (Third Revision)
2.	IRC:44-1976	Tentative Guidelines for Cement Concrete Mix Design for Pavements (for Non-Air Entrained and Continuously Graded Concrete) (First Revision)
3.	IRC:57-1974	Recommended Practice for Sealing of Joints in Concrete Pavements
4.	IRC:58-2002	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Second Revision) (with floppy)
5.	IRC:61-1976	Tentative Guidelines for the Construction of Cement Concrete Pavements in Hot Weather
6.	IRC:68-1976	Tentative Guidelines on Cement-Flyash Concrete for Rigid Pavement Construction
7.	IRC:77-1979	Tentative Guidelines for Repair of Concrete Pavements Using Synthetic Resins

Sr. No.	Code/ Document No.	Title of the Publication
8.	IRC:84-1983	Code of Practice for Curing of Cement Concrete Pavements
9.	IRC:91-1985	Tentative Guidelines for Construction of Cement Concrete Pavements in Cold Weather
10.	IRC:SP:49-1998	Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement
11.	IRC:SP:62-2004	Guidelines for the Design and Construction of Cement Concrete Pavement for Rural Roads
12.	IRC:SP:63-2004	Guidelines for the Use of Interlocking Concrete Block Pavement
13.	IRC:SP-68-2005	Guidelines for Construction of Roller Compacted Concrete Pavements
1.(J). Project Preparation, Contract Management and Quality Control		
1.	IRC:42-1972	Proforma for Record of Test Values of Locally Available Pavement Construction Materials
2.	IRC:SP:16-2004	Guidelines for Surface Evenness of Highway Pavements (First Revision)
3.	IRC:SP:19-2001	Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)
4.	IRC:SP-20-2002	Rural Roads Manual
5.	IRC:SP:57-2001	Guidelines for Quality Systems for Road Construction
1.(K). Hill Roads		
1.	IRC:52-2001	Recommendations About the Alignment Survey and Geometric Design of Hill Roads (Second Revision)
2.	IRC:SP:48-1998	Hill Road Manual
1.(L). Road Drainage		
1.	IRC:SP:42-1994	Guidelines on Road Drainage
2.	IRC:SP:50-1999	Guidelines on Urban Drainage
1.(M). Road Machinery		
1.	IRC:43-1972	Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction
2.	IRC:72-1978	Recommended Practice for Use and Upkeep of Equipment, Tools and Appliances for Bituminous Pavement Construction

Sr. No.	Code/ Document No.	Title of the Publication
3.	IRC:90-1985	Guidelines of Selection, Operation and Maintenance of Bituminous Hot Mix Plant
4.	IRC:SP:22-1980	Recommendations for the Sizes for each Type of Road Making Machinery to Cater to the General Demand of Road Works
5.	IRC:SP:25-1984	Gopi and his Road Roller-Guidelines on Maintenance of Road Rollers
6.	IRC:SP:29-1994	Directory of Indigenous Manufacturers of Road / Bridge Construction Machinery & Important Bridge Components (First Revision)
7.	IRC:SP:34-1989	General Guidelines About the Equipment for Bituminous Surface Dressing
2. Bridges		
2.(A). Codes of Practice		
1.	IRC:5-1998	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Seventh Revision)
2.	IRC:6-2000	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision)
3.	IRC:21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III – Cement Concrete (Plain and Reinforced) (Third Revision)
4.	IRC:22-1986	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (First Revision)
5.	IRC:24-2001	Standard Specifications and Code of Practice for Road Bridges, Section V – Steel Road Bridges (Second Revision)
6.	IRC:40-2002	Standard Specifications and Code of Practice for Road Bridges, Section IV – Brick, Stone and Block Masonry (Second Revision)
7.	IRC:78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure (Second Revision)
8.	IRC:83-1999	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings (First Revision)
9.	IRC:83-1987 (Part II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
10.	IRC:83-2002 (Part III)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS

Sr. No.	Code/ Document No.	Title of the Publication
11.	IRC:87-1984	Guidelines for the Design and Erection of Falsework for Road Bridges
12.	IRC:89-1997	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)
2.(B). Inspection, Maintenance & Rehabilitation		
1.	IRC:SP:35-1990	Guidelines for Inspection and Maintenance of Bridges
2.	IRC:SP:40-1993	Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
3.	IRC:SP:52-1999	Bridge Inspector's Reference Manual
2.(C). Project Preparation, Contract Management & Quality Control		
1.	IRC:SP:47-1998	Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)
2.	IRC:SP:54-1999	Project Preparation Manual for Bridges
2.(D). Other Important Publications		
1.	IRC:7-1971	Recommended Practice for Numbering Bridges and Culverts (First Revision)
2.	IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts (First Revision)
3.	IRC:SP:51-1999	Guidelines for Load Testing of Bridges

APPENDIX-4

LIST OF MINISTRY OF RURAL DEVELOPMENT AND MINISTRY OF SHIPPING, ROAD TRANSPORT & HIGHWAYS PUBLICATIONS

Sr. No.	Code/ Document No.	Title of the Publication
I.	**Ministry of Rural Development (MoRD)**	
1.	MoRD	Specifications for Rural Roads, 2004
2.	MoRD	Standard Data Book for Analysis of Rates, 2004
3.	NRRDA	PMGSY Handbook on Quality Control: Road Works, 2002
4.	NRRDA	PMGSY Operations Manual, 2005
5.	NRRDA	PMGSY Draft Guidelines for Quality Monitoring by National Quality Monitors.
II.	**Ministry of Shipping, Road Transport and Highways (MoSRTH)**	
6.	MoRT&H	Pocketbook for Bridge Engineers, 2000 (First Revision)
7.	MoRT&H	Pocketbook for Highway Engineers, 2002 (Second Revision)
8.	MoRT&H	Manual for Maintenance of Roads, 1983
9.	MoRT&H	Report of the Committee on Norms for Maintenance of Roads in India, 2001
10.	MoRT&H	Guidelines for Maintenance Management of Primary, Secondary and Urban Roads, 2004
11.	MoRT&H	Standard Plans for 3.0 m to 10.0 m Span Reinforced Cement Concrete Solid Slab Structure with and without Footpaths for Highways, 1991
12.	MoRT&H	Standard Plans for Highway Bridges R.C.C. T-Beam & Slab Superstructure – Span from 10 m to 24 m with 12 m width, 1991
13.	MoRT&H	Standard Plans for Highway Bridges PSC Girder and RC Slab Composite Superstructure for 30 m Span with and without Footpaths, 35 m Span with Footpaths and 40 m Span without Footpaths, 1991
14.	MoRT&H	Standard Drawings for Road Bridges – R.C.C. Solid Slab Superstructure (15° & 30° SKEW) Span 4.0 m to 10.0 m (with and without Footpaths), 1992
15.	MoRT&H	Standard Drawings for Road Bridges R.C.C. Solid Slab Superstructure (22.5º Skew) R.E. Span 4 m to 10 m (with and without Footpath), 1996
16.	MoRT&H	Standard Plan for Highway Bridges – Prestressed Concrete Beam & RCC Slab Type Superstructure Volume-II

Sr. No.	Code/ Document No.	Title of the Publication
17.	MoRT&H	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion
18.	MoRT&H	Type Designs for Intersections on National Highways, 1992
19.	MoRT&H	Manual for Safety in Road Design