Ministry of Rural Development
Government of India

Quality Assurance Handbook for Rural Roads

Volume - I

Quality Management System and Quality Control Requirements

(First Revision)
December 2016

National Rural Roads Development Agency

सत्यमेव जयते

Ministry of Rural Development

Government of India

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Volume-I

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December, 2016

National Rural Roads Development Agency (NRRDA)

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QUALITY ASSURANCE HANDBOOK FOR RURAL ROADS

VOLUME I

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VOLUME - II

EQUIPMENT AND PROCEDURES FOR TESTS

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नरेन्द्र सिंह तोमर
NARENDRA SINGH TOMAR



सत्यमेव जयते

ग्रामीण विकास, पंचायती राज और
पेयजल एवं स्वच्छता मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली

MINISTER OF RURAL DEVELOPMENT, PANCHAYATI RAJ
AND DRINKING WATER & SANITATION
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI

संदेश

मुझे यह जानकर प्रसन्नता हुई कि प्रधानमंत्री ग्राम सड़क योजना के तहत ग्रामीण सड़कों के लिए गुणवत्ता आश्वासन पुस्तिका का संशोधित और परिवर्द्वित स्वरूप एनआरआरडीए द्वारा जारी किया जा रहा है । ग्रामीण सड़कों के लिए गुणवत्ता आश्वासन पुस्तिका का प्रथम संस्करण पहली बार 2007 में प्रकाशित हुआ था । तब से योजना में बहुत से विस्तार और नवाचार हुए हैं, जैसे 2014 में ग्रामीण सड़कों के मानकों का संशोधन, ग्रामीण सड़कों के निर्माण में नई "हरित" तकनीकी की शुरूआत के लिए नीतियों और निर्देशों में बदलाव, सड़कों के रख रखाव पर जोर और इसके लिए नई नीतियों का निर्धारण इत्यादि प्रमुख हैं । इन सब बदलावों के परिपेक्ष्य में पुस्तिका का पहला संशोधन किया गया है ।

पुस्तिका के सभी अध्याय और वर्गों में अद्यतन मानकों की नवीनतम विशिष्टताओं, एनआरआरडीए के दिशानिर्देश और संबधित आईआरसी और बीआईएस कोड और मानकों के प्रावधानों को शामिल किया गया है और उनकी व्यापक समीक्षा की गई है । यह पुस्तिका न केवल सड़क निर्माण और गुणवत्ता आश्वासन की अद्यतन स्थिति को प्रस्तुत करती है अपितु ग्रामीण सड़कों के लिए विनिर्देशों के पुस्तक के वर्तमान संस्करण के अनुरूप भी है ।

मुझे आशा है कि ग्रामीण सड़कों के लिए गुणवत्ता आश्वासन पुस्तिका का यह संशोधित संस्करण विनिर्देशों और क्रियान्वित करने वाली एजेंसियों को मानकों की एक स्पष्ट समझ प्रदान करेगा और उन्हें गुणवत्ता से संबधित ग्रामीण सड़कों के सभी मुद्दों के प्रभावी समाधान में मदद मिलेगी ।

मैं एनआरआरडीए के अधिकारियों, विशेषज्ञ समिति के सदस्यों और सहकर्मी समीक्षा समिति के सदस्यों को इतने कम समय में पुस्तिका के संशोधित संस्करण को तैयार करने में किए गए प्रयासों के लिए धन्यवाद व्यक्त करना चाहता हूँ । मैं आशा करता हूँ कि यह पुस्तिका ग्रामीण सड़कों के गुणवतापूर्ण निर्माण में मील का पत्थर साबित होगी ।

6.12.16

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MESSAGE

Pradhan Mantri Gram Sadak Yojana (PMGSY) a programme for all weather village connectivity was launched in December, 2000. In the last 16 years, PMGSY has constructed about 4,86,000 kms. of rural roads. These rural roads are a key ingredient in ensuring sustainable poverty reduction in India. Since substantial investments are being made in the rural roads sector by Government of India, through PMGSY, it is imperative that good quality roads are constructed, meeting the laid down specifications. Rural roads should be able to perform well for the entire designed life and should adhere to quality assurance safeguards at every stage of their designed life.

I understand that the first edition of the document "Quality Assurance Handbook for Rural Roads under PMGSY" was published in 2007. Since then a number of developments such as revision of rural road specification by Indian Roads Congress (IRC), introduction of new technology in construction of rural roads and consequential revision of various Codes/ Manuals/Guidelines/Specifications etc. have taken place. Following this, various domain experts as also the programme managers have felt the need to update the Quality Assurance Handbook for Rural Roads.

I am pleased that building on the experience of last 9 years, the first revised edition of the Handbook contains latest MoRD specifications of Rural Roads, Guidelines of NRRDA relating to Quality Monitoring and the relevant IRC, BIS codes and standards. The revised edition is a thoroughly updated rendition of previous version and is in accordance with the current edition of the book of the specifications for Rural Roads. This is a unique document and would be of immense help to all States in the country to ensure quality assurance of all rural roads.

Maintenance of the huge assets created under PMGSY, is of paramount importance in keeping the rural road network in good condition. Hence, sections relating to maintenance in this Handbook have been revised and augmented to fully align with the revised MoRD specifications for Rural Roads and Maintenance Management Manual.

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I would like to acknowledge the sincere efforts put in by NRRDA officials, members of the Expert Group and Peer Review Committee in bringing out the revised edition of this document. I would also like to thank the State officials for their valuable contribution.

I am sure the revised document would help field engineers to further improve the quality of roads which has remained the hall mark of roads constructed under PMGSY.

[Amarjeet Sinha]

Dated: December 6, 2016

FOREWORD

The MoRD Specifications for Rural Roads published by National Rural Roads Development Agency (NRRDA), in collaboration with Indian Roads Congress (IRC), in January, 2014, incorporated technological developments that took place due to revision of various Codes / Manuals / Guidelines/ Specifications, etc. from the period of its first publication in the year 2004. Since then it has been extensively used by the Engineers, Contractors and others involved in the construction and maintenance of Rural Roads particularly PMGSY roads. Following this, technical experts as well as the program managers felt that there is a consequential need to revise the Quality Assurance Handbook for Rural Roads published by NRRDA in 2007. The task was entrusted to a team of domain knowledge experts, headed by Shri S.C. Sharma, Retd. DG (Roads), MoRTH.

This revised edition of Handbook has adopted the Principles of Quality Assurance as laid in the first revision of Book of Specifications, 2014 published by IRC. Volume-I of this Handbook deals with the quality management system and quality control requirements. Volume-II covers the testing equipments and test procedures.

All the Chapters and Sections have been comprehensively reviewed and updated to incorporate provisions of the latest MoRD Specifications of Rural Roads, guidelines of NRRDA in respect of Quality Monitoring and the relevant IRC and BIS codes and standards. This revised handbook presents a thoroughly updated edition of the previous version and is in accordance with the current edition of the book of Specifications for Rural Roads. "Do's and Don'ts" for each activity and items of work have also been revisited and enhanced for guidance of practicing engineer.

With extensive use of new and "green" technology as well as non-conventional/waste materials for construction of rural roads, the quality testing requirements and procedures for checking the quality of roads constructed through these new technologies and materials had become imperative. Therefore, the quality control requirements for use of cold mix, Waste Plastic, Modified Bitumen, Soil stabilization etc. and locally available marginal materials, in rural road construction, have been incorporated in the revised QAHB as per their extant Specifications. In addition to this, quality control requirements during construction and maintenance of long span bridges have been duly addressed in respective sections of this handbook.

Bio-engineering measures for slope protection and Aluminium composite materials, Retro reflective signs and road studs are new additions, in this Handbook. Quality control requirements in respect of various new Sections, which finds place in the MORD Specifications for Rural Roads, have also been added.

With enhanced significance on Maintenance of Rural Roads, sections related to Maintenance have been revised and augmented to fully align with revised MoRD Specifications for Rural Roads. Moreover, quality control requirements for maintenance of Cement Concrete Roads and Long Span Bridges have been elaborated.

Quality monitoring of the projects through independent, third party monitors at the State level as well as at the central level has also been updated in the light of the extant guidelines for field inspections, checking and reporting as prescribed by NRRDA. In addition, formats for inspection reports by second and third tier quality monitors have been covered.

This revised Handbook incorporates valuable suggestions and recommendations which were received during a National Workshop which was specifically organized to review the draft on 11th June, 2016 at IAHE, New Delhi. I would like to express my sincere appreciation to the members of Expert Group for their painstaking efforts and to all the members of Peer Review Committee for their meticulous review. I also acknowledge the valuable inputs of all the participants of the National workshop, the State officials and individuals, in bringing the document to its present shape.

I am sure that this revised and updated Quality Assurance Handbook would help field engineers to further improve the quality of PMGSY projects in significant measure. Feedback and suggestions for further improvement would be appreciated from users of this revised edition.



(RAJESH BHUSHAN)
(Director General, NRRDA) &
Joint Secretary, Ministry of Rural Development
Government of India

New Delhi
December, 2016

PREFACE

The Quality Assurance Handbook for Rural Roads was first published in 2007. Since then several developments, notably revision of the book of Specifications for Rural Roads in 2014, introduction of new technology in rural road construction and changes in policies and directives, have taken place through various initiatives of the NRRDA aimed at achieving increased cost effectiveness in the implementation of the rural road programs.

Following these developments, NRRDA undertook the task of revision of Quality Assurance Handbook for Rural Roads. For this purpose, NRRDA constituted an Expert Group headed by Shri S. C. Sharma, Former Director General (Roads) and Addl. Secretary, Ministry of Road Transport and Highways, comprising the following members experienced in various fields of roads and bridges:

1. Shri D.P. Gupta, Former DG (RD) & AS, MORTH
2. Dr. U.K. Guruvittal, Chief Scientist & Head, Geotechnical Division, CRRI
3. Shri R.S.Sharma, Former Chief Engineer, MORTH
4. Shri A.N. Dhodapkar, Former Chief Engineer(Bridges),MORTH
5. Dr. P.K. Jain Scientist (Retd.),CRRI, Delhi
6. Shri R.K. Jain, Former Chief Engineer, Haryana PWD
7. Dr. Anil Dixit, MD, Landmark Material Testing & Research Laboratory, Jaipur

All the Chapters and Sections have been comprehensively reviewed to incorporate provisions of the latest Specifications, guidelines of NRRDA and the relevant IRC and BIS codes and standards. The Expert Group prepared the draft revision of Quality Assurance Handbook in line with the revised MORD Specifications for Rural Roads-2014. The draft of Quality Assurance Handbook was reviewed by the Peer Review Committee, constituted by NRRDA under the Chairmanship of Director, Central Road Research Institute. The composition of the Peer Review Committee was as under:

1. Dr. Satish Chandra, Chairman, Director, CRRI
2. Dr. I. K. Pateriya, Director (Tech.), NRRDA
3. Shri S.S. Nahar, Secretary General, IRC
4. Dr. Lakshmy Parameswaran, Sr. Principal Scientist, CRRI
5. Shri Alok Pandey, Bridge Expert
6. Dr. Praveen Kumar, Professor, IIT, Roorkee
7. Dr. K. Sudhakar Reddy, Professor, IIT, Kharagpur
8. Shri K.N. Prasad SQC, BRRDA, Bihar
9. Shri K.C Dhruvkar, CGM, MPRRDA
10. Shri Sher Mohammad, SQC, PRBDB, Punjab
11. Shri P.B Ranbhor, CE, Maharashtra

12. Shri Prabhakar D.Hamigi, SQC, Karnataka
13. Shri C.V.Basnet, SQC, Sikkim
14. Shri. T.K Mukhopadhyaya, NQM
15. Shri Ashok Kumar Chopra, NQM
16. Shri Balwant Singh Thakur, NQM
17. Shri. K.G Mittal, NQM
18. Shri R.R Doddihal, NQM

The Peer Review Committee meeting was held on 3rd June, 2016 at CRRI. A National Workshop on Quality Assurance Handbook was organized on 11th June, 2016 at IAHE with the Chief Engineers and PIUs of State Executing Agencies along with Expert Group and Peer Review Committee. The workshop was attended by the SRRDAs and the Experts Group. The suggestions that emerged from the Peer Review Committee, State Rural Roads Development Agencies (SRRDAs) & NRRDA were incorporated in the draft of the handbook.

This handbook presents a thoroughly updated edition of the previous version and is in consonance with the current edition of the book of Specifications for Rural Roads. Volume I of the Handbook covers Quality Management System and details about Quality Control requirements. Volume II gives detailed description about equipment and test procedures. The major changes and additions incorporated in the first revision of the QA Handbook are:

Additions and modifications to Sections 401, 402, 404, 408 and 410 covering Gravel / Soil Aggregate Sub-base, Cement Stabilised Sub-base / Base, Local materials and Industrial wastes. In Section 500 for Bituminous surfacing courses, quality control requirements for two new specifications, semi-dense Bituminous Concrete and Bituminous Wearing Courses using Waste Plastic have been added.

Sections 1000, 1200, 1400 and 1900 have been completely revised and rewritten to add quality control requirements for Structural Steel, Pile foundations, Well foundations, Raft foundations, Superstructure with Reinforced Concrete construction, Prestressed Concrete construction and composite construction. Quality Control requirements have been specified for most commonly adopted type of bridge superstructures including RCC T-Beam and Slab, RCC Box Cell, Box Girder, Cast-in place voided Slabs, RCC Slab with Steel Girders. Testing and acceptance criteria for various types of Bearings and Expansion Joints have been specified.

Bio- engineering measures for slope protection in Section 1600 and Aluminum composite materials, Retro reflective signs and road studs have now been added in Section 1700.

Section 1900 for Maintenance has been revised and augmented to cover new features included in the Specifications for Rural Roads-2014. Additionally, classification of maintenance activities and maintenance inspections for roads and bridges have been added. A significant addition to the handbook is the quality control requirements for maintenance of Cement Concrete roads. Maintenance of bridges has also been elaborated to cover protective works, foundations, substructure, bearings, Superstructure and expansion joints.

Quality control requirements in respect Section 2000 (Materials for Structures) and Section 2100 (Environmental and Social Safeguards) which find place in revised Specifications for Rural Roads-2014 have been added in this updated version.

Quality Monitoring under Chapter 4 has been completely revised and updated in the light of the extant guidelines for the field inspections, checking and reporting as prescribed by NRRDA. The requirements for inspection and quality monitoring by SQMs and NQMs have been clearly defined for works under three stages (i) completed section (before commencement of DLP), (ii) during the first year of completion and (iii) during subsequent years thereafter upto end of DLP. The prescribed formats for inspection and reporting have been included in this book as Appendices 5 to 8.

Technology initiatives under PMGSY have encouraged adoption of several new specifications, materials and techniques in rural road construction (list attached at Appendix-B of this handbook). Accordingly, the quality control requirements for construction and maintenance of Rural Roads using cold mix technology (Appendix-A) and Cell filled technique (Appendix-C) have been added as in this revised version.

Quality Assurance Handbook Volume-II has also been revised and updated to include all new and additional tests, testing procedures, their significance and permissible limits as required for exercising quality control of the works executed as per the modified provisions, new materials and specifications incorporated in the current edition of the book of Specifications for Rural Roads and QA Handbook Volume-I (First Revision).

I would like to express my sincere gratitude to members of Expert Group especially Shri S.C. Sharma for his able leadership and members of Peer Review Committee for their efforts in bringing out revised version of the Handbook. I gratefully acknowledge the contribution made by the State officials and the executing agencies in providing their feedback on the draft document and support in this revision.

I would also like to give my special thanks to NRRDA team and support given by Dr. I. K. Pateriya, Director (Technical), Shri Mahesh Hiremath, Director (Projects-I), Shri R. Basavaraja, Director (Project-II) for giving valuable inputs and the team of Projects-III Division, Shri Rakesh Kumar, (Assistant Director), Smt. V.Madhavi, (Assistant Director), Shri B. R. Dhameja, (Deputy Director) & Young Engineers for their support.

We would greatly value the feedback and suggestions in this regard to keep this document updated.



(Uttam Kumar)
Director (Projects) & Chief Quality Coordinator
National Rural Roads Development Agency

New Delhi
December, 2016

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
Cu	:	Coefficient of Uniformity
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 special category states, hill states, desert areas, tribal areas and selected tribal and backward districts). 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 had been brought out in 2002 for adoption in case of all rural roads including works being carried out under the PMGSY programme. Subsequently, a detailed Book of Specifications for Rural Roads had been prepared and published through the Indian Roads Congress in August 2004. The Quality Assurance Handbook Vol I and II was developed in line with specifications and published by the NRRDA in May, 2007. The Specifications for Rural Roads have recently been revised and published in January, 2014. A strong technical under pinning has been given so that roads taken up under this programme conform to the MORD Specifications. The Quality Assurance Handbook has accordingly been revised and updated. It has retained the same structure as the original version

2. QUALITY ASSURANCE

2.1 A three-tier quality management mechanism is operational 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) engaged by NRRDA, constitutes the third tier of this arrangement. Both the first and the second tiers of the quality management structure are the responsibility of the State Government.

The scope of quality control has been extended to include the principles of Quality Assurance laid down by the Indian Roads Congress in their-guidelines on quality systems for roads(IRC:SP:57) and for bridges (IRC:SP:47). 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):** Four classes of Quality Assurance are prescribed as under:

Quality Assurance		Class
1.	Nominal QA	Q1
2.	Normal QA	Q2
3.	High QA	Q3
4.	Extra High QA	Q4

For rural roads, Class Q2 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 Q2. 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 revised in line with the Specifications for Rural Roads, MORD (First Revision, 2014). In keeping with the NRRDA's initiative to encourage use of new technologies and materials in rural road construction, quality control requirements for some new and proven materials have also been included in this Handbook.

2.4 The quality control requirements prescribed in the Book are 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 works 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 '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 including 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 at least 9 m length.

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

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

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 Chapter 3 of this Volume correspond to the Sections of the Specifications for Rural Roads of the Ministry of Rural Development, Government of India (First Revision,2014).

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

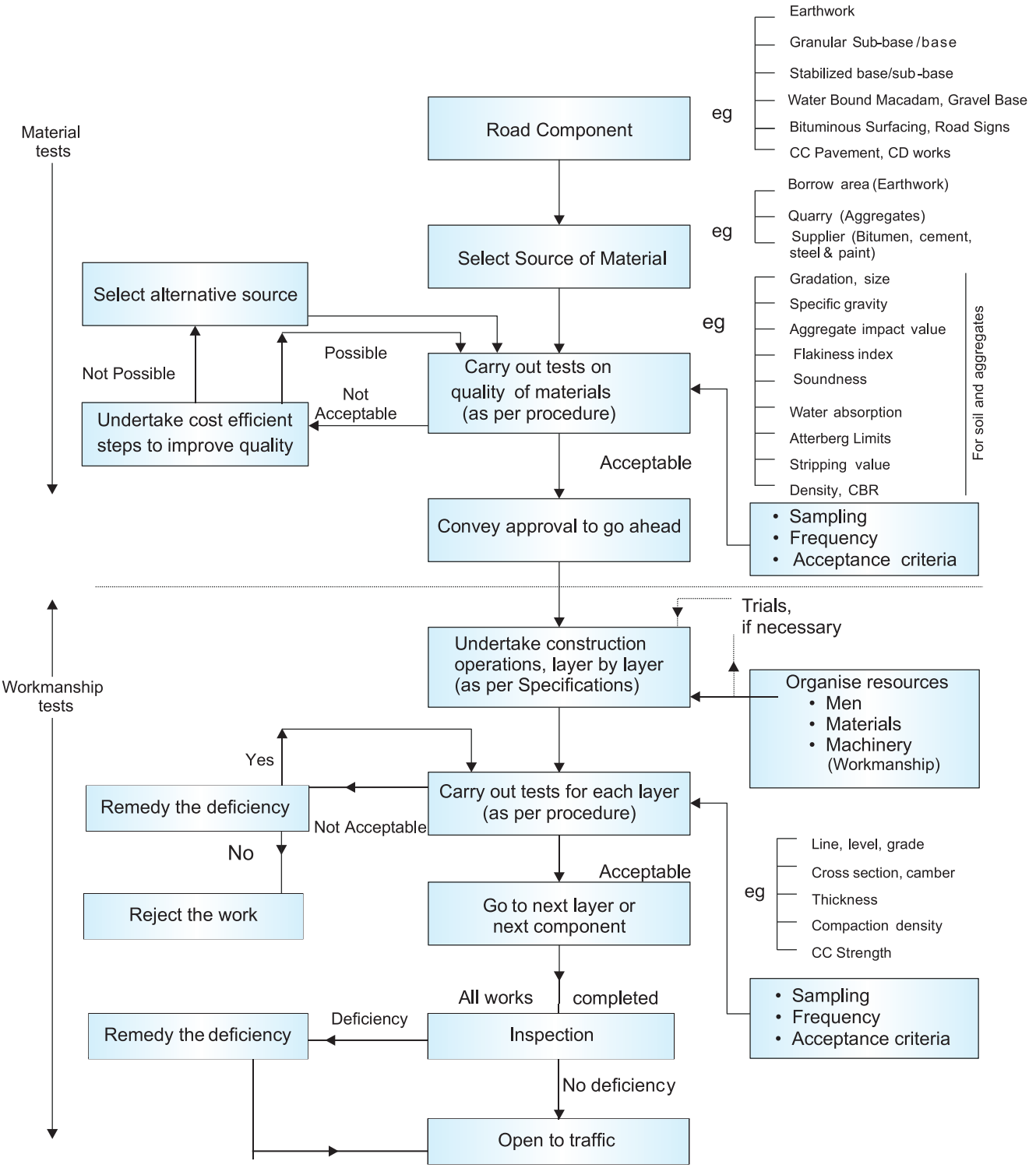


Figure 1.1: Typical Flow Chart for Quality in Road Works

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 small in size and widely scattered in remote areas with 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 locally available and other materials as provided in the MORD Specifications for Rural Roads and semi mechanized construction methods.

It is, therefore, necessary that while developing a suitable Quality Management System for both construction and maintenance work, such aspects 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.

For ensuring that the quality of assets created under various rural road programs conforms to the prescribed standards, 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 (SRRDA).

(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 and basic 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 estimates, bill of quantities etc of the project following MORD Specifications for Rural Roads, Rural Roads Manual and other

relevant IRC codes ,guidelines, standards and 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 by the Contractor.

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

(d) The work programme submitted by the Contractor has been approved by the Engineer

(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 nonconformance 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 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 oversight 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 procedures 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 the 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 and basic 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 to suggest possible improvements where required. For this, the State Quality Monitor (SQM) will be appointed by the SRRDAs to carry out and report:

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

(ii) Systemic flaws in the quality control process and action recommended 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. The number of inspections shall be limited to two inspections per day for on-going and completed works and to four inspections per day for maintenance works.

4.3 For PMGSY works, the NRRDA has prepared comprehensive Guidelines for quality monitoring under second tier in consultation with the state Governments and requested the States to ensure quality monitoring under the second tier as per these Guidelines. The State Quality Monitors are also required to upload their reports and digital photographs taken during the inspections on OMMAS.

4.4 Guidance for quality monitoring by SQMs has been provided in Chapter 4.

5. THIRD TIER

5.1 For PMGSY works, National Rural Roads Development Agency has prepared comprehensive Guidelines for quality monitoring by National Quality Monitors (NQM) under the third tier. The NRRDA has circulated the same to the states.

5.2 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.

5.3 The NQMs are also required to upload their reports and digital photographs taken during the inspections on OMMAS.

5.4 Guidance for quality monitoring by NQMs has been provided in Chapter 4**.**

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. 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. and the tests that may be required 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.

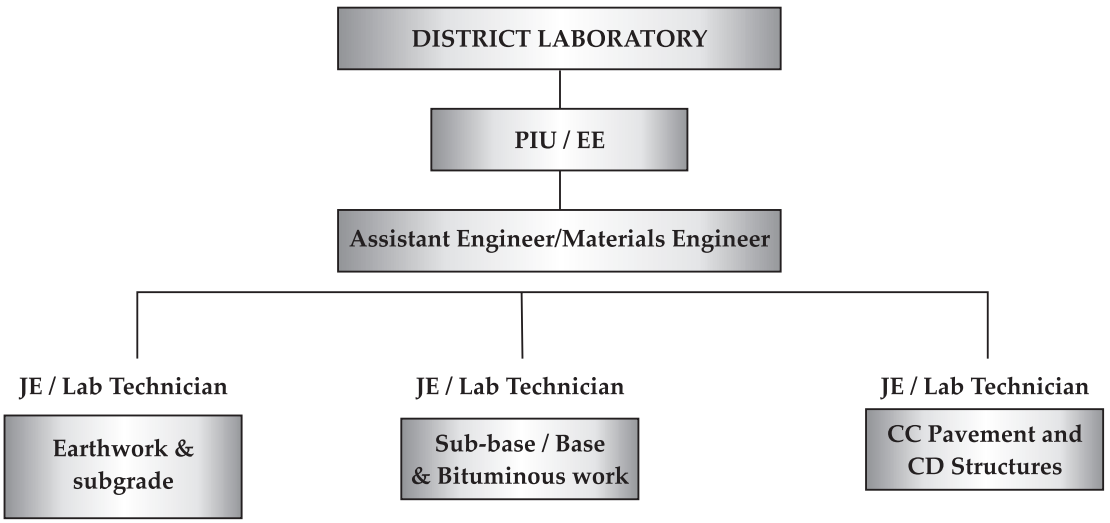


Fig. 2.1 Typical set up of a District Laboratory

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-2**.

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

QUALITY CONTROL OF WORKS

SECTION 100 GENERAL

105. CONSTRUCTION EQUIPMENT

1. For ensuring quality of work, an appropriate technology must be adopted. NRRDA has brought a Manual on Construction Equipments for Rural Roads. Suggestive List of equipments considered suitable for various components of works is given in 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 both sides of the road. All the bench marks should be tied with the Reference Bench Mark in the area. Reference Bench Marks shall be given by the Engineer as per clause 108.1 of MORD specifications.

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 terrain.

   For roads in hilly areas and on curves in plains, the interval of reference pegs should be 20 m.

   For sharp curves (radius less than absolute minimum), 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 and comply with the requirements of Section 2100 of MORD Specifications.

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 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. The workers should not handle hazardous materials without wearing protective clothing, masks, shoes etc.

111. ARRANGEMENTS FOR TRAFFIC DURING CONSTRUCTION

The Contractor shall carry out the work in a manner creating least interference to flow of traffic and take necessary measures for the safety of traffic during construction and for the safety of workers engaged for the works.

A. Methodology

1. The Contractor shall prepare a Traffic Management and Safety Plan (TMSP) for each work zone and seek approval of the Engineer.

2. The TMSP shall include inter alia provision of traffic safety devices as per IRC: SP:55, safety measures for workers engaged, first aid arrangements, personal protection equipment for workers.

3. Before taking up construction, arrangements for diversion of the traffic shall be made in consultation with the Engineer.

4. The channel for traffic at the work zone shall be clearly marked with the aid of pavement marking, painted drums or similar devices.

5. All the signs, delineators, pavement markings, lights, barricades and other traffic control devices as well as riding surface of the diversions shall be maintained in a satisfactory condition.

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. CLEARING, GRUBBING AND DISMANTLING

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, stacked and conserved for re-use.
3. All trees, stumps, etc. falling within the excavation and embankment lines should be cut to atleast 500 mm depth below ground level and in no case these fall within 500 mm of the bottom of the subgrade.
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).The girth shall be measured at a height of 1 m above ground or at the top of stump, if the height of stump is less than 1 m from the ground.
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 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 including suitability of fill material).

2 After clearing the site, mark the limits of embankment by fixing batter pegs and marking toe lines on both sides at regular intervals with reference to the centre-line as per sub-section 108.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. Any unsuitable material occurring in the embankment foundation shall be removed to the required depth and replaced with suitable material and compacted as directed by the Engineer.

5 After removing the top soil / unsuitable material, foundation for embankment construction shall be prepared. The ground shall be levelled, watered if necessary, and rolled to a well compacted surface for placement of embankment. In case where the difference between the top of the subgrade and ground level is less than 600 mm, 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 B.5.

6 The soil should be spread over the entire width of the embankment (from toe to toe) in layers not exceeding150 mm compacted thickness for compaction with static smooth wheeled rollers of 80 100 kN weight. The clods should be broken to less than 75 mm size. Each layer shall be compacted at moisture content within (±) 2% of the optimum moisture content 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 vibratory rollers of 80 to 100 kN static weight are used). If the moisture content of soil is outside (±) 2% of the optimum moisture content, it shall be made good by adding water or drying by aeration and exposure to sun till the moisture content is acceptable for compaction. Clayey soils shall be compacted on wet side of OMC.

7 Layers shall be placed, at such cross-falls so that run-off water, after a storm, shall not stagnate and water ponding does not happen. Compaction should be commenced from the edges towards centerline.

8 Each layer should be compacted to at least 98 per cent of the Standard Proctor Density. The top 300 mm of the embankment constituting the subgrade should be compacted to 100 per cent Standard Proctor Density according to Para B.5.

9 Ensure that the longitudinal and cross profiles are in conformity with the approved drawings.

10 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).

11 For widening an existing road embankment with its slopes steeper than 1 Vertical: 4 Horizontal, horizontal benches, each at least 300 mm wide, should be cut in the existing slope to accommodate placement of compaction equipment. The material obtained from cutting of benches may be utilized in the widening of embankment / subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical to 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

12 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. It shall be ensured that the compaction equipment deployed is of adequate weight and capacity to achieve the specified density.

13 The filling around culverts and bridges, for forming approaches up to a distance of twice the height of the road from the back of abutments should not be placed until the concrete or masonry has been in position for 14 days. Where it is specified to provide filter medium behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. Approval for the sequence of work and compaction equipment should be obtained from the Engineer before taking up the work.

14 Earthwork over an existing road surface shall be carried out as follows:

(a) If the existing road surface of granular or bituminous type and lies within 1m of the new formation level (top of subgrade), the same shall be scarified to a depth of 50 mm or more as specified, so as to provide ample bond between the old and new material ensuring that the thickness of the compacted soil layer interposed between the pavement and the scarified surface shall not be less than 300 mm and the soil and its compaction shall meet the requirements for the subgrade.

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

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

15 Where embankment filling is to be placed under water, only acceptable granular material shall be

used unless otherwise approved by the Engineer. Acceptable granular material shall consist of non plastic, hard, durable material with maximum particle size not exceeding 75 mm, and uniformity coefficient not less than 10. The material shall be deposited by end tipping without compaction.

16 Where provided, earthwork for high embankments (more than 6m) shall be done in stages with controlled rate of filling and allowing for settlement period as specified and approved by the Engineer.

B Quality Control Requirements

1. Materials

(a) The material used in embankment, sub-grade, shoulders, etc. shall be soil, moorum, gravel, fly ash, slag, a mixture of these or any 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 (soils containing decayed vegetable or bio-degradable material)

(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 per cent 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, when tested as per IS 2720 (Part 40).

(vii) Materials in a frozen condition.

(viii) 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 prescribed 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 percent 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 for embankment fill and 50 mm when placed in subgrade.

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

TABLE 301.1: MINIMUM DENSITY REQUIREMENTS FOR SUITABILITY OF EMBANKMENT

Type of Work	Max. laboratory dry unit weight (IS:2720 Part7)
(a) Embankments not subject to flooding	Not less than 14.4 kN/m^3
(b) Embankments subject to flooding or exceeding 3 m height	Not less than15.2 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 Terrain	Hilly Terrain
Edges of carriageway	(±) 20 mm	(±) 30 mm
Edges of roadway and lower layers of pavement	(±) 30 mm	(±) 50 mm

3. Surface Levels

The permitted tolerance in surface level for sub-grade shall be (+) 20mm and (-) 25mm.

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 and15 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

Type of Work/Material	Relative Compaction as percentage of maximum laboratory dry density
Embankment	Not less than 98 percent of Standard Proctor Density as per IS:2720 (Part7)
Sub-grade (Top 300 mm of embankment and shoulders)	Not less than100 percent of Standard Proctor Density as per IS:2720 (Part7)
Expansive clays	
i) Sub grade and 500 mm portion just below the sub-grade.	Not allowed
ii) Remaining portion of Embankment	90 -95 Percent of Standard Proctor Density as per IS:2720 (Part 7)

Note:

Compaction requirements indicated above (except for expansive clays) represent minimum threshold values which

should be attained. However, achieving compaction higher than above mentioned threshold limit values is desirable as it contributes to better performance of road.

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 TO BE USED IN EARTHWORK FOR EMBANKMENT AND FOR SUBGRADE

Type of Test	Frequency
A. Earthwork for Embankment	
1 Soil Classification as per IS:1489 i) Sieve Analysis (Wet Sieve Analysis except for cohesionless soils) ii) LL ,PL and PI as per IS 2720 (Part 5)	One test from each source for one km length or part thereof.
2. Standard Proctor Compaction Test (IS:2720 Part7). Test results to ascertain DryDensity-Moisture Content Relationship	-do-
3. Free Swell Index Test (IS: 2720 Part40)(1).	-do-
4. Deleterious Content(2) (i) Organic matter content by loss-on-ignition method or as per IS:2720-Part22 (ii) Total soluble sulphate content (IS: 2720-Part27) where suspected on past experience. This can be easily confirmed by a quick test using barium chloride.	-do- -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.) (ii) CBR Test (IS:2720Part16) soaked / unsoaked as specified	One test for each km length or par thereof, from each source.(3) 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:

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

(2) 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- Part22 and Part27 shall be done only after presence of deleterious content is confirmed by simple tests.

(3) 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: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
	Placement Moisture (IS:2720Part2) Any of the rapid test methods for determination of moisture content can be used:	At least 3 tests daily (well spread over the day's work)
	In-situ Density Measurements (IS:2720Part28) (Each layer)	At least 3 tests daily (well spread over the day's work) (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 obtained shall not be less than 1% of the specified value of degree of compaction. (For example, for the specified 100% Proctor density, 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).
	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 Part28)	(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 / cross fall and super elevation	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. Use tractor towed implements such as disc harrow, plough, etc to carry out blading, discing or harrowing until desired moisture content is obtained uniformly through the depth of the layer.	3. Do not use unsuitable material for embankment construction (Refer para B.1).
	4. Do not compact soil when it is dry or too wet not meeting the prescribed moisture requirement.
	5. Do not allow construction or other vehicular traffic over the prepared surface of embankment / sub-grade.

Do's	Don'ts
Adding the needed amount of water preferably in the previous evening helps in permeation of moisture throughout soil mass. Allow water to evaporate if soil is too wet, compact soil when moisture is within (±)2% of the optimum moisture content 4. Do maintain a camber / crossfall of 4 percent during construction for effective drainage and prevention of ponding of water. 5. 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). 6. For widening of an existing embankment cut benches in slopes and start earth work from the toeline. 7. Special attention should be paid to ensure specified compaction behind abutments / retaining walls.	6. Do not place successive layers of embankment until the previous layer has been compacted to the specified requirements and duly approved by Engineer. 7. Do not allow any damage to works, crops or other property while discharging stagnant water found in embankment foundation. 8. 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 above and away from the edge of proposed back cutting line of formation width on hill side, 1.5 m below the proposed trace cutting level on valley side) with reference to the centre-line as per sub-section 108.

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

3. Excavation shall be done manually or mechanically using excavator or tractor fitted with excavation arrangement. Two stage constructions, making 2.5 m wide track and then widening, shall be done if light vehicle communication is to be established as an urgent requirement. After excavation, the sides of excavated area should be trimmed and the area contoured to minimize erosion and ponding, allowing natural drainage to take place. Suitable material available from excavation shall be stacked and utilized as directed by the Engineer.

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 no 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 Standard Proctor density, the formation material shall be loosened to a depth of 300 mm and compacted in layers to its 100 percent Standard Proctor density (IS: 2720-Part7).

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 or the level indicated on the drawings. 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 or as otherwise specified.

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 or providing treated shoulders, the existing shoulders shall be removed to their full width and up to sub-grade level or as directed by the Engineer to enable proper compaction in the widened portions. The subgrade material in the portion excavated for widening shall be loosened up to 300 mm thickness or as directed by the Engineer and re-compacted to 100 percent Standard Proctor density.

12. All suitable materials obtained from the excavation shall be stacked for use and the unsuitable materials disposed of to the identified disposal sites as per the directions of the Engineer.

B. Quality Control Requirements

1. Horizontal Alignment

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

3. Surface Levels

The tolerance in surface level for subgrade 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 and their Frequency

In the cut formation, subgrade material shall be tested as per tests given in Table301.4-(B). If the material in the subgrade (within 300 mm depth) has a density of less than 100% of maximum dry density (IS:2720 Part7) ,the same shall be loosened to a depth of 300 mm and compacted in layers to 100% of maximum dry density. The density of compaction shall be tested as per Table 301.5 and quality control checks shall be exercised 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. 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. 3. Rocks and boulders, which are likely to cause differential settlement, should be removed to the extent of 500 mm below the formation level. 4. Take precautions during construction to ensure stability and safety of slopes. 5. Near village settlements, trenches and foundation pits should be securely fenced and provided with caution signs in the interest of public safety. 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.	1. Do not remove the benchmarks, reference lines, stakes etc. used for setting out of works without informing the Engineer. 2. Do not let the loose material / debris remain on the slopes of cutting / along the road. 3. Do not allow the rock to protrude above the formation level at any point. 4. Do not stack stone boulders on embankment or in the roadway to ensure free flow of traffic especially on hill roads. 5. Do not throw the debris on the valley side in hilly areas to avoid damage to property / environment.

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 usually compacted in two layers 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. The CBR strength of the subgrade shall satisfy the design requirements as specified.

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 (Part7).

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 up to 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(Part7).

5. If the subgrade soil does not possess the requisite engineering properties or does not meet the design CBR value, the same should be improved to meet the design and specification requirements by an appropriate stabilization technique as envisaged in section 400 or as specified in the contract or directed by the Engineer.

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. The gradation of sand shall be as per Table 8.3 in IRC SP: 20.

7. For a road in cutting, prepare the subgrade in accordance with subsection 302.

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/cum determined as per IS: 2720 (Part7) 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 (-) 25mm.

3. Surface Regularity

The maximum allowable difference between the subgrade and underside of a 3m straight edge shall not exceed 20 mm for longitudinal profile and15 mm for cross profile.

4. Quality Control Tests and their Frequency

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

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

4.3 The Quality Control Checks by AE/EE shall be as per Table 301.6- (B) Finished Subgrade.

C. Do's and Don'ts

Do's	Don'ts
1. Do ensure that borrow area material for use in subgrade satisfies the specified requirements and design CBR. 2. Do ensure that all layers in subgrade are compacted to 100% of Proctor Density as per IS: 2720 (Part7). 3. Ensure prepared subgrade surface is not disturbed by vehicular traffic.	1. Do not proceed with subgrade work until the foundation for subgrade has been duly approved by the Engineer.

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 Explosive Department concerned 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 lunch one 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 than10 charges are prepared and fired.

(xv) After blasting operations, all loose residual material below subgrade is compacted and any material removed from below subgrade 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. An audible blast warning system (siren) must be employed to warn workers on the site of the impending blast as well as clearance to re-enter the blast zone ("all clear signal"). 5. Do drill the charge holes to required depths and at suitable places. 6. 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. In case it is required to prepare the same location for more than one round of blasting, previous blast holes should be identified and new blast holes should not be drilled on top of them, as this may set off partially detonated charges present in that hole. 2. Don't use heavy dose of blasting charge.

II Pre splitting 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 pre split, 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 pre splitting holes.

3. Ensure that the slope holes for pre splitting are drilled along the line of the planned slope within the specified tolerances. The drill holes shall be 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 pre split hole. Ammonium nitrate composition blasting agents shall not be permitted in pre splitting 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 pre split 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 nor more than 75 mm in diameter. 2. Ensure that all charges in each pre splitting pattern are detonated simultaneously.	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.

305. EXCAVATION FOR STRUCTURES

A Methodology

1. Clear the site as per Section 200 and set out the limits of excavation as per Section 100. The width of excavation shall be equal to the width of the lowest footing.

2. The depth of excavation shall be equal to the depth of foundation. Where the nature of soil or depth do not permit vertical slopes, put up necessary shoring, shuttering and planking or cut slope to a safer angle.

3. Where blasting is required, carryout work and observe precautions in accordance with sub-section 304. Controlled blasting shall be done where blasting is likely to endanger adjoining foundations or other structures.

4. Where water is met within excavation, keep the foundation trenches dry when so required by pumping, bailing, providing diversion, bunds as necessary. No pumping shall be done during the placing of concrete or for at least 24 hours thereafter.

5. The foundation shall be levelled both longitudinally and transversely and slightly watered and rammed before footing is laid.

6. In case the excavation is made deeper than required, the extra depth shall be made up with concrete or masonry of the foundation.

7. Where rock stratum is encountered it shall be freed of all soft and loose material, cleaned and cut to a firm surface level or stepped as directed by the Engineer. All seams and crevices shall be cleaned and filled with cement mortar or grout. Annular space around footing shall be filled with lean concrete (1:3:6 nominal mix) up to the top level of rock. If it involves filling of more than 1.5 m above footing, lean concrete filling beyond 1.5 m shall be followed by boulders grouted with cement.

8. Refill with approved material all space between foundation masonry or concrete and the sides of excavation to the original surface in layers not exceeding 150 mm compacted thickness. Each layer shall be compacted to a density not less than the field density (before excavation) using suitable compaction equipment such as mechanical tamper, rammer, plate vibrator, etc.

9. Surplus excavated material shall be disposed of as directed by the Engineer.

B Quality Control Requirements

1. The limits of excavations for foundations shall be correct and checked in order to avoid excess cutting and refilling.
2. Shoring, shuttering and planking where required to retain side slope shall be checked for their design and adequacy with regard to the safety of works and personnel.
3. Adequacy of measures adopted for securing Safety of adjoining foundation and structures shall be checked.
4. For blasting operations sub-section 304 shall govern.
5. Concrete or masonry as specified for the foundation shall be used for making up any extra depth of excavation.
6. Material for backfilling shall be of suitable quality and compacted in layers to the density not less than the field density before excavation.
7. Ensure concrete of prescribed mix is used for filling annular space around footing in rock excavation.

C Do's and Don'ts

Do's and Don'ts for cuttings and blasting as per sub-sections 302 and 304 shall apply in addition to the following:

Do's	Don'ts
1. Ensure that slopes of foundation trench excavation are safe with due regard to safety of works and personnel 2. Near towns, villages and frequented places, provide fencing, cautions signs, markings and lights to avoid accidents.	1. Do not carry out excavation in excess of the specified dimensions. 2. Do not permit pumping during placing of concrete.

306. FLY ASH EMBANKMENT CONSTRUCTION

Fly ash is a waste residue produced after burning coal in a thermal power station. The term fly ash shall cover all types of coal ash such as pond ash, bottom ash and mound ash.

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 fly ash 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 FLY ASH 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

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 near it's 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 fly ash should start as early as possible after spreading. Each layer of fly ash 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 fly ash core and earth cover on the sides shall proceed simultaneously. After construction, fly ash 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 (Part7) 100%

9. On the top of fly ash 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-section303.

10. Following precautions should be taken while handling fly ash:

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

(ii) Stock piling of fly ash at site should be avoided.

(iii) If stock piling at site cannot be avoided, dust nuisance 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 fly ash is temporarily stock piled at site

B. Quality Control Requirements

1. Material

(a) Fly ash (Pond Ash):

Fly ash for embankment construction shall conform to the geotechnical and chemical properties specified in IRC SP: 58 "Guidelines for Use of Fly ash in Road Construction". Test results of Particle size analysis, Proctor standard Compaction test showing dry density versus optimum moisture content curve as per IS:2720 (Part 7) shall be submitted for approval of Engineer, before execution of work.

(b) Soil:

Soil for cover to the fly ash 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 Tables 301.4 and 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. 2. Place subsequent layer only after finished layer has been tested for density requirements and duly approved by the Engineer. 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. 4. Do transportation of fly ash, normally at night. 5. Location of lined drains / pucca drains should be selected judiciously, so as to avoid erosion of cover soil	1. Do not allow addition of side cover subsequent to the construction of the fly ash core. 2. Do not allow traffic in areas where fly ash is temporarily stockpiled and kept moist to avoid dusting. 3. Do not allow construction traffic or other vehicular traffic directly over the prepared surface of embankment/ sub-grade.

307. SURFACE DRAINS

A. Methodology

1. Ensure that the surface drains/roadside ditches are provided strictly according to the Drainage Plan for the road. Construction of drains needs utmost care in setting out longitudinal level, besides regular and smooth alignment in accordance with road curves. Inner edge of side drain should generally be parallel to centre line of 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. Any rock out crop in the bed of side drain should be suitably removed to avoid obstruction in smooth flow of water.
4. Ensure that the excavated bed and sides of the drains are in conformity with the specified dimensions, levels and slopes. Bed of the side drains carrying heavy discharge where longitudinal gradient of the road is steep should be made stepped to slow down velocity of flow and avoid erosion of bed.
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 and 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. 2. Do ensure that grass, when used as a lining forms a firm dense turf. 3. Ensure that vertical height of V-Shaped Drain is about 45 to 60 cms. 4. Take special precautions in built-up areas to make sure that water from any adjacent habitations does not flow over the road. 5. Take care to see that a drain/roadside ditch is deep enough to drain the sub-base/base course. 6. Side drains should be constructed backward from the location of culvert	1. Do not provide ordinarily side slopes steeper than 2:1 to avoid damage by erosion. 2. Do not leave any road side ditch/drain unlined even if it be a grass lining. 3. Do not leave any sharp edges within the cross-section to avoid damage by erosion. 4. Do not allow the bottom of road side 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.

308. SOIL EROSION CONTROL

Erosion control is one of the main factors to be considered for design of road cross section. Erosion can be minimised by using flatter slopes which blend with the terrain, design and construction of road side drains and promoting grass turfing on exposed soil surfaces. The measures for soil erosion control can be divided into two categories - temporary measures (which are required only during construction phase) and permanent measures (which become a part of finished road). Various measures required (both temporary and permanent) include construction of berm, bunds, surface drains, providing natural or synthetic geonettings, mulching and turfing, etc.

A. Methodology

1. Prepare schedules for carrying out temporary and permanent erosion control measures as applicable to different construction activities (like clearing and grubbing, excavation, etc). Ensure that such measures are as shown on drawings or as approved by the Engineer.

2. Construction of bunds and berms should be taken up as per sub-section 301. Construction of surface drains should be taken up as per sub-section 307.

3. On cut and fill slopes and verges (earthen shoulders) where erosion control measures such as

turfing with sods / seeding and mulching is provided, the work shall be done as per Clause 309 / 310 of MORD Specifications

4. When nettings are to be laid as per drawings, before laying the netting, slopes which are being treated, are to be initially demarcated, graded and levelled so that when netting is laid, it may cover the entire area flush to the ground ensuring that run-off would flow over the nettings. The demarcated area should be fertilised and a dose of seed broadcasting of locally available suitable type of grass should be carried out.

5. Jute netting or coir netting or geonettings are then laid on the prepared slope surface firmly in the direction of water flow. The netting is secured against displacement by pegging down with 15 cm long steel nails about 1.0 m apart. The top and bottom ends of fully stretched netting are to be anchored in trenches of 30 cm depth.

   Another dose of seed broadcasting or dibbling of locally available grasses is then carried out, to ensure turfing.

B. Quality Control Requirements

1. Materials

When nettings are required to be provided, ensure that they are as per relevant IS or IRC specifications. Jute nettings should be as per IS 14715, coir nettings should be as per IS 15872 and synthetic nettings should satisfy IRC 56.

When berms or bunds are constructed, quality control requirements for fill material should be as mentioned in section 301. B.

2. Dimensions

The area of treatment, side slopes and cross sections of the berms/ bunds should conform to the specified dimensions.

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that construction activities are as per approved drawings and plan. 2. Net installation and seeding should be taken up at the start of monsoon season after one or two initial rains. 3. Take up permanent measures for erosion control in time, so that necessity for temporary measures is minimized. 4. Obtain manufacturer's test certificate for every lot of geonetting. 5. Overlap of adjoining rolls of nettings should be at least 100 mm.	1. During clearing and grubbing operations do not carry out vegetation cutting and clearing beyond the area required for road construction. 2. Do not leave erodible material like excavated soil or sand exposed or unprotected during construction 3. Do not take up installation of nettings and seeding operations during summer months or during heavy rains.

SECTION 400

SUB-BASES, BASES & GRANULAR SURFACINGS

401. GRANULAR SUBASE

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 its gradation shall conform to Table 401.1-A. Where naturally occurring gravel is specified for sub-base, the material shall conform to one of the gradings given in Table 401.1-B. The physical requirements for material for sub-base (GSB) shall conform to Para B-1.

2. Remove all vegetation and other extraneous material, etc. from the subgrade already prepared as per sub- section 303, lightly sprinkle water, if necessary, and roll with two passes of 80-100 kN road roller or any other suitable compactor.

3. The sub-base material of specified gradation should be spread in layers not exceeding 100 mm compacted thickness with the help of appropriate tractor towed appliances. 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, mix can be designed as per IRC SP:89 and, mixing shall be done mechanically by the mix-in-place method using appliance like tractor towed rotavator.

5. Each layer shall be uniformly spread and thoroughly compacted. Spreading and compaction shall be carried out as per Clause 401.3.2 of the MORD Specifications.

6. Compaction should be carried out at OMC, with a tolerance limit of one per cent above to two per cent below OMC. If the loose material is dry, as compared to OMC, water should be added by sprinkling additional water from a truck mounted or trailer mounted water tank with suitable arrangement for applying water uniformly and at controlled quantities to variable widths of surface and thoroughly mixed using tractor towed disc harrows or rotavators for uniform wetting. If the GSB material has more water than OMC+2 per cent, 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 measurements and compaction control tests.

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

B Quality Control Requirements

1. Materials

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

Table 401.1-A. Where naturally occurring gravel is specified for sub-base, it shall conform to one of the gradings given in Table 400.1-B. The grading specified in the Contract shall be adopted.

TABLE 401.1-A: GRADING FOR GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Percent 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
75 micron*	< 15	< 15	< 15

* On clayey subgrades where adverse drainage conditions are encountered, the per cent passing 0.075 mm IS Sieve shall not exceed 5

TABLE 401.1-B: GRADING FOR GRAVEL SUB-BASE

IS Sieve Designation	Percent by Weight Passing the IS Sieve	
	Grading I	Grading II
53 mm	100	–
37.5 mm	–	100
26.5 mm	75 – 95	–
19 mm	–	80 –100
9.5 mm	40 – 75	55 – 80
4.75 mm	30 – 60	40 – 60
425 micron	15 –30	15 – 30
75 micron	< 15	< 15

In case river borne gravel is used, about 20 to 30 percent of crushed gravel / aggregate shall be mixed. The combined grading shall satisfy any of the prescribed grading specified in Table 401.1.A or 401.1-B

(ii) The material passing 425 micron sieve for all the gradings given in Table 401.1-A and Table 401.1-B when tested according to IS:2720 (Part 5) shall satisfy the Liquid Limit and Plasticity Index characteristics specified in Table 401.1-C.

TABLE 401.1-C: PLASTICITY CHARACTERISTICS OF GRANULAR / GRAVEL SUB-BASE

Climate	Liquid Limit	Plasticity Index	Remarks
Areas having annual rainfall more than 1000 mm	< 35	< 10	Design traffic upto 1 million standard axles (msa)
Areas having annual rainfall less than 1000 mm	< 40	< 15	Design traffic upto 1 msa
All areas irrespective of rainfall	< 25	< 6	Design traffic more than 1 msa

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

(iv) The wet Aggregate Impact Value (IS:5640) shall not exceed 50 per cent.

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 shall be formed to check the surface levels. The cross profile should conform to the required camber.

4. Surface Regularity

The maximum permitted difference between the sub-base and 3m 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

Compacted 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 at least 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
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.
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.
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.
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.
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: For new sources, test frequencies shall be at least three tests for each source)

6.2 Tests during Construction

The quality control tests to be carried out during construction are indicated in Table 401.3.

TABLE 401.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test	Frequency
Wet Sieve Analysis (IS: 2720 Part 4) on the GSB material combined in the design proportions from various sources.	At least one test to be carried out daily.
Liquid and Plastic Limit tests (IS: 2720 Part 5).	-do-
Placement Moisture Content (IS:2720 Part 2)	At least 3 tests to be carried out daily well spread over the day's work.
In-situ Density measurements (IS: 2720 Part 28).	-do-
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 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	AE / EE
2. Finished GSB Layer	(i) Degree of compaction (IS:2720 Part-28)	(a) Three tests per 2 km length or part thereof. (b) One test for each km length or part thereof.	EE
	(ii) Surface Regularity and Transverse Profile (Camber / cross fall / super elevation)	Random Checking	AE / EE

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 rotavator or grader attachment. Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. 2. Ensure that on clayey sub-grades, the percent fines passing 75 micron in the GSB material do not exceed 5 percent. 3. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly. 4. Ensure that roller speed while compacting, is about 5 kmph (About normal walking speed of humans).	1. Do not permit organic or other deleterious materials. 2. Do not use materials, which do not conform to the specified requirements. 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 SUB-BASE/BASE AND SURFACE COURSE

Gravel / Soil-Aggregate is a mixture of stone, sand and fine-sized particles in the form of naturally occurring materials or processed to meet the specified requirements for use in construction of sub-base, base and surface courses.

A. Methodology

1. The Gravel / Soil-Aggregate in sub-base, 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-A or Table 402.1-B for sub-base and base courses and as per Table 402.2-A or 402.2-B for surface course.
2. Before receiving the Gravel / Soil-Aggregate material, the subgrade, sub-base or 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 tractor with grader attachment 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, mix can be designed as per IRC SP:89 and, 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 per cent 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 Clause 402.4.2 of MORD Specifications. The thickness of compacted layer shall not exceed 100 mm for compaction with a smooth wheel roller of 80-100 kN weight and not exceed 225 mm for compaction with a vibratory roller of 80-100 kN static weight.
8. The density of each compacted layer shall be 100 per cent 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 Sub-Base/ Base shall conform to the requirements given in Table 402.1-A or Table 402.1-B while the grading for Gravel/Soil-Aggregate Surface

Course shall conform to the requirements as per Table 402.2-A or 402.2-B. For the fraction passing 4.75 mm, wet sieve analysis should be done.

The material passing 425 micron sieve for all the gradings given in Table 402.1-A and Table 402.1-B when tested according to IS:2720 (Part 5) shall satisfy the Liquid Limit and Plasticity Index characteristics specified in Table 401.1-C. for its use in sub-base course. When gravel/ soil-aggregate is being used in base course and in case a bituminous surfacing is to be provided over that base course, the material for use in construction of base shall have Liquid Limit and Plasticity Index not more than 25 and 6 respectively, when tested according to IS:2720 (Part 5). Gravel / Soil-Aggregate material to be used for surface course shall satisfy plasticity requirement as shown in Table 402.2-C.

TABLE 402.1-A: GRADING REQUIREMENTS FOR GRAVEL / SOIL-AGGREGATE MIXTURES AS PER GRADING DESIGNATION FOR SUB-BASE / BASE COURCE

Sieve Size	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 micron	10 - 19	12 - 21	12 - 21
75 micron	4 - 15	4 - 15	4 - 15

TABLE 402.1-B: GRADING REQUIREMENTS FOR GRAVEL/ SOIL-AGGREGATE MIXTURES AS PER NOMINAL MAXIMUM SIZE FOR SUB-BASE/ BASE COURCE

Sieve Size	Per cent by Weight Passing IS Sieve (Grading Designation by Nominal Maximum Size)		
	80 mm	40 mm	20 mm
80 mm	100		
40 mm	80-100	100	
20 mm	60 - 80	80 - 100	100
10 mm	45 - 65	55 - 80	80 -100
4.75 mm	30 - 50	40 - 60	50 - 75
2.36 mm	-	30 - 50	35 - 60
600 micron	10 - 30	15 - 30	15 - 35
75 micron	5 - 15	5 - 15	5 - 15

TABLE 402.2-A: GRADING REQUIREMENTS OF GRAVEL FOR SURFACE COURSE

Sieve Size	Percent by Weight Passing Designated Sieve
26.5 mm	100
19 mm	97 - 100
4.75 mm	41 - 71
425 micron	12 - 18
75 micron	9 - 16

TABLE 402.2-B: GRADING REQUIREMENTS FOR SOIL-AGGREGATE MIXTURES FOR SURFACE COURSE

Sieve Size	Percent by Weight Passing Designated Sieve
10 mm	100
4.75 mm	80 - 100
2.36 mm	50 - 80
1.18 mm	40 - 65
300 micron	20 - 40
75 micron	10 - 25

Note: Less than 10% should be retained between each pair of successive sieves specified for use except for the pair comprising the first two sieves

TABLE 402.2-C: PLASTICITY REQUIREMENT FOR SOIL-AGGREGATE MIXTURES FOR SURFACE COURSE

Climate	Liquid Limit (Max)	Plasticity Index
High Rainfall Areas (Annual rainfall > 1500 mm)	< 35	4 - 9
Medium Rainfall Areas (Annual rainfall 750 mm - 1500 mm)	< 40	6 - 15
Low Rainfall Areas (Annual rainfall < 750 mm)	< 55	15 - 30

(ii) CBR value: The material with a minimum CBR value of 20 per cent will be acceptable for gravel/ soil-aggregate sub-base layer. In case the sub-base material of 20 per cent CBR is not available within economical leads, the sub-base material meeting prescribed grading and other requirements with a soaked CBR of not less than 15 per cent can be permitted with the approval of the competent authority.

Gravel / Soil-Aggregate material for use in lower base course (layer immediately above the sub-

base) shall have a minimum soaked CBR value of 50 per cent, for use in the construction of upper base course layer; minimum soaked CBR value shall be 80 per cent.

(iii) Wet Aggregate Impact Value (IS: 5640) shall not exceed 50, 40 and 30 respectively when used in sub-base, base and surfacing course.

(iv) Flakiness Index (IS: 2386 Part I)for crushed aggregates shall not exceed 25 percent when used in base and 20 per cent when used in surfacing.

(v) In high rainfall areas, coastal areas and where local soils are salt infested, if the water absorption value of the coarse aggregate is greater than 2 per cent, the Soundness test shall be carried out on the material delivered to 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

(vi) If crushed slag is used, Clause 405.2.5 of MORD Specifications shall apply.

(vii) If crushed gravel/shingle is used in base courage 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. For using river borne gravel in sab-base layer, 20-30% per cent of the material shall be crushed before using it.

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

(ix) 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 Sub-base and 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 in sub-base layer shall be (+) 10 mm to (-) 20 mm. 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 sub-base / base / surface layer of Gravel / Soil-Aggregate 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

Compacted density shall be 100 percent 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 sub-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 sub-base / base, where predominant irregularities exist, make sure that the surface profile is corrected before spreading the Gravel/Soil-Aggregate Mix. 2. For the equipment used for mix-in-place construction, carry out trial runs to establish the suitability for the work. 3. Look for soft patches, if any and rectify them by removing or adding fresh material and compacting the same thoroughly. 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. 5. Choice of grading for sub-base shall be made depending on availability of material locally.	1. Do not permit any organic or deleterious material. 2. Do not allow manual mixing unless the width of laying is not adequate for mechanical operations, as in small-sized jobs. 3. Do not allow the speed of the roller to exceed 5 km per hour.

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

Lime treatment (also known as lime stabilization) 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 depends on the type of clay and its quantity 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 / Unconfined Compressive Strength (UCS) value as specified in the Contract. The laboratory CBR / UCS value shall be at least 1.5 times the maximum field value of CBR / UCS stipulated in contract.

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

   Alluvial soils and Moorum (PI: 10-15) 3% by weight

Clays/BC soil of medium plasticity (PI: 15-30)	3-5% by weight
Highly expansive Clays (PI: over 30)	5-6% by weight

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

TABLE 403.1 SOIL PULVERISATION REQUIREMENTS FOR LIME STABILISATION

IS Sieve Designation	Per cent Passing
26.5 mm	100
5.6 mm	80

3. The minimum thickness of layer to be lime treated shall be 100 mm when compacted. The maximum thickness of any single lime treated layer shall be 200 mm provided the mixing equipment and the roller are accepted by the Engineer based on field trials. Requisite thickness can be constructed in suitable number of layers.

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 moist soil by addition of 2 per cent lime in the first instance and leaving it overnight before adding the remaining portion of lime the next day.

6. Appropriate tractor-towed equipment, approved by the Engineer, should be used for various operations in the construction process, like pulverisation 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 during compaction shall be within (±) 2 per cent of the optimum moisture content determined as per IS: 2720 (Part 7). Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with 80-100 kN static weight smooth wheeled roller or other roller approved by the Engineer. Rolling shall be done as per Clause 403.3.8 of MORD Specifications. During rolling, the surface shall be checked for grade and camber. Rolling shall be continued until the density achieved is at least 100 per cent of the maximum dry density of the material, as determined in accordance with IS: 2720 (Part 7). Compaction should be started within 60 minutes of the start of mixing and completed within 3 hours of mixing or such shorter period as necessary during dry weather.

8. Curing of compacted lime treated layer shall be carried out for a minimum period of 7 days by spreading moist straw/ wet gunny bags or moist sand and periodical sprinkling of water.

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 Plasticity **I**ndex of the soil to be treated should 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 per cent by weight of quick-lime (CaO) when tested in accordance with IS: 1514. However, where lime of 70 percent purity is not available, Engineer may allow usage of lime having purity of not less than 50 percent, with suitable increase in lime content to achieve required strength.

(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 lime treated subgrade and 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 sub-base 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. Stabilized Mix Strength

When lime is used for improving the subgrade, the soil-lime mix shall be tested for CBR value. When lime stabilised soil is used in a sub-base, it shall be tested for CBR value or unconfined compressive strength (UCS), in accordance with Contract stipulations. The laboratory CBR/ UCS value shall be at least 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
Purity of lime (IS 1514)	One test for each lot of lime
Determination of optimum quantity of lime to attain the specified reduction in PI and/or to achieve the specified CBR/UCS	Average of two tests
Plasticity Index test (IS:2720 Part5) of the lime-treated soil(mixed with required amount of lime)	Average of two tests per km length on the representative sample of a lime-treated soil mix with required amount of lime
CBR(IS:2720 Part16) or Unconfined Compressive Strength (IS:4332 Part5) as specified, with optimum quantity of lime determined from test mentioned above	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
Pulverisation of soil clods	At least 3 tests daily, well spread over the day's work
Placement Moisture Content (IS:4332Part2)	-do-
In-situ Density measurements (IS:2720Part28)	-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
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 one test per km length or part there of	EE
	(ii) Plasticity Index of the lime-treated mix from the layer	Minimum 3 tests for each km length or part thereof	AE / EE
	(iii) Unconfined Compressive Strength (IS:4332 Part 5) when specified, sample to be 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 / EE

C. Do's and Don'ts

Do's	Don'ts
1. Use lime with Calcium Oxide (CaO) content not less than 70 per cent by weight. Where lime of the minimum specified purity (70%) 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 specified value.	1. Slaked lime supplied in air tight bags should not be stored for more than 3 months.
2. Ensure uniformity of mixing of lime with soil by mechanical means using tractor-towed rotavator.	2. Do not allow the spread lime to be blown away by wind.
3. Carry out field trials to determine optimum thickness of lime treated layer by using available mixing equipment and roller.	3. Do not accept the completion of the mixing process if any white streaks or pockets of lime are visible after mixing lime with soil.
	4. Do not use graders for mixing since they are inefficient for mixing and a large number of passes may be required.
	5. Do not allow any traffic other than mixing equipment to pass over the spread lime till mixing has been completed.

Type of Test	Frequency
4. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly. 5. After the curing period is over, subsequent pavement layers shall be laid as soon as possible to prevent surface from drying out.	6. Do not allow traffic until the lime treated layer is cured for at least 7 days. 7. Do not resort to water ponding for curing the lime treated layer.

404. CEMENT STABILISED SUB-BASE AND BASE

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

A. Methodology

1. Mix Design should be worked out to determine the optimum quantity of cement to be added to soil or locally available materials for stabilisation. A minimum laboratory 7-day unconfined compressive strength of 3.00 MPa is required for use in base courses, whereas in sub-base courses, a minimum laboratory 7-day unconfined compressive strength of 1.70 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 by weight

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

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

3. The pulverisation of soil clods, meeting the requirements of Table 403.1 and mixing of pulverised soil should be accomplished by tractor-towed implements.

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

5. The minimum thickness of layer to be cement stabilised shall be 100 mm when compacted. The maximum thickness of any single cement stabilised layer shall be 200 mm provided the mixing equipment and the roller are accepted by the Engineer based on field trials. Requisite thickness can be constructed in suitable number of layers.

6. The cement stabilised sub-base/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 pulverising and mixing the soil or locally available material with additive and water to specified degree to the full thickness of the layer being processed and of achieving the desired degree of mixing and uniformity of the stabilised material.

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 suitable for performing various operations in the construction process are tractor-towed disc harrows for pulverisation of soil clods and tractor-towed rotavator for mixing of soil or locally available material with stabiliser. Use of such equipment should be approved by the Engineer.

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

11. Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out. The moisture content of cement stabilised mix during compaction should be within (±) 2 percent of optimum moisture content (as per IS-2720 Part 7). During rolling, the surface shall be checked for grade and camber. Compacted density of at least 100 per cent 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.If total thickness of stabilized layer is being constructed in two layers, the two hour time limit will be measured from the instant water and cement are added to the sand or gravel of the first layer to the instant when compaction of the uppermost lift is completed. If the target cannot meet within this time limit, curing period of five days should be completed for the first layer before applying the next layer.

13. Curing of compacted cement stabilised layer shall be carried out for a minimum period of 7 days by spreading moist straw/ wet gunny bags or moist sand and periodical sprinkling of water.

B. Quality Control Requirements

1. Materials

(i) Materials to be stabilised: The material for cement stabilisation shall be soil including sand and gravel, laterite, kankar, brick aggregate, crushed rock, metallic slag or fly ash, pond ash or any locally available materials/ industrial wastes or any combination of these materials approved by the Engineer. For use in a sub-base course, the material shall have a grading shown in Table 404.1, and a coefficient of uniformity (Cu) not less than 5, capable of producing a well closed surface finish. For use in a base course, the material shall be sufficiently well graded to ensure a well closed surface finish and have a grading within the

range given in Table 404.1. If the material passing 425 micron sieve is plastic, it shall have a liquid limit not greater than 45 per cent and a Plasticity Index not greater than 20 determined in accordance with IS 2720 (Part 5).

TABLE 404.1: GRADING LIMITS OF MATERIALS FOR CEMENT STABILISATION

IS Sieve	Percent by weight passing within the range for Sub-base / Base
53 mm	100
37.5 mm	95 - 100
19.0 mm	45 - 100
9.5 mm	35 - 100
4.75 mm	25 - 100
600 micron	8 - 65
300 micron	5 - 40
75 micron	0 -10

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

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

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

2. Horizontal Alignment

The edges of the cement stabilised layer 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 cement stabilised sub-base will be restricted to (+) 10 mm and (-) 20 mm while for cement stabilsied 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 stabilised 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 3.0 MPa and 1.7 MPa respectively is required for cement stabilised material.

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
Quality of cement and Purity of Lime (IS:1514) (if used for pre-treatment)	One test for each lot (as per Tables 2000.4 and 2000.5 in case of cement)
Unconfined Compressive Strength Test (on 150 mm cube samples) 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
Pulverisation of soil clods	At least 3 tests daily, well spread over the day's work
Placement Moisture Content (IS:2720Part2)	-do-
Insitu Density measurements (IS:2720Part28)	-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.
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 Table403.3	AE

Stage	Test	Frequency	Designation of Inspecting Officer
	(ii) Unconfined Compressive strength (IS:4332 Part-5) Compacted cubical samples (minimum 3 samples for each test) to be prepared from mix being laid.	(a) One test for each 250 m length or part thereof. (b) One test for each 500 m length or part thereof.	AE 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. 2. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly. 3. It must be ensured that the compaction of cement stabilized materials is completed within two hours of its mixing. If total thickness of stabilised layer is being constructed in two layers, the two hour time limit will be measured from the instant water and cement are added to the sand or gravel of the first layer to the instant when compaction of the uppermost lift is completed. If the target cannot be met within this time limit, it will be required to wait for five days curing period before applying the next layer. 4. Lime, if used for pre treatment should have a minimum purity of 70 percent by weight of CaO. 5. A sample of the field mix should be brought to the laboratory for conducting various tests.	1. Do not allow soil clods larger than 26.5 mm in size before mixing of soil with cement. 2. Do not permit any organic or other deleterious material in the soil. 3. Do not carry out soil-cement stabilization when air temperature is less than 10°C. 4. Do not allow any traffic other than mixing equipment to pass over the spreaded cement till mixing has been completed. 5. Do not use graders for mixing since they are inefficient for mixing and a large number of passes may be required. 6. Do not allow any traffic until the surface is cured for 7 days. 7. Do not resort to water ponding for curing the cement stabilised layer.

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, which is known as 'Inverted Choke Layer'.

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 (Jhama) brick aggregate, or any other naturally occurring aggregates, such as kankar and 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. The edges should be first compacted with roller running forward and backward. Rolling shall proceed from inner edge to outer edge at the super-elevated portions and from the edges towards the centre in other portions.

8. Check the profile transversely and longitudinally with templates and 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. After the screenings have been applied, sprinkle water on the surface copiously, swept and rolled 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 having Plasticity Index (PI) between 4 and 6, after application of screenings. The binding material should be applied in two or more layers at a slow and uniform rate. Generally, the

quantity required for 10 sqm area of 75 mm thickness of WBM layer would be 0.06 to 0.09 cum and for 100 mm thickness it would be 0.08 to 0.10 cum. In case WBM surface is not to be covered with Bituminous surfacing, PI of binding material should be between 4 and 10.

15. The process of water sprinkling, sweeping and rolling should continue and the resulting slurry swept in with brooms to fill the voids properly and continue the operation till the resulting slurry forms a wave ahead of the 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. For lateral confinement of aggregates and proper compaction, 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

Materials other than crushed or broken stone and slag shall be used in sub-base course only. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces

(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 (After 5 cycles)			
• Loss with Sodium Sulphate	Less than 12%	Less than 12%	Less than 12%
• Loss with Magnesium Sulphate	Less than 18%	Less than 18%	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	Percent 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	75 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

*(i) The gradings for the aggregate are to be met with before using them for WBM construction. After rolling, compaction and retrieving of WBM layer for test, the grading may vary from the specified values as given in para(ii) below.

(ii) Engineer may allow ±5 per cent variation from the specified upper and lower limits excluding the first sieve in the gradings.

(iii) Grading 1 shall be used for sub-base course only. For base course Grading 2 or 3 shall be used. For surfacing, Grading 3 shall be used.

(ii) Screenings

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

(a) Physical Requirements

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

(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 9.5 mm 5.6 mm 180 micron	100 80-100 50-70 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 MM / 75 MM COMPACTED THICKNESS OF WBM SUB-BASE/ BASE / SURFACING COURSE FOR 10 M^2 AREA

	Coarse Aggregates			Screenings			
Classi-fication	Size range	Compacted thickness in mm	Loose quantity in m^3	Stone Screenings*		Crushable Screenings	
				Grading classification and size in mm	For WBM Sub-base/ Base course (loose quantity) in m^3	Properties	loose quantity in m^3
Grading 1	90 mm to 45 mm	100	1.21 to 1.43	Type A 13.2 mm	0.27 to 0.30	LL < 20; PI < 6; Per cent passing 0.075 mm sieve < 10	0.30 to 0.32
Grading 2	63 mm to 45 mm	75	0.91 to 1.07	Type A 13.2 mm	0.12 to 0.15	-do-	0.22 to 0.24
Grading 2	63 mm to 45 mm	75	0.91 to 1.07	Type B 11.2 mm	0.20 to 0.22	-do-	0.22 to 0.24
Grading 3	53 mm to 22.4 mm	75	0.91 to 1.07	Type B 11.2 mm	0.18 to 0.21	-do-	0.22 to 0.24

* Quantity of stone screenings for surface course will be about 80% of the quantity for sub-base /base course.

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 sub-base/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.

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 3M STRAIGHT EDGE

Type of Construction	Maximum Permissible Difference	
	Longitudinal Profile	Cross 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
Aggregate Impact Value Test (IS:2386 Part4)	One test from each identified source
Aggregate Water Absorption Test(IS:2386 Part3)	- do -
Soundness Test of Aggregates (where water absorption, exceeds 2 percent) (IS:2386 Part5)	- do -
Grading, LL and PI of Crushable Screenings (IS:2720 Part5) (where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed)	- do -
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
Grading of Stone Aggregates and Screenings (IS:2386Part1)	At least 2 tests to be carried out for a day's work
Flakiness Index of Stone Aggregates (IS:2386Part1)	- do -
PI of Crushable Screenings/binding material (IS:2720Part5)	- do -
Aggregate Impact Value (IS:2386 Part4)	At random one test per km
Thickness of Compacted layer	At random one test per km

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
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 (average 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. 2. Soft aggregate should bê tested for wet Aggregate Impact Value. 3. Construct shoulder simultaneously along with WBM layers. 4. Use inverted choke layer over fine grained soil sub grade. 5. Remove BT surface before WBM is laid on an existing black top road. 6. Adequate overlap (about half of the width of roller wheels) should be given during rolling operations. 7. Removed defective macadam to full depth and replace by fresh material and recompact.	1. Do not use any material derived from rocks such as phyllites, shales or slates. 2. Do not allow rounded pebbles/ shingles as coarse aggregates. If pebbles/ shingles are to be used, not less than 90 per cent of pieces retained on 4.75 mm sieve shall have at least two fractured faces. 3. Do not use local soil/ clayey material as binding material unless it meets the requirements of PI mentioned in para B1 (iii). 4. Do not use binding material if screenings are of crushable type. 5. Do not spread coarse aggregate more than 3 days in advance of any subsequent operations. 6. Do not roll if sub-grade is soft or yielding or causes a wave like motion while rolling. 7. Irrespective of roller type (vibratory or static) roller should not be driven at high speeds during rolling. Rolling speed should be about 5 kmph (Normal walking speed). 8. Do not lay WBM layer on lime treated sub-base until it has attained its strength. 9. Do not use screenings to make up depressions. 10. 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 preparing 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 same weight of material having particle size between 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 as per sub-section 407.

5. Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-base/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 by a motor grader.

6. Thickness of a single compacted WMM layer shall not be less than 75 mm. When vibratory roller or other similar types of compacting equipment approved by the Engineer are used, single compacted WMM layer thickness can be increased up to 200 mm after satisfactory field trials.

7. The surface of aggregate shall be carefully checked with templates and all high or low spots should be remedied by removing/ adding aggregates 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/ superelevation, the same shall be uniformly compacted with a suitable roller. Rolling shall commence from the lower edge and progress towards the upper edge. Thereafter, rolling should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width. Rolling shall be continued till the density achieved is at least 100 per cent 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 per cent 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
Aggregate Impact Value	IS:2386(Part4) or IS:5640	40%(maximum)
Flakiness Index	IS:2386(Part1)	25%(maximum)
If water absorption value of coarse aggregate is greater than 2 per cent, soundness test shall be carried out		
Aggregates should confirm to soundness test requirements given in table for 405.1		

(ii) Grading Requirements

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

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

IS Sieve Designation	Percent by weight passing the sieve (Maximum)
53.00 mm	100
45.00 mm	95 - 100
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 - 5
Material finer than 425 micron sieve 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 for machine laid course and ± 15 mm for manually laid course. 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
Aggregate Impact Value Test(IS:2386Part4) orIS:5640	One to two tests on representative sample from each source identified by the Contractor, depending on variability
Flakiness Index Test (IS:2386Part1)	- do -
Water Absorption Test (IS:2386Part3)	- do -
Soundness Test, if the water absorption exceeds 2 per cent. (IS: 2386 Part 5)	- do -
Grading Test (IS:2386Part1)	- do -
Atterberg Limits of portion of aggregate passing 425 micron sieve(IS:2720Part5)	- do -
Proctor Compaction Test (IS:2720Part7) (after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size) along with 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
Grading Test(IS:2386Part1)	At least one test per day
Aggregate Impact Value Test(IS:2386Part4) or IS:5640	At random one test per day
Placement Moisture Content(IS:2720Part2)	At least three tests per day
Density of Compacted Layer(IS:2720Part28)	- do -
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
Top of the Finished WMM Layer	(i) Density of the compacted layer (IS:2720Part28)	(a) One test for every 500 m length or part there of for each layer (b) One test for every 1000 m length or part there of or each layer	AE 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 per cent. 3. Build shoulders simultaneously along with WMM layers. 4. Remove BT surface before WMM is laid on an existing road. 5. Carry out field trials before using vibratory .roller to determine allowable thickness of compacted WMM layer.	1. Do not use material other than crushed stone for preparing WMM mix. 2. Do not allow segregation or pockets of coarse or fine material to be formed in WMM layer during spreading. 3. Do not allow heavy vehicles on the WMM surface without covering it with a wearing course.

407. SHOULDER CONSTRUCTION

A. Methodology

1. The construction of shoulders, comprising of either hard shoulders or earthen shoulders with brick or stone block edging on both sides 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 simultaneously along with adjoining pavement 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 (pavement layer and shoulder layer) 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 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 earthen shoulders with brick or 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. Earthen/ hard shoulder should be compacted to at least 100 per cent of the maximum dry density of the shoulder material 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 one per cent higher than the camber on the main carriageway.

B. Quality Control Requirements

1. Materials

(i) Soil to be used for earthen shoulders should have maximum laboratory dry unit weight not less 16.5 kN/m^3 (as per IS: 2720 Part 7) and Plasticity Index (PI) less than 10. Desirably, the soil used for subgrade may be used for shoulder construction. Material for hard shoulders should conform to the requirements as per Subsections 401 or 402 or as specified in the contract.

(ii) For earth shoulders with brick or stone edging, the bricks should conform to Subsection 2003. The stone blocks should conform to Subsection 2004 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 compacted 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-sections:

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 2. For protection of earth shoulders, do provide the pavement with brick/stone block edging. 3. The material for earthen shoulders should be good quality, having similar dry density requirement specified for the subgrade material. 4. Provide turfing over earth shoulders.	1. Do not resort to box cutting for the construction of shoulders. 2. Do not compact the shoulder layer before the compaction of the adjoining pavement layer. 3. Do not allow stacking of shoulder material on the carriageway nor should any spilled shoulder material be dragged on to the pavement surface.

408. LOCAL MATERIALS FOR ROAD CONSTRUCTION

1. The local materials which can be used for rural road construction are the locally available soils and low grade/ marginal aggregates possessing requisite engineering properties so as to make it suitable and economical for incorporation in road works(as such or after suitable processing, as may be required)in lieu of the conventionally used road materials.

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

3. Usually some processing of the locally available materials is required to make their best possible use. This Sub-section brings out the quality aspects of processing the locally available materials to use them to their 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 maximised use of locally available materials, it is essential that adequate soil and materials surveys in the vicinity of the project site are carried out at the time of DPR Preparation rather than depending only 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/marginal aggregates, and stabilisers like cement, lime, etc., including industrial wastes 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 maybe made to previous subsections.

2. When the locally available / marginal materials do not meet the engineering properties required for use in any layer of the pavement crust, suitable processing like modification/ stabilisation technique required to render these materials suitable for use in appropriate 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 or base courses, these material can be used as such. However, if these materials are found to be deficient in grading only, processing by mechanical stabilisation 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 or non plastic locally available industrial waste like fly ash 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 / STABILISATION TECHNIQUES

Sl. No.	Soil/ Aggregate Properties	Processing / Stabilisation Technique	Test Procedure
1.	Sands, moorums / gravels having missing fraction sand clayey soils	Mechanical Stabilisation to meet the prescribed grading and plasticity requirements	Refer Sub-sections 401 and 402
2.	Medium and heavy clay having PI>10 and containing at least 15 percent of material finer than 425 micron. A soil whose 7 day unconfined compressive strength increases by at least 0.3 MPa with lime treatment is suitable	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 having organic content less than 2 percent, deleterious salts (sulphates and carbonates) less than 0.2 per cent and uniformity coefficient greater than 5	Cement Stabilisation to improve strength (CBR/UCS)	Refer Sub-section 404
4.	Soils of medium plasticity (PI between 5 and 20) and clayey soils not reactive to lime	Lime-fly ash Stabilisation to reduce PI and increase in 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 Stabilisation and increase in strength in terms of CBR	Refer Sub-section 404

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

Sl. No.	State of Occurrence of Material	Manner of Use in Pavement	Test / Quality Requirements
1.	In blocks or large discrete particles such as Kankar, Laterite,Dhandla, etc.	As WBM without screenings/filler after breaking the material into required sizes	Wet Aggregate Impact Value (IS: 5640) not to exceed 50, 40 and 30 per cent when used in sub-base, base and surfacing respectively. For constructing lower base course in case of roads carrying design traffic upto 60,000 standard axles (Traffic T1 or T2 category) wet AIV can be increased upto 50 per cent and flakiness index upto 30 per cent
2.	Graded form without appreciable amount of soil, such as naturally occurring gravels	Directly as a granular layer for sub-base/base or surfacing	Plasticity characteristics to meet requirements as specified for GSB materials based on annual rainfall and traffic conditions. Evaluated for Strength by soaked CBR
3.	As discrete particles mixed with appreciable amount of soil such as soil-gravel mixtures, quarry wastes, etc	Directly as soil-gravel for sub-base /base or surfacing	The material should be well-graded and the plasticity characteristics to meet requirements as specified for GSB materials based on annual rainfall and traffic conditions. Evaluated for Strength by soaked CBR

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

(a) Use of locally available aggregates

1.	As WBM	Sub-section 405
2.	As GSB	Sub-section 401
3.	As soil-gravel mix for sub-base	Sub-section 402

(b)	**Use of stabilized soil**	
1.	Mechanical Stabilisation	Sub-section 401 or 402 for desired gradation
2.	Lime Stabilisation	Sub-section 403
3.	Cement Stabilisation	Sub-section 404
4.	Lime-Fly ash Stabilisation	Sub-section 409
5.	Two-stage (Lime-Cement) Stabilisation	Sub-section 404

B. Quality control requirements

1. Materials

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

2. Horizontal Alignment

The edges of sub-base and base courses constructed with local materials 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 sub-base courses constructed with local materials will be restricted to (+) 10 mm and (-) 20 mm. For base courses as well as surface course 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 base course as well as surface course 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/ surfacing courses built with local materials as such or after appropriate processing, please refer to the relevant Subsection 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. 2. Look for any problematic and non-standard materials available near road construction project and local experience on their use in the past. 3. Choose the most appropriate soil stabilization technique based on the properties of locally available soils and materials. 4. In case of an expansive clay, if a particular unconfined compressive strength is aimed at, a two-stage stabilisation with pretreatment of lime in the first stage and cement in the second stage should be resorted to. 5. Ensure prior testing for satisfying the various requirements before using industrial wastes like fly ash and slag.	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. Do not decide on the percentage of stabilizer for use in base course without working out scientifically, the design of mixes. 3. Do not use lime treated soil in the base course considering the durability aspects of soil-lime mixes. 4. Do not adopt mechanical stabilization without ascertaining the available quantities of materials to be combined.

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. Officials from local Geological Department / concerned STA faculty / local PIU / Public Works Department / Panchayat Raj/ Irrigation Department engineers can be consulted to collect information on locally available materials which can be used in road works. Industry Department officials / Industrialists / Mining Companies in the nearby areas can be consulted for availability of industrial wastes.
- 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 kilometer length should be made.
- In addition to boreholes, test pits of 1 m x 1 m,upto a depth of 1 m (usual maximum depth of borrow pits) can be made at nearby locations where deposits of locally available road construction materials or good earth is expected.
- Use of hand-operated post hole auger will help for making bore holes.
- 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 and test pits (generally 2 to 5 kg sample is enough). Location and depth of strata is 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/ hard/ marginal) collected for laboratory testing.
- Besides collecting representative samples of naturally occurring soils, moorums, gravels, soft/hard/ marginal aggregates, any industrial wastes and stabilisers like lime from roadside kilns etc. should also be collected for laboratory testing.

409. LIME-FLY ASH STABILISED SOIL SUB-BASE

The lime-fly ash stabilised soil is a mixture of soil and fly ash, which is stabilized using lime.

A. Methodology

1. Before receiving the lime-fly ash stabilised 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 as well as soft and yielding spots should be rectified and adequately compacted.

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

   Per cent by weight of soil passing IS Sieve 26.5 mm - 100%

   Per cent by 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 pulverisation requirements.

3. On the prepared subgrade, the pulverised soil should be spread uniformly, the uncompacted thickness being about one-third more than the specified compacted thickness. Accurate determination of thickness of loose layer to be laid to achieve required compacted thickness can be carried out through field trials.

4. Lime and Fly ash 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 per cent of the optimum moisture content as per IS:2720 Part 7. 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-fly ash mix by discing or harrowing using tractor-towed disc harrows or rotavators 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 per cent 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 after 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 moist 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 300 degrees.

B. Quality Control Requirements

1. Materials

(a) **Fly ash** 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, whether it is Antracitic coal or Lignitic coal.

TABLE 409.1: CHEMICAL REQUIREMENTS FOR FLY ASH AS A POZZOLANA

Characteristics		Requirements for Fly ash		
		Fly ash from Antracitic Coal	Fly ash from Lignitic Coal	Method of Test
1.	SiO_2+Al_2O_3+Fe_2O_3 in per cent by mass, Min	70.0	50.0	IS 1727
2.	SiO_2 in per cent by mass, Min	35.0	25.0	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	1.50	1.50	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 FLY ASH AS A POZZOLANA

Characteristics		Requirement
1.	Fineness - specific surface in m^2/kg by Blaine's permeability test, Min	250
2.	Particles retained on 45 micron IS Sieve, Max	40
3.	Lime reactivity in N/mm^2, Min	3.5
4.	Soundness by autoclave test expansion of specimen in 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 per cent 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 Plasticity Index (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 considered to be satisfactory.

2. Horizontal Alignment

The edges of the lime-fly ash stabilised 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-fly ash stabilised soil sub-base 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-fly ash stabilised soil sub-base 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-fly ash-soil mix can be omitted, provided the specified minimum strength requirement is achieved.

6. Quality Control Tests

Quality control tests for lime-fly ash stabilised soil sub-base 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/sub-base.

C. Do's and Don'ts

Do's	Don'ts
1. While spreading lime and fly ash, ahead of mixing, take care to prevent dust nuisance. 2. The suitability of particular equipment for pulverization of soil clods and for mixing should be verified on a test strip. 3. The thickness of uncompacted layer to yield the specified compacted thickness after rolling should be determined by field trials. 4. Compaction should be completed within 3 hours after mixing lime and water with soil-fly ash or such shorter periods as may be necessary during dry weather.	1. Do not carry out Lime-fly ash soil stabilisation when air temperature in the shade is lessthan10°C. 2. Do not allow any soil clods larger than 26.5 mm in size. 3. Do not allow any soft yielding spots, ruts, etc., on the sub grade before laying the sub-base. 4. Do not allow more than 60 minutes to elapse between the start of moist mixing and start of the compaction process. 5. Do not allow the roller to bear directly on hardened or partially hardened treated material previously

Do's	Don'ts
5. Ensure that the final surface is well closed, free from roller marks, ridges, cracks or loose material. 6. All loose or segregated or otherwise defective areas on the completed surface should be made good to the full thickens of the layer and re-compacted.	laid other than those what may be necessary for achieving the specified compaction at the joint. 6. Do not allow traffic to ply during the curing period.

410. INDUSTRIAL WASTES FOR ROAD CONSTRUCTION

Industrial wastes can be defined as waste materials produced by the industries, having requisite engineering properties for use in rural road works and available in the vicinity of such road works. This Subsection covers the techniques for incorporating (i) Fly ash (waste from thermal power stations which includes pond ash, bottom ash, fly ash and mound ash) in road embankments, sub-base/base course (ii) Metallic slags like iron and steel slag, copper slag, zinc slag, etc (waste material from metal extraction industries like iron and steel making, copper smelting, zinc extraction, etc)(iii) Mining, quarrying and stone processing waste like marble slurry, jarofix, Kimberlite tailings, quarry over burden material, etc (iv) Construction and Demolition (C&D) waste like crushed concrete, crushed material obtained after dismantling and crushing existing structures/ buildings, etc., in road works suitably, according to lines, grades and cross sections shown on the drawings or as directed by the Engineer. Any of the industrial waste material to be used in road work should be 'Non Hazardous' as per MOEF Notification on Hazardous Materials (Management, Handling and Transboundary Movement) Rules 2007. The Engineer may request for necessary test to determine whether any waste material proposed to be used fulfils the criteria for reuse as laid down by MOEF before approving its usage.

A. Methodology

I. Fly ash

Fly ash can be used in road works in various forms as given below:

1. Use in fly ash embankment construction: As per Sub-section 306.
2. Use in lime-fly ash stabilised soil sub-base: As per Sub-section 309.
3. Fly ash as a non plastic admixture for preparing GSB/ Soil-Aggregate sub-base or base:

   As per Sub-section 401 or 402
4. Use in cement stabilised sub-base or base: As per Sub-section 404,
5. Use in Lime-fly ash bound macadam:

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

II. Metallic Slags

Slags which are available in the form of coarse aggregates can be used for constructing soil-aggregate sub-base / base / surface course. For the construction of soil-aggregate sub-base/ base/ surface layer, 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/ granulated metallic slag available in the form of gravel/ sand is used in cement stabilized granular material, the methodology given in Subsection 404 will apply. Granulated slag can be adopted as a component of soil-aggregate sub-base/ base as per sub-section 402.

III. Other Industrial wastes

Other industrial wastes like mining and quarrying waste, quarry over burden materials, tailings, C&D waste, etc can be used in the following form:

i)	In soil-aggregate sub-base/ base layer:	As per sub-section 402
ii)	In WBM construction:	As per sub-section 405
iii)	In cement stabilised granular material:	As per sub-section 404

B. Quality Control Requirements

1. Materials

(i) Fly ash

The term fly ash shall cover all types of coal ash such as pond ash, bottom ash, fly ash or mound ash. The properties of fly ash vary from plant to plant. Typical Geotechnical properties of Fly ash are given in Table 410.1

TABLE 410.1: TYPICAL GEOTECHNICAL PROPERTIES OF FLY ASH

Parameter	Normal Range
Specific Gravity	1.90 - 2.55
Plasticity	Non Plastic
Maximum Dry Density (kN/m^3)	9.0 - 16.0
Optimum Moisture Content (%)	38.0 - 18.0
Cohesion (kN/m^2)	Negligible
Angle of internal friction (ϕ)	30^0 - 40^0
Coefficient of Consolidation C_v (m^2/day)	$1.5x10^{-4}$ - $1.7x10^{-2}$
Compression Index C_c	0.05 - 0.40
Permeability (m/ day)	0.007 - 0.60
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 C_u	3 - 11

(ii) Metallic Slags

Many of the metallic slags like copper slag, zinc slag, granulated blast furnace slag (from iron and steel industry) are available in granular form (granulated slag) similar to gravel or sand. Iron and Steel slag is also available in the form of coarse aggregates. The broad types of iron and steel slags are:

1. Air cooled Blast Furnace Slag (Available as coarse aggregates)

2. Granulated Blast Furnace Slag (Available in granular form)

3. Steel Slag (Available as coarse aggregates)

Physical characteristics of Air Cooled Blast Furnace Slag and Steel Slag are given in Table 410.2

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

Physical Properties	Test Method	Air Cooled Blast Furnace Slag	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 (indicative)	IS 2386 (Part 3)	2.65	3.22

It may be noted that some varieties of Steel Slag could be found to be lacking in stability in the presence of water owing to hydration of calcium oxide present in them. Such varieties need to be left for weathering in stockpiles for about one year to render them suitable for road works. In general, the unit weight of slag should not be less than 11.2 kN/cum.

III. Other Industrial wastes

These materials which can be used in soil-aggregate sub-base/ base (sub-section 402, WBM (sub-section 405) or cement stabilised layer (sub-section 404) should meet the material specification provided in their respective sub-sections.

2. Horizontal Alignment

When used in sub-base 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 sub-base 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) Fly ash

- For use of fly ash in embankment construction, the Quality Control tests given in Subsection 306 shall apply.
- For use of fly ash in Lime-fly ash stabilised soil sub-base, the Quality Control tests given in Sub-section 409 shall apply.
- For use of fly ash in Lime-fly ash bound macadam, the Quality Control tests given in Sub-section 405 shall apply.
- For use in GSB/ Soil-Aggregate sub-base or base, Quality Control tests given in Sub-sections 401 or 402 shall apply.
- For use in cement stabilised sub-base or base, Quality Control tests given in Sub-section 404 shall apply.

(b) Metallic Slag and other industrial wastes

- 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. Embankments constructed using Fly ash, granular slag, crushed C&D waste should be covered on the sides and top by selected soil to prevent erosion. Thickness of earth cover on side slopes can be 30 to 60 cm. 2. The work on use of industrial wastes in road construction should be so organised that ideally, supply of waste material to the site equals the Contractor's demand for an efficient rate of placement. 3. The industrial waste to be used in road works should always be tested in the laboratory to ensure that in meets the required geotechnical properties or as a pozzolana as the case may be. 4. The compaction of industrial waste core and soil cover must be carried out simultaneously. 5. The lime used in Sub-base/Base courses for stabilising industrial waste must have a purity of not less than 70% by weight of calcium oxide. 6. Ensure that steel furnace slag has been left in the open atmosphere for at least one year after production (weathering) so that it acquires volume stability.	1. Do not stockpile huge quantities of fine grained industrial wastes like fly. ast fine copper slag, etc at the site. Requisite qualitites of such materials when collected at site, should be sprinkled with water and covered with tarpaulins to avoid dust nuisance. 2. Do not transport fine grained industrial wastes in open trucks without cover to avoid dust nuisance and environmental pollution. 3. Do not use any industrial waste for road construction without testing it in laboratory and verifying that it meets all the specified requirements including tests required for establishing its non hazardousness as per MOEF Guidelines.

411. CRUSHER RUN MACADAM BASE

A. Methodology

1. The sub-base 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 407.
3. The aggregate should be uniformly deposited on the prepared sub-base and distributed over the surface to the required thickness. After distribution, the material shall be thoroughly mixed to the full depth of the layer by alternately blading the entire layer to the centre and back to the edges of the road. It shall then be spread and finished to the required cross-sectional levels, lines and grades by means of suitable tractor with grader attachment.
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 80 to 100 kN smooth wheel static roller or 80 to 100 kN vibratory roller to achieve 100 per cent 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 static 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 per cent 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(Part4) or IS:5640	40% (maximum)
2.	Flakiness Index	IS:2386(Part1)	25%(maximum)
3.	Water Absorption*	IS:2386(Part3)	2%(maximum)
4.	Liquid Limit of material passing 425 micron sieve	IS 2386 (Part 5)	Not more than 25%
5.	Plasticity Index of material passing 425 micron sieve	IS 2386 (Part 5)	Not more than 6

* If the water absorption is more than 2 per cent, soundness test should be carried out on the aggregates as per IS 2386 (Part 5). Aggregate should conform to soundness test requirements as given in table 405.1

TABLE 411.2: AGGREGATE GRADING REQUIREMENTS

IS Sieve Designation	Percent Passing by Weight	
	53 mm Maximum size	37.5 mm Maximum size
63 mm	100	
45 mm	87 - 100	100
22.4 mm	50 - 85	90 - 100
5.6 mm	25 - 45	35 - 55
710 micron	10 - 25	10 - 30
90 micron	2 - 5	2 - 5

2. Horizontal Alignment

Quality control requirements for horizontal alignment shall be 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 compacted crusher run macadam base course and 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/ shingle is used, ensure that not less than 90 per cent by weight of crushed gravel/ shingle, retained on 4.75mm sieve, shall have at least two fractured faces. 2. Use templates at about 6m apart to check surface profile conforming to camber requirements. 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 having maximum dry density as per IS:2720(Part7) 4. Construct shoulders along with crusher run macadam base layer.	1. Do not use material other than crusher run material. 2. Do not use any filler material. 3. Do not spread aggregate more than three days in advance of the construction operations.

412. BRICK SOLING

A. Methodology

1. The edges of soling shall be marked with reference to the centre line by 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) The bricks to be used shall be burnt clay bricks conforming to IS 1077 and have minimum compressive strength (when tested flat) of not less than 8.4 MPa for individual bricks and 10.6 MPa for average of five specimens.

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

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

2. Horizontal Alignment: As per Sub-section 401

The edge of the brick soling 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 inside edge of shoulders to make it vertical and remove any spillage.	1. Do not excavate into finished formation layer for laying bricks.
2. Allow sand to remain on the soling till a subsequent pavement layer is laid.	2. Do not allow traffic over brick soling layer during its construction.

413. STONE SET PAVEMENT

A stone set pavement has a pavement crust comprising of 100 mm compacted GSB / soil-aggregate sub-base, 75 mm WBM (Grading 2) / soil-aggregate base and 150 mm thick hammer dressed stones paved on a bedding sand layer over the WBM / soil-aggregate Base. It is best suited where good quality stones and crafts men experienced in stone paving are locally available.

A. Methodology

1. Over a suitably prepared subgrade as per Sub-section 303, construction of 100 mm thick compacted GSB/ soil-aggregate sub-base will be carried out as per Sub-section 401 or 402.
2. The construction of 75 mm thick WBM (Grading 2) or soil-aggregate base, will be carried out as per Sub-section 405 or 402.
3. A properly graded coarse sand bedding layer of 40 mm compacted thickness will be laid over the WBM / soil-aggregate Base.
4. This will be followed by laying of hammer dressed stones in the herringbone or stretcher bond pattern.
5. The stones are to be compacted into bedding sand over the WBM / soil-aggregate base, bounded by edge stones laid with their longitudinal axis parallel to the length of the road.
6. The joint gaps will be filled with fine sand, stone dust, sand-cement mortar or hot sand-bitumen mix as specified.
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/ soil-aggregate sub-base and 75 mm WBM (Grading 2) / soil-aggregate base as given in Sub-section 303, 401, 402 and 405 shall apply.

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

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

(iv) The stones for stone set pavement should meet the following physical requirements.

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

(b). Water Absorption (IS:2386 Part 3): not more than 2 per cent

(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 terrain 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 stones should be hard and rectangular and tested for the Polished Stone Value besides other tests. 2. 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 stones in the stone setpavement. 2. Do not open the road immediately to traffic if sand-cement or bitumen is used for filling joints.

SECTION 500

BITUMINOUS CONSTRUCTION

501. PREPARATION OF SURFACE

This Subsection deals with preparing an existing granular or blacktop surface prior to laying a bituminous course

A. Methodology

1. Preparing an existing granular surface

(i) All loose and extraneous materials shall 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 shall be slightly watered and the granular profile corrective course laid.

(ii) The surface of all granular layers on which a bituminous course is to be laid shall 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 shall be primed with a suitable liquid 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 with care by a suitable method such as hand picking or milling 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 shall be primed as per Sub-section 502

3. Preparing an existing bituminous surface

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

(a) Pothole and Patch Repairs

(i) The existing bituminous surface shall be inspected and all pothole and patch areas shall be made free of loose and 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 shall be removed from site. Layers below the bituminous construction should be replaced using material of equivalent specification to the original construction and degree of compaction

and primed and/or tacked with an emulsion (meeting requirements of IS: 8887) depending on whether the lower layer is granular or bituminous in nature. The sides of the excavated portion should be applied with a tack coat using a suitable hand brush/sprayer.

(ii) The bituminous material for pothole repair and patching should be either a hot-mix prepared in plant or a cold mix as per specifications. Cold mix may be prepared in a concrete mixer. Use of cold mix and pothole repair machines (automatic/semi-automatic) may be preferred. Storable cold mixes for repairing potholes may also be used. Storable pothole patching bituminous mixes may be prepared using cutback bitumen or bitumen emulsion as per specifications laid down in IRC: 116 or IRC: SP-100. Procedures and quality control requirements are given in Appendix: A Cold mixes. The bituminous mixture shall be placed in layers of not more than 75 mm (loose) and compacted in layers with roller /walk-behind 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 as per Sub-section 508 shall be applied. 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) shall be sealed by Fog Spray or application of liquid rejuvenating material, which is a very light application of low viscosity Slow Setting Bitumen Emulsion as given in Appendix: A. 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/sq. m of slow setting bitumen emulsion, using equipment such as pressure tank fitted with flexible hose and spray bar. For sites in sub-zero temperature area, Medium Curing Cutback conforming to IS 217 can be used.

(ii) The medium and 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 bitumen emulsion (SS-2 grade) 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 (more than 6 mm wide), shall be cut and patched as per Section 501. Cracks of different types and severity level may also be repaired using rubberized bitumen.

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 crack filling shall be a Slow Setting bitumen emulsion (SS-2 grade) as per IS: 8887. For sub-zero temperatures, however, a Medium Curing (MC) Cutback bitumen conforming to IS: 217 can be used. Prime coat shall 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 the base course.

(i) Horizontal Alignment

Edges of the pavement layer

In plain & rolling terrain	(±) 30 mm
In hilly terrain	(±) 50 mm

(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.
6 Ensure that the backfilling of potholes is done in layers and each layer is compacted thoroughly using appropriate compaction equipment.	6. Do not heat bitumen on open fire.
7. Provide protective equipment to workers for bituminous work.	

502. PRIME COAT OVER GRANULAR BASE

A Methodology

1. Bituminous primer shall be slow setting bitumen emulsion (SS-1 grade). Use of cutback bitumen primer shall be 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 should be prepared as per sub-section 501. Where required, it may be lightly and uniformly sprinkled with water to moist the surface.

3. The primer should be sprayed uniformly over the dry surface, using self- propelled or tractor towed bitumen pressure distributor fitted with spray bar capable of spraying primer at specified rates and temperature so as to provide a uniformly unbroken spread of primer. Normal temperature range for spraying bitumen emulsion should be 10°C to 60°C. The rate of application

of primer depends upon the porosity characteristics of the surface to be primed. The rate of application for primer of emulsion and for primer of cutback is given in Table 502.1A and 502.1B.

TABLE 502.1 A: Quantity of Bitumen Emulsion for Various types of Granular Surfaces for Priming

Type of Surface	Quantity per 10 sqm (kg)
WBM/WMM	7 -10
Stabilised Base	9 12
Gravel Base / Crusher run Macadam	12 - 15

Table 502.1 B: Type and Quantity of Cutback Bitumen Primer for Various types of Granular Surfaces for Priming

Type of Surface	Type of Cutback	Rate of Spray (kg/sqm)
WMM/WBM	MC 30	0.6-0.9
Mechanical stabilized soil base, lime stabilized soil, soil cement and lime cement base	MC 70	0.9-1.2
Gravel Base, Crusher Run Macadam and Crushed Rock base	MC 250	1.2-1.5

4. 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. Materials

The primer shall be cationic bitumen emulsion of SS-1 grade complying with IS:8887 or medium cut back bitumen conforming to IS:217 or as specified in the contract. The use of cutback bitumen shall be restricted only for sites of sub-zero temperature and for emergency applications.

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 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.	Residue Content Test	-do-
5.	Flash Point Test, where bituminous cutback is to be used (IS:217)	-do-
6.	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-

2.2 Tests During Construction

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

TABLE 502.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1.	Temperature of Binder	Regularly
2.	Rate of Spread of Binder	At least two tests per day.
3.	Curing of Primer	Before any subsequent treatment.

2.3 Quality Control Checks

JE / AE shall carry out quality control checks at the prescribed frequency as per Table 502.3

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. 2. Use only pressure sprayers. 3. Preferably lay a trial section. 4. The Contractor to demonstrate at a spraying trial to ensure that the equipment is capable of producing a uniform spray. 5. Roll bitumen emulsion drums to and fro 5-6 times.	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. Do not allow pouring of primer using perforated cans. 3. Do not allow traffic on primed surface. 4. Do not apply bituminous material to a wet surface.

503. TACK COAT

A. Methodology

1. Tack coat of a low viscosity bituminous material shall be applied to an existing bituminous, concrete or primed granular surface before laying a bituminous treatment as specified in the contract.

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 self- propelled or tractor towed bitumen pressure distributor capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. For smaller jobs, a pressure hand sprayer may be used. Normal range of spraying temperature should be 10°C-60°C for emulsion and 50°C-70°C for cutback bitumen. Paving bitumen, if specified for tack coat, shall be heated to an appropriate temperature in a bitumen boiler to achieve a viscosity of less than 2 poise. The rate of application of binder depends upon the type of surface and is given in Table 503.1.

5. The tack coat of bitumen emulsion should be allowed to cure until all the volatiles have evaporated before starting subsequent construction.

B. Quality Control Requirements

1. Materials

(i) Binder for Tack Coat

Binder for tack coat shall be rapid setting bitumen emulsion Grade RS-1 complying with IS: 8887 or paving bitumen of VG 10 grade conforming to IS: 73 as specified in the Contract. For sites at sub-zero temperature or for emergency applications cutback bitumen (Medium Curing grade) as per IS: 217 shall be used.

(ii) Rate of application of Binder

TABLE 503.1: RATE OF APPLICATION OF BINDER FOR TACK COAT

Type of Surface	Rate of spray of Binder (kg / sqm)
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. 3. Roll emulsion drums 6-7 times before use.	1. Do not apply tack coat when atmospheric temperature is less than 10°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

(Single course of 50 mm to 75 mm thickness using paving grade bitumen for hot mix)

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 as per sub-section 501. Apply prime coat on granular base as per Sub-section 502.
2. Apply tack coat over the base preparatory to laying of the Bituminous Macadam as per Sub-section 502.
3. Bituminous Macadam should be prepared in a Hot Mix Plant of adequate capacity with essential features as per IRC 27. Ensure mixing temperatures as given in Table 504.1. If a continuous mixing plant is used, it shall be demonstrated that the cold feed combined grading is within permissible grading limits.

TABLE 504.1: MIXING, LAYING AND ROLLING TEMPERATURES FOR BITUMINOUS MIXES

(Degree Celsius)

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

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

1. Transport the mixed material quickly to site of work in covered vehicles and lay by means of an approved self-propelled mechanical paver conforming to IRC: 27. The mix shall be supplied continuously to the paver and laid without delay before the temperature of the mix falls below the laying temperature given in Table 504.1

2. Commence initial or break-down rolling with 80-100 kN rollers (static three-wheel or vibratory tandem in static mode), 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 roller of 80-100 kN weight or pneumatic tyred roller of 120 to 150 kN weight with a tyre pressure of at least 0.56 MPa This should be followed by final rolling with 60-80 kN smooth wheel roller while the material is still workable.

3. 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. The rolling operation should be completed before the mix temperature falls below the rolling temperature given in Table 504.1. Where modified bitumen is used, the mixing, laying and rolling temperatures shall be as given in sub-section 511.

4. For single lane roads only transverse joints are made, while for double-lane roads longitudinal joints are provided in addition to transverse joints.

5. For making longitudinal or transverse joint, cut to vertical face 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 to the vertical face. Lay adjacent new layer and compact flush with the existing layer. Ensure that the mix is fully compacted. The joints and edges shall be compacted with static roller.

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

B. Quality Control Requirements

1. Materials

(a) Bitumen

The bitumen shall be viscosity grade paving bitumen complying with IS 73 or as specified in the contract. The binder content shall be within the range specified in Table 504.3

Refer to Annex- 500.3 for selection of viscosity grade bitumen based on climatic conditions.

(b) Aggregates

The aggregates shall consist of crushed rock or crushed gravel and meet the physical requirements indicated in Table 504.2. The combined aggregate grading shall fall within the limits shown in Table 504.3

TABLE 504.2: PHYSICAL REQUIREMENTS FOR AGGREGATES FOR BITUMINOUS MACADAM

Property	Test	Specification
Cleanliness	Grain size analysis Max. 5% passing 75 micron sieve	
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 Sodium Sulphate 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 Viscosity Grade	VG-10 to VG -30

In cooler areas, 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 shall be (±) 6 mm

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge shall 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 (Paving Bitumen as per IS:73)	One test per lot
(a) Absolute viscosity and Penetration Test	-do-
(b) R&B Softening Point Test	-do-
(c) Ductility Test	-do-
2. Quality of Binder (Modified Bitumen) (IS 15462 & IRC: SP:53)	
(a) Penetration Test	-do-
(b) R&B Softening Point Test	-do-
(c) Elastic Recovery Test	-do
(d) Separation Test	-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)	At least one test per day.
2.	Binder Content	At least two tests per day.
3.	Density of Compacted Layer	At least 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 displa*

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
	(ii) Binder Content part thereof	(b) One test for every one km length	EE AE/EE
	(iii) Surface Regularity and Transverse Profile	One test for each 500 m length or part thereof	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° 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° 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. SURFACE DRESSING

A. Methodology

1. Design the surface dressing following the guidelines given in IRC 110 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 difference between the quantities and spread rates of binder and aggregates as specified in Table 505.1 and those as per actual design shall be brought out and got approved from the Engineer 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) at the rate of spread of binder given in Table 505.1 or as designed over the prepared base. Binder shall be sprayed uniformly using a self-propelled or towed sprayer capable of supplying the binder at specified rate to provide a uniformly unbroken spread of binder. The spraying temperatures for viscosity grade bitumen are given in Table 505.2

TABLE 505.1: NOTIONAL RATES OF SPREAD OF BINDER AND AGGREGATES

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

TABLE 505.2: SPRAYING TEMPERATURES FOR BINDER.

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

1. Immediately after application of binder, spread clean dry stone aggregate at the rate given in Table 505.1 or as designed with the help of a mechanically operated chip spreader, in a single layer. In the case of emulsion, the aggregate may be slightly damp. Synchronized spreading of binder and stone chips using modern truck-mounted machine with bitumen sprayer and chip spreader shall be preferred.

2. Immediately after spreading of aggregates, roll the surface with the help of suitable smooth wheeled or pneumatic tyred 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

3. Where two-coat surface dressing is specified, the second coat should be applied after the first coat is open to traffic for 2 to 3 weeks. The surface shall be cleaned and second coat applied following the procedures stated above. Traffic shall not be allowed on newly surface dressed road until the following day. In exceptional circumstances, traffic may be allowed immediately after rolling provided the traffic speed is limited to 20 km/h until the following day.

4. Where use of pre-coated chips is specified, the first step will be to pre-coat chips. The stone chips will be heated to 160°C and mixed with 0.75 to 1% of bitumen by weight of chips heated to its application temperature. The pre-coated chips shall be cured for one week or till such time as they become non-sticky.

B. Quality Control Requirements

1. Materials

(a) Aggregates (Stone Chips)

(i) Physical requirements:

Stone chips should satisfy the requirements given in Table 504.2 except that water absorption shall be 1% maximum and have a Polished Stone Value of minimum 60.

(ii) Grading:

The stone chips should be single sized, clean, of cubical shape and free from dust, soft, organic and other deleterious material and conform to one of the gradings given in Table 505.3. The size of the chip shall depend on the type of surface on which it is laid and traffic intensity.

TABLE 505.3 GRADING REQUIREMENTS FOR AGGREGATES FOR SURFACE DRESSING

IS Siev Designation(mm)	Cumulative Percent by weight of Total Aggregates Passing for the following Nominal Sizes (mm)			
	19	13	10	6
26.5	100	-	-	-
19.0	85-100	100	-	-
13.2	0-40	85-100	100	-
9.5	0-7	0-40	85-100	100
6.3	-	0-7	0-35	85-100
4.75	-	-	0-10	-
3.35	-	-	-	0-35
2.36	0-2	0-2	0-2	0-10
0.60	-	-	-	0-2
0.075	0-1.5	0-1.5	0-1.5	1-5
Minimum 65% by weight of aggregate	Passing 19 mm retained 13.2 mm	Passing 13.2 mm retained 9.5 mm	Passing 9.5 mm retained 6.3 mm	Passing 6.3 mm retained 3.35 mm

(b) Binder

The binder shall either be viscosity grade bitumen conforming to IS: 73 or rapid setting cationic emulsion of RS-2 grade conforming to IS 8887 or as specified in the contract.

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

2. Horizontal Alignment

The edges of the Surface Dressing should be correct within a tolerance limit of (±) 20 mm 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 straightedge shall not exceed10 mm for longitude in al 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 505.4.

Table 505.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

	Type of Test	Frequency
1.	Quality of Binder (Paving Bitumen as per IS:73)	
	(a) Absolute viscosity and Penetration Test	One Set of tests per lot (Average of three tests)
	(b) R&B Softening Point Test	-do-
	(c) Ductility Test	-do-
2.	Quality of Binder (Bitumen Emulsion)	
	(a) Viscosity (IS:8887)	-do-
	(b) Residue content	-do-
	(c) Residue on 600 micron sieve (IS:8887)	-do-
	(d) Storage Stability Test (IS:8887)	-do-
3.	Quality of Binder (Modified Bitumen) (IS:15462)	
	(a) Penetration Test	-do-
	(b) R&B Softening Point Test	-do-
	(c) Elastic Recovery Test	-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 505.5.

TABLE 505.5: 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	-do-
3.	Grading of Aggregate (IS:2386 Part 1)	At least one test per day
4.	Temperature of binder during spraying	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 505.6

Table 505.6: 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. 2. Add approved Anti-Stripping agent to binder where aggregate fails to pass the stripping test. 3. Alternatively use pre-coated chips. Correct any excessive deposit of bitumen before spreading the chips.	1. Do not carry out work when atmospheric temperature is less than 10°C or when weather is foggy, rainy or windy. 2. Do not carry out the work on wet surface. 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.

506. OPEN GRADED PREMIX CARPET

506.1 Open Graded Premix Carpet using Paving Bitumen

A. Methodology

1. Prepare the base on which premix carpet is to be laid to the specified lines, grade and cross- section as per sub-section 501.

2. Apply a prime coat followed by tack coat over a granular base preparatory to laying of the carpet. Apply only tack coat over an existing bituminous surface.

3. The quantities of material required for 20 mm thick open graded premix carpet shall be as indicated in Table 506.1.1

TABLE 506.1.1: QUANTITIES OF MATERIALS REQUIRED FOR 10 Sqm OF ROAD SURFACE

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 cum of 13.2 mm nominal size stone at 52 kg bitumen per m^3	9.4 kg
(b) For 0.09 cum of 11.2 mm nominal size stone at 56 kg bitumen per m^3	5.2 kg
Total	**14.6 kg**

4. Prepare the mix in a hot mix plant of suitable capacity with separate dryer arrangement for aggregate. For small jobs, mini hot mix plants of 6-10 tonne per hour capacity or mobile plant may be used. The hot mix plant shall be approved by the Engineer. Mixing should be thorough to ensure that a homogenous mixture is obtained. The temperatures of bitumen and aggregate at the time of mixing and of the mix should be in the range specified in Table 504.1. The difference between the temperature of aggregate and the binder should not exceed 14°C. If modified bitumen is used, mixing temperature should be as specified in sub-section 511.

5. The mixed material should be transported quickly to the site of work and laid uniformly on the prepared base by suitable means to the desired thickness and camber. The mixed material can be spread and leveled using rakes. The mix laying and rolling temperatures shall be in the range specified in Table 504.1

6. Immediately after spreading the premix in sufficient length, commence rolling with smooth wheeled tandem rollers of 80-100 kN static weight or other approved roller. Rolling shall begin from the edge and progress towards the centre longitudinally. On super elevated 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.

7. Correct any high spots or depressions noticed after the roller has passed over the whole area once by removing or adding premixed material and re compacting. Rolling should be completed before the temperature of the mix falls below the rolling temperature indicated in Table 504.1

8. Provide a seal coat conforming to sub-section 508 to the surface immediately after laying the carpet.

9. The road may be opened to traffic after laying the seal coat with restrictions given in Sub-section 508.

B. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 504.2 except that water absorption shall be 1% maximum

(b) Binder

The binder shall be a viscosity grade bitumen of a suitable grade depending on climatic condition of the area and satisfying the requirements of IS: 73, or of the type as specified in the Contract. Guidance may be taken from Annexure-500.3 for selection of appropriate grade of viscosity grade bitumen. Where modified binder is specified Sub-section 511 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 Premix Carpet shall be (±) 6 mm for machine laid work and (±) 10 mm for work executed manually.

4. Surface Regularity

The maximum allowable difference between the pavement surface 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 505.5 of sub-section 505.

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 506.1.2

TABLE 506.1.2: 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 before and after compaction	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 506.1.3

TABLE 506.1.3: QUALITY CONTROL TESTS 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) Surface Regularity and Transverse profile	Random Checking	AE
	(iii) Visual inspection of finished surface	Full length	EE

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 the specified minimum rolling temperature according to the grade of binder used.	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.

506.2 20mm COLD MIXED OPEN GRADED PREMIX CARPET

A. Methodology

1. Prepare the base on which cold mixed premix carpet is to be laid to the specified lines, grade and cross section as per sub-section 501

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

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

   (i). Aggregate as per Table 506.1.1 of Sub-section 506.1

   (ii). Binder: Cationic Bitumen Emulsion of MS or SS-2 (with min 65% residue) grade conforming to IS: 8887. The quantity of bitumen emulsion shall be in the range of 20 - 23 kg for 10 sqm of road surface area.

4. Premix bitumen emulsion and aggregates in a suitable mixer such as cold mixing plant as per IS: 5435 (revised) or concrete mixer. When concrete mixer is used for preparing the premix, the quantity of aggregate and bitumen emulsion required per batch shall be proportioned as per the specified quantities.

5. Spread the premix to the desired thickness, grade and camber 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 and 7 of the methodology described in Sub-section 506.1

7. Provide a seal coat as specified in the contract within 4-6 hours after laying the premix carpet.

   Follow Sub-section 508 for the work of seal coat.

8. Preferably, the road should be opened to traffic after 24 hours of laying the seal coat. Ordinarily, traffic may be allowed after 6-8 hours after laying the seal coat. In single lane roads, traffic may be allowed after 4 hours or when the mix is properly set and the speed is restricted to not more than 16 km/h

B. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 504.2 except that water absorption shall be 1% maximum

(b) Binder

The binder for premix carpet shall be bitumen emulsion of Medium Setting (MS) grade or

SS-2 grade or as specified in the contract and complying with IS: 8887 and having a bitumen content of 65% minimum by weight.

Bitumen emulsion for liquid seal coat shall be of RS-2 grade or MS grade where specified. Emulsion for premix seal coat shall be of SS-2 grade.

2. Horizontal Alignment, Surface Levels, Surface Regularity and Quality Control Tests (Prior to Construction, During Construction, and Quality Control Checks by AE/EE) shall be exercised in accordance with the requirements given in Sub-section 506.1

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. 4. In hot weather, aggregate may be moistened where required.	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° C. 3. Do not allow any traffic unless the emulsion is properly set and the surface has acquired adequate stability.

507. MIX SEAL SURFACING

(Close graded 20 mm thick premix using Paving Bitumen)

A. Methodology

1. Follow the methodology described in Sub-section 506.1, 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 mix seal surfacing shall be 0.27 cum per 10 sqm area. The quantity of binder for premixing 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 aggregates shall conform to the physical requirements indicated in Table

504.2 except that water absorption shall be 1% maximum..

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 507.1

TABLE 507.1 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 506.1 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 506.1

C. Do's and Don'ts

Follow do's and don'ts given under Sub-section 506.1

508. 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 which is required to be sealed. 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). Heat bitumen to a temperature as per Table 504.1 and apply to the prepared surface uniformly with the help of a bitumen pressure distributor fitted with a spray bar.

(ii). Immediately thereafter, spread stone chips over the bitumen layer at a uniform rate with the help of a mechanical grit spreader so as to cover the surface completely.

(iii). Commence rolling with smooth wheeled rollers of 80-100 kN weight 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 bitumen emulsion

(i). Apply bitumen 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). Prepare the premix and lay on the prepared surface as per the methodology described in Paras 4 and 5 of Sub-section 506.1

(ii). Roll the surface with 80 to 100 kN roller as per the procedure given in Para 6 and 7 of methodology in Sub-section 506.1

(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 506.2 except that for small jobs manual mixing may be required.

5. Type-C seal coat with bitumen

Follow paras 4 to 7 of Methodology described in Sub-section 506.1 for preparation of premix, spreading and rolling. Ensure a uniform close surface at completion of rolling operation.

6. Type-C seal coat with emulsion

Follow provisions of Sub-section 506.2 for preparation of premix, spreading and rolling. Ensure a uniform close surface at completion of rolling operation.

7. 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 may 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

Aggregates (chips) for Type A and Type C seal coats shall conform to the physical requirements indicated in Table 504.2 except that water absorption shall be 1% maximum. Aggregate for Type B seal coat shall be sand or grit. Quantities and grading requirements for aggregates are given in Table 508.1

TABLE 508.1 QUANTITY AND GRADATION REQUIREMENT OF AGGREGATES FOR SEAL COAT

Type of seal coat per 10 sqm area	Quantity of Aggregates	Gradation requirements	
		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 micron
Type C	0.09 cum	9.5 mm	2.36 mm

(b) Binder

The requirements of Sub-section 506.1 and 506.2 shall apply. The quantities of binder required for seal coat are given in Table 508.2.

TABLE 508.2: 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 505.5. 505.6, 505.7 for Type A Seal Coat, and Tables 505.5, 506.1.2 and 506.1.3 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. 2. Ensure that Stone chippings conform to the specified size and are dry and clean at the time of mixing. 3. Ensure that the seal coat results in a smooth, uniform and closed surface. 4. Maintain requisite temperature control at the time of mixing and rolling if bitumen is used as a binder.	1. Do not use soft or disintegrated stone, organic or other deleterious material as an aggregate for seal coat. 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. 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. Do not allow traffic on Type A seal coat till the following day. 5. Do not use hand sprayers for spreading binder for Type A seal coat.

509. 25 mm SEMI DENSE BITUMINOUS CONCRETE

(Hot mix using bituminous binder)

A. Methodology

1. Design bituminous mix using the aggregates from the approved source for the work and the specified type and grade of binder following the Marshall Mix Design Method. The mix design shall meet the requirement given in Table 509.4.

2. Grading of aggregates is given in Table 509.3.

3. After mix design, the hot mix plant as approved by the Engineer shall be calibrated for delivery of the material conforming to the job mix formula. The permissible variation in the actual mix from the job mix formula is given in Table 509.5

4. Construct a test track of 30- 50 m length using designed mix and equipment proposed to be used for the project and evaluate test section for compliance of mix properties, compaction requirement and requirement of finished surface prior to undertake full construction.

5. Prepare the base on which semi dense bituminous concrete is to be laid to the specified lines, grade and cross section. The surface shall be cleaned by means of mechanical broom or other approved equipment.

6. Apply tack coat over the base before laying of the semi dense bituminous concrete.

7. Ensure that the hot bituminous mix delivered from the plant is of uniform quality and is as per the approved job mix formula.

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

9. Ensure mixing and rolling temperatures as specified in Table 504.1. Where modified bitumen is specified the mixing, laying and rolling temperatures shall be as specified in Table 511.1.

10. 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.

11. Any high spots or depressions noticed in the surface after the roller has passed over the whole area should be corrected by removing or adding premixed material. Rolling should be continued till all roller marks have been eliminated. Each pass should overlap at least one-third of the track made in the preceding pass. Rolling operations should be completed before the temperature of the mix falls below the rolling temperatures specified in para 9 above.

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

13. For making longitudinal or transverse joint, cut the edge of the bituminous layer laid earlier to its full depth and to a vertical face. Apply a thin coat of binder on the exposed vertical face and lay along the joint the adjacent new layer such that the material overlaps 25-50 mm over the previously laid mix and compact flush with the existing layer.

B. Quality Control Requirements

1. Material

1.1 Aggregates

(a) Coarse aggregate

Coarse aggregate shall be crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve and shall be clean and satisfy the physical requirements given in Table 509.1. Where crushed gravel is used, not less than 90 percent by weight of material retained on 4.75 mm sieve shall have at least two fractured faces.

TABLE 509.1 PHYSICAL PROPERTIES OF COARSE AGGREGATE

Property	Test	Requirement	Test Method
Cleanliness	Grain size analysis	Max. 5% passing 0.075mm	IS:2386 Part I
Particle Shape	Flakiness and Elongation Index(combined)	Max. 35%	IS:2386 Part I
Strength*	Los Angeles Abrasion Value	Max. 35%	IS:2386 Part IV
	Aggregate Impact Value	Max. 27%	IS:2386 Part IV
Polishing	Polished Stone Value	Min. 55	IS:2386 Part IV
Durability	Soundness (Either Sodium or Magnesium Sulphate)-5 cycles		
	Sodium Sulphate	Max. 12%	IS:2386 Part V
	Magnesium Sulphate	Max. 18%	IS:2386 Part V
Water absorption	Water absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Min. Retained Coating 95 %	IS: 6241
Water sensibility	Retained Tensile strength**	Max. 80%	AASHTO T283

Notes:

*The aggregate may satisfy either of two tests.

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

(b) Fine aggregate

Crushed or naturally occurring mineral material or their combination, passing 2.36 mm sieve and retained on .075 mm sieve and shall meet the following requirements:

Test	Requirement
Sand equivalent value	(IS:2720 Part 37)Not less than 50
PI (IS: 2720 Part 5)	Not exceed 4

(c) Filler

Rock dust, hydrated lime or cement as approved by the engineer. Grading requirements of the filler are given in Table 509.2

TABLE 509.2 GRADING REQUIREMENTS OF MINERAL FILLER

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

1.2 BINDER

Binder shall be VG grade paving bitumen or Modified bitumen as specified in the contract. Requirements specified in Para B.1 (b) of Sub-section 506.1 shall apply.

1.3 Aggregate Grading for SDBC

The combined grading of the coarse aggregate, fine aggregate and filler shall conform to limits specified in Table 509.3

TABLE 509.3: AGGREGATE GRADING FOR SDBC

Nominal Maximum Aggregate Size*	9.5mm
Layer Thickness	25 mm
IS Sieve Size (mm)	Cumulative Percent by weight of total aggregate passing
13.2	100
9.5	90-100
4.75	35-51
2.36	24-39
1.18	15-30
0.3	9-19
0.075	3-8
Bitumen Content (Min)**	5%
Type of Binder	Viscosity Grade bitumen or modified binder

* Normal maximum aggregate size is the largest specified size upon which any of the aggregate is retained.

** Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where higher daily mean air temperature is 30oC or lower and lowest daily mean temperature is -10oC or lower, the bitumen content may be increased by as much as 0.5 percent. The exact bitumen content required shall be determined following the Marshall Mix Design Procedure.

2 DESIGN OF MIX

2.1 The mix shall meet the requirements given in Table 509.4

Table 509.4 Requirement of the Mix Using Viscosity-Grade paving bitumen/Modified Bitumen

Properties	Viscosity Grade Paving Bitumen	Modified Bitumen		Test Method
		Hot Climate*	Cold Climate	
Compaction level (Number of blows)	75 blows on each face of the specimen			
Minimum Stability (KN at 60°C)	9	12	10	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245
Marshall Quotient (stability flow)	2-5	2.5-5		
% Air Voids	3 - 5			MS-2 and STM D2041
% Voids filled with Bitumen (VFB)	65 - 75			MS - 2
Tensile Strength Ratio	80% (Minimum)			AASHTO T283
Coating of Aggregate Particles with bitumen	95% (Minimum)			IS:6241
% Voids in Mineral Aggregate VMA				
Nominal Maximum Particle Size	Min % VMA related to designed percent of air voids			
9.5 mm	14	15	16	

*Maximum Average air Temperature >30oC

2.2 Binder Content

The binder content shall be selected to obtain 4% voids in the mix design and shall meet the requirements given in Table 509.4.

3 PLANT TRIAL

The permissible variation of the various ingredients in the actual mix from the job mix formula shall be within the limits given in Table 509.5.

TABLE 509.5 Permissible Variation from the Job Mix Formula

Description	Permissible Variation
Aggregate	passing
13.2 mm/9.5 mm	±6%
4.75 mm	±5%
2.36 mm,1.18 mm,0.6 mm	±4%
0.3 mm, 0.15 mm	±3%
0.075 mm	±1.5%
Binder Content	±0.3%
Mixing Temperature	±10°C

4. Horizontal Alignment

As per Sub-section 506.1

5. Surface Level

The tolerance in surface level of SDBC shall be (±) 6 mm.

6. Surface Regularity

The maximum allowable difference between the SDBC surface and underside of a 3 m straight edge shall not exceed 6 mm for the longitudinal profile and 4 mm for the cross profile.

7. Quality Control Tests

7.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction given in Table 504.4 shall be applicable. In addition to the tests specified therein, Sand equivalent test with a frequency of one test per source shall also be carried out.

7.2 Tests During Construction

The quality control tests to be carried out during construction are given in Table 509.6.

TABLE 509.6 Quality Control Tests During Construction

	Type of Test	Frequency
1)	Mix Grading (IS:2386 Part 1)	Individual constituent and mixed aggregate from dryer. At least two tests per day.
2)	Stability and voids analysis of mix	At least two tests per day.
3)	Binder content	At least two tests per day.
4)	Temperature of binder in boiler,and aggregate in dryer	At regular intervals
5)	**Temperature of mix during laying and compaction	At regular intervals
6)	Rate of spread of mix and thickness of compacted layer	Regular, at close intervals
7)	Density of compacted layer	One test per 700 sqm area minimum 3 tests per day
8)	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.

7.3 Quality Control Checks by AE/EE

The quality checks to be exercised by AE/EE shall be as indicated in Table 504.6

C. Do's and Don'ts

Do's	Don'ts
1. Ensure that stone aggregate conforms to the physical and grading requirements and are dry and free from organic and deleterious substances. 2. In case the aggregate has poor adhesion, use anti stripping agent with the approval of the Engineer. 3. While transporting the mixture, it should be suitably covered by tarpaulin. 4. Rolling operations should be complete before the mix becomes unworkable. 5. Maintain strict control on temperature while mixing and rolling. 6. Regulate the rate of delivery of material to paver to enable it to operate continuously.	1. Do not undertake the work in foggy, rainy or windy weather or when the atmospheric temperature in the shade less than 10°C. 2. Do not allow the difference in temperature of binder and aggregate to increase beyond 14°C. 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 use lubricant oil on the wheels of the roller to prevent mix from adhering. 5. Do not allow traffic until the SDBC surfacing has cooled below 60°C in full depth. 6. Do not move roller at a speed more than 5 km/h.

511. MODIFIED BITUMEN

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

A. Methodology

1. Where use of modified bitumen is specified, it shall be from refinery sources or blended at the central plant using appropriate industrial process and plant as specified in IRC: 53 or a Proprietary product. Ensure that the product meets the various quality requirements laid down in Clause 511 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 / re-circulated in hot condition with suitable mixing device for achieving homogeneity of the blend.

3. Ensure that the material is used at appropriate temperatures of mixing and rolling. The mixing and rolling temperatures are higher for Modified Bitumen as compared to viscosity grade bitumen.

4. The broad range of temperature for different stages is given in Table 511.1

TABLE 511.1: BROAD RANGE OF TEMPERATURE REQUIREMENTS FOR MODIFIED BINDERS

Stage of Work	Indicated Temperature (°C)
Binder at mixing	165-185
Mix at mixing plant	140-160
Mix at laying site	130-150
Rolling at laying site	115-135

5. The construction operations for various bituminous constructions using modified bitumen are by and large the same as those for viscosity grade bitumen covered in previous Sub-sections except for any special requirements indicated by the Manufacturer.

B. Quality Control Requirements

1. Modified bitumen shall meet the requirements given in Table 511.2.

Table 511.2 Properties of Modified Bitumen

	Highest Mean Air Temperature	<20°C	20°C to 35°C	Above 35°C	
	Lowest Mean Air Temp.	>-10 °C <-10 °C	>-10 °C <-10 °C	>-10 °C	
S.No	**Characteristics**	**Specified Values of the Modified Bitumen**			**Method of Test .IS No.**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
i)	Penetration at 25°C 0.1mm, 100g, 5s	60 to 120	50 to 80	30 to 50	1203
ii)	Softening point, (R&B), ° C, Min.	50	55	60*	1205
iii)	FRAASS** breaking point, ° C, Max.	-20	-16	-12	9381
iv)	Flash point, COC, ° C, Min.	220	220	220	1209
v)	Elastic recovery of half thread in ductilometer at 15° C, percent, min	50	60	60	
vi)	Complex Modulus (G*/Sinδ) Min 1.0 kPa at 10 rad/s, at a temperature, ° C	58	70	76	
vii)	Separation, difference in softening point (R&B), ° C, Max.	3	3	3	
viii)	Viscosity at 150°C, Poise	1-3	3-6	5-9	1206(Part 2)
ix)	Thin film oven test and tests on residue: a) Loss in mass, percent, Max. b) Increase in softening point, °C, Max. c) Reduction in penetration of residue, at 25°C, percent, Max. d) Elastic recovery of half thread in ductilometer at 25°C, percent, Min. Or Complex modulus as (G*/sinδ) as Min 2.2 kPa at 10 rad/s, at temperature °C	 1.0 7 35 58	 1.0 6 35 70	 1.0 5 35 76	 9382 1205 1203 -

*where max. temperature exceeds 40°C, softening point should be 65°C

**FRAASS breaking point requirement will be applicable for areas of sub-zero temperatures.

2. Modified bitumen shall be subjected to tests for quality control before and during execution besides test reports furnished by the supplier/manufacturer. The essential tests to be carried out are given in Table 511.3

Table 511.3 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 / re-circulate hot modified bitumen using suitable high shear stirrers from time to time to avoid separation. 2. Obtain certificates and test reports in respect of other essential requirements to be met.	1. Do not multiple heat modified bitumen 2. Do not allow local mixing.

512: Bituminous Wearing Course Using Waste Plastic

Use of waste plastic in 25 mm SDBC, Mix Seal Surfacing and 20 mm thick Open Graded Premix Carpet using dry process

A. METHODOLOGY

1. In the dry process, shredded waste plastic (passing 4.75 mm sieve and retained on 1.18 mm sieve) is added in hot aggregate.

2. Plastic waste meeting the requirements specified in Para B shall be used. Care shall be taken to ensure that the waste plastic collected by rag pickers is free from PVC material, mud or organic waste.

3. Waste plastic litter in the form of thin carry bags, use and throw cups, containers, milk bags and water bottles shall be de-dusted and cleaned.

4. The cleaned and sorted plastic waste shall be shredded into size between 4.75 mm and 1.18 mm using an appropriate shredding machine.

5. The quantity of waste plastic shall be 6 to 8 percent of the weight of bitumen.

6. The aggregate mix shall be heated to 150°C to 165°C in an approved hot mix plant and the requisite quantity of the waste plastic is added to heated aggregate using an appropriate method depending upon the type of the hot mix.

7. In the next stage, bitumen heated to the appropriate temperature, is added to the plastic waste coated aggregates. The plastic waste coated aggregate is mixed with hot bitumen for 10 to 15 seconds and the resulting mix is transported for construction of surfacing.

8. The laying and rolling temperature of mix at site shall be in the range of 140°C to 110°C.

9. All construction operations for bituminous construction using plastic waste shall be in accordance with sub-sections 509 for SDBC, 507 for MSS and 506.1 for OGPC.

10. The SDBC mix using plastic waste shall meet the requirements given in Table 512.1.

TABLE 512.1 Requirements of SDBC Mix Using Waste Plastic

Minimum Stability (kN at 60˚C)	12
Minimum flow (mm)	2
Maximum flow (mm)	4
Marshall Quotient (kN/mm)	2.5-5
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
% Air Voids	3-5
Retained Stability (%)	98
ITS (min) MPa	0.9
VMA	16
VFB	65-75

B. QUALITY CONTROL REQUIREMENTS

1. Materials

(a) **Aggregates, filler and viscosity grade paving bitumen:** The provisions of sub-sections 509 for SDBC, 507 for MSS and 506.1 for OGPC shall apply.

(b) **Waste Plastic** shall be thermoplastic materials conforming to low density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET) and polyurethane (PU) and shall meet the following requirements

(i) Waste plastic shall be clean and shredded to size passing 4.75 mm sieve and retained on 1.18 mm sieve.

(ii) Dust and other impurities shall not be more than 1% and determined by ash content at 600°C

(iii) Melt-flow value tested as per ASTM D 1238-2010 shall be in the range of 0.14-58 gm/10 min for LDPE and 0.02 -9.0 gm/10 min for HDPE.

2. Horizontal Alignment, Surface Levels, Surface Regularity and Quality Control Tests (Prior to Construction, During Construction, and Quality Control Checks by AE/EE) shall be exercised in accordance with the requirements given in the relevant Sub-section 509 for SDBC, 507 for MSS and 506.1 for OGPC.

C. Do's and Don'ts

Do's	Don'ts
Plastic waste should be clean of all impurities before use and stored, away from fire.	Plastic waste should not come in contact with flame in HMP
Suitable modification in plant is necessary for smooth addition of plastic waste.	Do not use excess quantity of plastic waste as it may make mix stiff and cause difficulty in rolling.

Annex 500.1

Requirements of Paving Bitumen as per IS:73

Sl.No.	Characteristics	Paving Grade				Method of Test Ref to (7)
		VG10	VG20	VG30	VG40	
i.	Penetration at 25°C 100g, 5s, 0.1 mm, Min.	80	60	45	35	IS1209
ii.	Absolute viscosity at 60°C, Poises.	800-1200	1600-2400	2400-3600	3200-4800	IS 1206(Part 2)
iii.	Kinematic viscosity at 135°C,cSt Min.	250	300	350	400	IS 1206(Part 3)
iv.	Flash Point(Clevefand open cup)°C, Min.	220	220	220	220	IS 1448(P:69)
v.	Solubility in trichloroethylene, percent, Min.	99	99	99	99	IS 1216
vi.	Softening Point (R&B), °C, Min.	40	45	47	50	IS 1205
vii.	Test on residue from rolling thin film oven test.					
	a) Viscosity ratio at 60°C, Max.	4.0	4.0	4.0	4.0	IS 1206(Part 2)
	b) Ductility at 60°C,cm, Min.	75	50	40	25	IS 1206

Annex 500.2

Physical and Chemical Requirements of Bitumen Emulsion(Cationic Type) as per IS: 8887

Sl. No.	Characteristics	Grade of Emulsion					Method of Test, Ref to	
		RS-1	RS-2	MS	SS-1	SS-2	IS No	ANNEXURE at IS 8887
i)	Residue on 600 mm IS sieve, percent by mass,Max	0.05	0.05	0.05	0.05	0.05	-	B
ii)	Viscosity by Saybolt Furol Viscometer,seconds						3117	-
	At 25°C	-	-	-	20-100	30-150		
	At 50°C	20-100	100-300	50-300	-	-		
iii)	Coagulation of emulsion at low temperature	Nil	Nil	Nil	Nil	Nil	-	C
iv)	Storage Stability after 24 hours(% mass)	2	1	1	2	2	-	D
v)	Particle Charge	Positive	Positive	Positive	Weak Positive	Positive	-	E
vi)	Coating Ability and water resistance:						-	F
	1) Coating dry aggregate			Good				
	2) Coating after spraying			Fair				
	3) Coating wet aggregate			Fair				
	4) Coating after spraying			Fair				
vii)	Stability to mixing with cement(percent coagulation).Max	-	-	-	2	2	-	G
viii)	Miscibility with water(coagulation)	No Coagulation	No Coagulation	No Coagulation	-	No Coagulation	-	H
ix)	Tests on residue:							
	1) Residue by evaporation,%	60	67	65	50	60		J
	2) Penetration at 25°C /100g/5s	80-150	80-150	60-150	60-350	60-120	1203	-

Annex-500.3

Selection Criteria for Viscosity Grade (VG) Paving Bitumen Based on Climatic Conditions

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

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. Preload the centering of arches resting on soils with full designed dead load and observe for 24 hours prior to approval.

4. 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

5. 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.

6. 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.

7. 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.

8. Keep thickness of joint not less than 5 mm or more than 15 mm.

9. Adopt minimum 1:4 cement mortar in masonry work.

10. 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 at least 7 days.

5. Provide weep holes to masonry structures to drain water from back filling. Use100 mm diameter AC/PVC/HDPE pipes and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 1m in horizontal or 1 m in vertical direction, with the lowest one at about 150 mm above the low water level or ground level whichever is higher.

6. Provide architectural coping over the top of wing/return/parapet wall in cement mortar 1:3. Lay cement mortar evenly to an average thickness of 15 mm to the full width of the top of the wall and in a band of 150 mm depth along the top outer face of the wall.

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
Portland Slag Cement	-	IS:455
Portland Pozzolana Cement	Fly ash based	IS:1489-Part1
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 groundwater in concentration of 0.2 percent and 0.03 percent respectively.

(ii) Fine Aggregates

Fine aggregate shall be sand or crushed stone sand or crushed gravel sand or suitable combinations thereof as per Section 2000 and shall conform to the requirements given in Table 2000.8.

(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 600.2

TABLE 600.2 CONSISTENCY AND WATER RETENTIVITY

Property	Work	Value
Consistency	- Laying of solid brick walls	90-130 mm
	- Filling cavities	130-150 mm
Water retentivity (Flow of suction)	Masonry work with high suction characteristics	More than 70% of flow before suction

(iv) Bricks

First class bricks of any of the two types specified and meeting the physical requirements of Table 2000.1shall be used in masonry works.

(v) Storage of material

For storage of bricks, cement, lime and sand, follow provisions of section 2000.

2 Workmanship and Tolerances

Permissible values of workmanship and tolerances for bricks and brick masonary are given in Table 600.3

Table 600.3: WORKMANSHIP AND TOLERANCES

Item	Permissible Value
Dimensions of Bricks	+5 percent in size
Compressive Strength of Bricks	As in Table 2000.1.
Thickness of joints for general brickwork	Not more than 10 mm
Thickness of joints for Arches	5 mm to15 mm
Plaster finish	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 600.4.

TABLE 600.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material	Test/Check	Frequency
1.	Brick	a) Colour and Dimensional check	3 samples at random at source
		b) Water absorption (IS:3495 Part 2)	3 samples at source or after procurement
		c) Efflorescence (IS:3495 Part 3)	In case of doubt, 3 samples at random, at source
		d) Compressive strength (IS:3495 Part 4)	3 samples at random at source.
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)	3 samples for each source of supply
		b) Deleterious material and organic impurities (IS:2386 Part 2)	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 600.5

TABLE 600.5: 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	-do-
4.	Top	Sloping to drain off water	Daily
5.	Mortar for Joints	a) Mix proportions (Control on quantity of cement/ lime by weight)	Each batch
		b) Consistency and water retentivity (IS:2250)	As required at close interval
		c) Compressive Strength(IS:2250)	One cube for every 2 cum of mortar. Minimum 3 cubes for a day's work.
6.	Arches	a) Dimensions of abutment-pier for multiple arches (IS:2118)	Regularly
	(Additional Tests)	b) Centering for arch	For each span
		c) Compaction and thickness of filling material over crown and haunches	Regularly
		d) Thickness of Joints	Regularly

3.3. Quality Control checks by AE / EE

The quality checks by AE / EE are indicated in Table 600.6

TABLE 600.6: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material/Work	Test/Check	Frequency	Designation of Inspecting Officer
1.	Brick masonry	Verticality of Brickwork and horizontality of courses/general workmanship and compressive strength (IS3495Part1).	Once in each inspection	AE/EE
2.	Weep holes	Location, size and spacing	For each work	AE
3.	Mortar for Joints	a) Consumption per cum 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 test also

C. Do's and Don'ts

Do's	Don'ts
1. Test the cement if it is more than 3 months old. 2. Use lime undamaged by rain, moisture or air slaking. 3. Use bricks of rectangular faces with sharp corners. 4. Mix Cement mortar in a mechanical mixer operated manually or by power for large works. 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. 6. For arch construction, ensure proper centering and simultaneous commencement of work from both ends.	1. Do not Substitute 33 Grade Cement with 43 Grade or 53 Grade. 2. Do not mix different types of cement together. 3. Do not use sand containing dust lumps, soft or flaky particles, mica or other harmful materials. 4. Do not use lime which is in storage for more than a month. 5. Do not use cement mortar 30 minutes after addition of water or initial setting whichever is earlier. 6. Do not use brick bats or cut bricks except to obtain dimensions of different courses. 7. Do not start masonry work earlier than 48 hours of casting foundation block. 8. Do not build brick masonry arch bridges having spans more than 6 m in seismic zones IV and V.

SECTION 700

STONE AND CONCRETE BLOCK MASONRY FOR STRUCTURES

700: STONE AND CONCRETE BLOCK 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 (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 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 Concrete Block Masonry Work

1. Use only solid concrete block of normal weight having least dimension not less than 200 mm and minimum density of 2.2 tonne/cum. Minimum compressive strength of solid concrete shall be 10.5 MPa.

2. Produce solid concrete blocks of required size, density, shape, quantity and soak them in water for at least 15 minutes before laying.

3. clean, wet and cover the bed with thin layer of mortar for receiving the concrete blocks .Lay masonry work to lines levels, course and shapes shown on the drawing

4. For battered section make the beds of concrete blocks and plane of course horizontal. Manufacture face blocks of such section specially for the purpose.

5. Construct the concrete block masonry generally like fine tooled Ashlar masonry. Fit each block in place dry and lay full in thin mortar. Strike each block with a wooden mallet when laid in place in mortar to provide solid bearing in bed and for joints. Ensure thickness of joints less than 15 mm.

6. Lay the course horizontal and side joints vertical throughout and joints shall be struck.

7. For providing adequate bond, lay face blocks header and stretcher alternately and arrange the header to come as nearly as possible in the middle of stretcher below. Ensure that the blocks in the courses above and below break joints at a distance of about half the height of the course throughout the section.

8. Use templates prepared to the correct shape to ensure the specified batter and shapes of masonry especially cut and ease water end while carrying out masonry work.

9. Acute angle at corners in case of skew bridges and cut and ease water, shall not be less than 45 degrees.

A4 Miscellaneous items

1. Carryout pointing, finishing and curing as detailed in Section 600.
2. Provide architectural coping as specified in Section 600.
3. Provide weep holes 80 mm wide, 150 mm high or circular with 150 mm diameter and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 1 m horizontal direction or 1 m vertical direction with the lowest one at 150 mm above low water level or ground level whichever is higher.

B. Quality Control Requirements

1. Materials

(i) Cement, Lime, Fine aggregates, Stones and Concrete blocks

Use cement, lime, fine aggregates, and concrete blocks conforming to the requirements of Section 2000.

(ii) Cement Sand Mortar

Cement sand mortar shall be as per Section 600. Adopt Cement mortar not leaner than 1:5, above bed ground level and 1:4 below bed/ground level.

Cement mortar for arches shall not be leaner than 1:4.

(iii) Stone Masonry

a. Use Random Rubble (RR) Masonry for wing / return / toe walls of height less than 5 m. For all other components, adopt coursed Rubble (CR) masonry (First or second sort or Concrete block masonry).

b. Use of dry rubble masonry should be restricted for breast/retaining walls/toe wall and other incidental works of height up to 3 m and not subjected to flood/stagnated water.

c. The specifications and requirements of Stone Masonry shall satisfy those given in Table 700.1.

TABLE 700.1: 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 cum for each cum of stone masonry

(iv) 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 700.2

TABLE 700.2: SIZE OF PRECAST CONCRETE BOND BLOCKS

Size	Height of course (mm)	Minimum Acceptable size of of Face Stones (mm)	Perferable Size of Force Stones (mm)	Size of Longer Stones 1/3rd of Total Face Stone (mm)	Size of precast concerte 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

(v) Storage of Materials

Provide storage for cement, lime and fine aggregates in conformity with Section 2000.

2 Thickness of Joints

The thickness of cement sand mortar joints for different types of masonry is given in Table 700.3

TABLE 700.3: THICKNESS OF JOINTS

Type of Masonry	Joint Thickness (mm)	Remarks
CR Masonry (I sort)	<10mm	The thickness should be adequate to prevent stone to stone/block to block contact and the joint completely filled with mortar
CR Masonry (II sort)	<20mm	
RR Masonry	<20mm	
Concrete Block Masonry	<15 mm	

3. Workmanship

The cement fine aggregate ratio for different cement mortars used in stone/ concrete block masonry is given in Table 700.4.

TABLE 700.4: CEMENT-FINE AGGREGATE RATIO

Location	Ratio
Above bed/ground level	1:5
Below bed/ground level and Arches	1:4

4. Curing

Carry out curing of all masonry work in cement mortar in conformity with Section 600.

5. Quality Control Tests

5.1 Tests prior to construction

The tests / checks to be carried out prior to construction are indicated in Table 700.5.

TABLE 700.5: 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.	Concrete blocks	Dimension, density and compressive strength (IS:2185 Part-1)	3 samples on receipt at site
3.	Cement	Setting time of cement (IS:4031part-5)	As per Table 600.4.
4.	Lime (If used)	Purity (IS:1514)	As per Table 600.4.
5.	Sand	a) Gradation (IS:2116) b) Deleterious materials and organic impurities (IS:2386part2)	As per Table 600.4.
6.	Water	If impurities are present test as per IS:3025 (parts17,24,32)	As per Table 600.4.
7.	Pre cast concrete bond blocks when natural stone of appropriate size not available	a) Size (Table700.2) b) Cube strength of mix used	3 samples for each size (A,B,C) On receipt at site 3 samples
8.	Mortar for Joints	a) Consistency and water. retentivity (IS:2250) b) Mix proportions for different works c) Compressive Strength(IS:2250)	As required Daily one cube for every 2 cum of mortar. Minimum 3 cubes for a day's work.

5.2 Tests / checks during construction

The tests / checks to be carried out during construction are indicated in Table 700.6

TABLE 700.6: 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 coursestone Concrete Block	Height, Joint Thickness and laying (IS:1597 part 1&2 and IS:2212). Para A3 of this section	-do- -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	Sloping to drain off water	Once one it her side of parapet

5.3 Quality control checks by AE / EE

Quality checks to be exercised by AE / EE are indicated in Table 700.7

TABLE 700.7: QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material/Work	Test/Check	Frequency	Designation of Inspecting Officer
1.	Stone/Concrete Block Masonry	Verticality of masonry work, Horizontality of courses, shape and batter and Architectural features.	Once in each inspection	AE/EE
2.	Mortar	a) Quality of Mortar* b) Consumption per cum of stone masonry work	For each work as recorded by JE -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 test 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. 2. Mix mortar thoroughly and pour fluid mortar in joints. 3. Restrict use of chips to fill interstices. 4. Ensure that mortar is confined to joints without smearing the faces. 5. Protect stone masonry during construction against rain or frost. 6. Use only solid concrete blocks of normal weight for bridge work. 7. Use templates prepared to correct shape and check the finished work at every stage to ensure that it has the correct shape and batter as required by design while carrying out concrete block masonry work.	1. Do not have any dry or hollow space in masonry or use water to push mortar in to joints. 2. Do not dress or hammer masonry once placed in position. 3. Do not use quantity of chips more than 20 percent of the quantity of stone masonry. 4. Do not use stone masonry arch bridges having span more than 6m in seismic zones IV and V. 5. Do not use hollow light weight concrete blocks in bridge works.

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 -designated as per Table 800.1, 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.

TABLE 800.1 GRADE OF CONCRETE

Type of Concret /grade Designation		Characteristic strength in MPa
Nominal Mix Concrete	Design Concrete	
M15	M15	15
M20*	M20	20
M25*	M25	25
	M30	30
	M40	40
	M45	45

*Refer para 2 below

2. Choose Design Mix of grades higher than M 20 for large works. For culverts and small bridges involving small quantity of concrete, nominal mix of grades M 20 and M 25 may be used with adequate supervision and quality control measures.

3. The suggested grades of concrete (based on 20 mm aggregate) together with minimum cement content, maximum water-cement ratio for different exposure conditions are indicated in Table 800.2.

TABLE 800.2: CEMENT CONTENT AND WATER CEMENT RATIO

	Grade of Concrete			Minimum Cement Content (kg/cum)			Minimum Water Cement Ratio		
Exposure Condition	Moderate Severe	Severe	Very severe	Moderate Severe	Severe	Very severe	Moderate Severe	Severe	Very severe
(a) Plain Cement Concrete(PCC)	M 20	M 25	M 30	320	340	360	0.50	0.50	0.45
(b) Reinforced Cement Concrete	M 25	M 30	M 40	340	360	380	0.45	0.45	0.40

Note:

i. All these provisions for particular exposure condition given in above table shall be satisfied.

ii. The term cement for maximum w/c ratio and minimum cement content shown in table includes cementitious materials .The maximum limit of fly ash and ground granulated slag in blended cement shall be as specified in IS:1489(part1) and IS:455 respectively.

iii. Cement content indicated in above table shall be increased by 40 kg/cum for use of 12.5 mm nominal size aggregate and decreased by 30 kg/cum for 40 mm nominal size aggregate.

4. Adopt cement content as low as possible but not less than the quantities specified above subject to a maximum of 450 kg/cum of concrete in any case.

5. Use Mechanical mixer (min. one bag capacity) fitted with water measuring device for culverts and small bridges with length less than 60 m and individual span less than 15 m. However for control mix of M 25 for superstructure, use mechanical mixer of minimum 200 litre capacity having integral weigh batching facility, automatic water measuring and dispensing device.

6. Avoid hand mixing of concrete for use in structural concrete except for isolated culverts.

(upto 2 m) in remote areas or for certain other reasons. Add 10% extra cement in such situations.

7. Use Admixtures where necessary 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 for the same mix placed in the 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°C 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°C 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 one or 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, except in the case of concrete with rapid hardening cement where it can be reduced to five days.

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 to 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 types of cement given in Table 2000.4 for Structural Concrete. Obtain samples of cement once for each source of supply and occasionally when called for determine the properties given in Table 2000.5.

(ii) Coarse aggregates

The gradation of coarse aggregate shall satisfy the requirements given in Table 2000.10.

(iii) Fine Aggregates

The gradation of fine aggregates shall satisfy the requirements given in Table 2000.9.

(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 2000.11.

(v) Concrete

a. The grades of concrete and their equivalent nominal mix (using 43 Grade cement) are given in Table 800.3

TABLE 800.3: 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

b. Proportion of materials nominal mix concrete shall be as given in Table 800.4

TABLE: 800.4 REQUIREMENTS FOR NOMINAL CONCRETE

Concrete Grade	Total Quantity of Dry Aggregates by mass per 50kgof cement to be taken as the sum of individual masses of fine and coarse aggregates(kg)	Proportion of Fine to Coarse Aggregate (by mass)	Maximum quantity of water for 50kg of cement (litres)		
			Lean concrete	PCC	RCC
M10	480	Generally 1:2 Subject to upper limit 1:1.5 and lower limit of 1:2.5	34		
M15	350		28		
M20	250			25	25
M25	180			25	22

c. maximum nominal size of aggregates for concrete to be used in various components shall be as given in Table 800.5

TABLE: 800.5 MAXIMUM NOMINAL SIZE OF COARSE AGGREGATES

S.No.	Components	Maximum Nominal Size of Coarse Aggregate
1.	RCC Well curb	20 mm
2.	RCC/PCC well steering	40 mm
3.	Well cap or pile cap, solid type piers and abutments	40 mm
4.	RCC work in girder, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, pier/abutment caps, piles	20 mm
5.	PSC work	20 mm

d. Maximum slump for different type of work shall be as given in Table 800.6

TABLE: 800.6 REQUIREMENT OF CONSISTENCY

S.No.	Type of work	Slump(mm) (at the time of placing of concrete)
1.	Structures with exposed inclined surface requiring low slump concrete to allow proper compaction	25
2.	Plain concrete	25
3.	RCC structure with widely spaced reinforcements, e.g. solid columns, piers, abutments, footings, well steining	40-50
4.	RCC structure with fair degree of congestion e.g. pier and abutment caps, walls with thickness greater than 300 mm	50-75
5.	RCC and PSC structure with highly congested reinforcements e.g. deck slab girders, box girders, wall with thickness less than 300 mm	75-125
6.	Under water concreting through tremie e.g. bottom plug, cast in-situ piling	150-200

e. The workability of fresh concrete by slump test is determined as per IS:1199 at the rate of one test per 3 cum of concrete at the place of mixing and/or at worksite.

f. 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-days 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 800.7

TABLE 800.7: FREQUENCY OF SAMPLING

Quantity of concrete in work (cum)	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 800.8

TABLE 800.8: SULPHATE AND CHLORIDE CONTENTS

Details	Content
Sulphate content as (SO3)	4 percent
Chloride content	0.3 percent by mass of cement (Moderate condition)
(As Chloride ion)	0.2 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 800.9

TABLE 800.9 REQUIREMENTS 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)

The requirements of storage for cement and fine and coarse aggregates are as per Section 2000.

2. Tolerances

The accuracy of the measuring devices used for different ingredients shall fall within the limits given in Table 800.10

TABLE 800.10: 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 800.11

TABLE 800.11: 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 800.12

TABLE 800.12: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency
1.	Cement	a) Setting Time (IS:4031 Part 5)	One test for 10 tonnes of cement (same brand & grade)
		b) Soundness (IS:4031 Part 3)	- do
		c) Compressive strength of mortar cube	3 specimens for each lot
2.	Coarse Aggregates	a) Gradation for PCC or RCC works (Table 800.4)	3 samples for each quarry source
		b) Flakiness index (IS:2386 part 1)	-do -
		c) Deleterious constituents (IS:2386 part 2)	If in doubt
		d) Water absorption/content (IS:2386 part 3)	Once for each source of supply
		e) Aggregate Impact Value (IS:2386 part 4)	One test per source of supply
3.	Fine Aggregates	a) Gradation (IS:2386 part 1) (Table 800.5)	3 samples for each source of supply
		b) Deleterious Constituents (IS:2386 part 2)	If in doubt, one test
		c) Alkali silicate reactivity (IS:2386 part 7)	If in doubt, one test
4.	Water	Normally potable water is good enough for making concrete Determination of Impurities - Suspended matter IS:3025 (Part 17) - Organic IS:3025 (Part 16) - Inorganic IS:3025 (Part 19)	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 800.13

TABLE 800.13: 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/cum)	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 800.14

TABLE 800.14: 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 Striking with 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. 2. Use 20 mm (nominal) size aggregate for RCC unless stated otherwise. 3. Use potable water with pH value between 6 and 8 for producing concrete. 4. Determine moisture content in both fine and coarse aggregates as frequently as possible to adjust. 5. Remix concrete, if there is segregation after unloading from the mixer. 6. Compact before initial setting of concrete but not later than 30 minutes of its discharge from the mixer.	1. Do not mix different types of cement or mix Blast. 2. Do not use fine aggregates having positive alkali-silica reaction. 3. Do not use sea water for mixing and curing of concrete. 4. Do not increase water content in concrete mix to 'enhance' its workability. 5. Do not use aggregates or wooden pieces to provide cover to reinforcements instead of concrete briquettes. 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 minimum 100 mm diameter of heights not more than 4 m without any joint in ballies. Provide cross and diagonal bracings of 75 mm diameter (ballies) in both directions. For metal forms, the diagonal bracings shall be of the same size of angles used for columns. Use structural steel tubes with minimum 4 mm wall thickness for supporting the forms.

7. Check for design deficiencies such as shoring or re-shoring, insufficient allowance for unsymmetrical or eccentric loading due to placement sequence of concrete.

8. Pay attention to detailing which otherwise may cause instability, local failure or progressive collapse. Lay emphasis on attention to details.

9. In case of false work erected on normal ground, ensure distribution of loading to the ground, through timber or base plates to avoid differential settlement.

10. Control the alignment of the distribution members, so that shores of the 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.

12. Provide temporary opening in the shuttering of walls, sloping members and thin sections of considerable height to permit inspection and cleaning out before placing of concrete.

A2 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.

A3 Removal of Formwork

1. Plan removal of formwork (de-shuttering and de-centering) 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 re-entrant 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

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

5. For concrete made with Portland pozzolana cement, Portland slag cement or mineral admixtures, take additional cube samples to verify the strength of concrete for deciding the time of de-shuttering/de-centering.

A 4 Reuse of Formwork

1. After dismantling examine individual components for damage and remove damaged pieces for rectification.

2. Straighten all bent steel props before reuse, the maximum deviation from straightness being 1/600th of its length. Reduce permissible axial loads on props after each reuse, depending on their condition.

B. Quality Control Requirements

1 Tolerances in Formwork

(a) Deviations from the specified dimensions of cross section of columns, beams: +12 mm, -6 mm

(b) Deviations in 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.	Diameter 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 joins to a minimum.	1. Do not use form panels of height abutments, piers and return walls less than 1.0 m height.
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 25x25 mm (minimum) size tall angles of form work.	3. Do not allow releasing agent to come into contact with reinforcement.
4. Uses crew jacks or hard wood wedges to make up for any settlement of formwork before and after concreting.	4. Do not use Lubricating machine oil coating as releasing agent.
5. Provide suitable camber of 1/500 of span in horizontal members to counter the effects of any deflection.	5. Do not keep centering and shuttering on soft or filled up earth.
6. Use angle iron (not steel bars) bracings for column support.	6. Do not allow stagnation of water near the base plate supporting the staging.
7. Maintain a close watch to check for settlement of formwork during concreting and promptly rectify any settlement of formwork during concreting.	7. Do not use more than one plank/timber block at the base of a prop to plug the gap, if any.
8. Take additional cube samples to verify the strength of concrete for deciding the time of de-shuttering/de-centering, when Concrete is made with Portland Pozzolana cement, Portland slag cement or mineral admixtures.	

SECTION 1000

STEEL REINFORCEMENT (UNTENSIONED)

1001: Steel Reinforcement (Untensioned)

A. Methodology

A1 Bending and Placing

1. Use new steel of the same type and grade for main reinforcement in construction. Use of different types 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 intersection using annealed binding wire. Position the bars on industrially produced polymer cover blocks or concrete cover blocks of required thickness of the same strength and specification as those of the member, 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 diameter 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.

A2 Splicing and Welding of Bars

1. Stagger the lapped splices as per the provisions in IRC: 112 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 diameter 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.

A3 Coating of Reinforcing Bars

a. Fusion Bonded Epoxy Coated Reinforcement

1. Use fusion bonded epoxy coated reinforcement in marine environment where the rate of corrosion

is greater than 0.25 mm per year or for bridges located within a distance of 15 km from the sea or creek.

2. Use fusion bonded epoxy coated reinforcement comforming only to IS: 13620 or other international standards in reinforced concrete or prestressed concrete components of the bridges.

3. Ensure that the location of supply of the fusion bonded epoxy coated bars does not require transportation for a distance of more than 300 km.

4. Satisfy following additional requirements for the use of fusion bonded epoxy coated reinforcement.

   i. Patch up materials shall be procured in sealed containers with certificate from the agency who has supplied the fusion bonded epoxy bars.

   ii. PVC coated GI binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.

   iii. Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.

   iv. The cut ends and damaged portions shall be touched up with repair patch up material.

   v. The bars shall be cut by saw-cutting rather than flame cutting.

   vi. While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.

   vii. The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque poly ethylene sheets or such other approved materials.

   viii. While concreting, the workmen or trolley shall not directly move on coated bars but can move on wooden planks placed on the bars.

b. Hot Dipped Galvanized Bars

Provide hot dipped galvanized reinforcing steel, wherever specified, in conformity with IS:12594.

A4 Storage and Protection

1. Provisions of Section 2000 shall apply for the storage of steel reinforcement and protection of the reinforcement bars shall conform to Clause 1001.3 of MORD Specifications for Rural Roads.

B. Quality Control Requirements

1. Material:-

(i) The Steel reinforcement used and works executed shall conform to the requirements given in Table 2000.14.

(ii) The workmanship for welding of steel reinforcements shall conform to the specifications given in Table 1001.1.

TABLE1001.1: 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 1001.2.

TABLE 1001.2: TOLERANCES FOR PLACEMENT OF REINFORCEMENT

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 1001.3.

TABLE 1001.3: 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	Random checking
3.	Protection of Steel (Clause 1001.3 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 1001.4

TABLE 1001.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Test	Frequency
1.	Bending and placing of reinforcement (Clauses 1001.4, 1001.5 of MORD Specifications or IS:2502)	Daily/Regularly
2.	Splicing and welding (Clause 1001.6 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 1001.5.

Table 1001.5: 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
3	Substitution of bar sizes	AE/EE
4	Detailing of reinforcement cage	AE/EE

C. Do's and Don'ts

Do's	Don'ts
1. Use new steel for works.	1. Do use not scaled or re-rolled steel in works.
2. Protect reinforcement steel from rusting or chloride contamination, by thorough cleaning using suitable method before use.	2. Do not allow rough handling, dropping or shock loading of reinforcement prior to embedment.
3. Bend the bars cold only by using a proper bar bender.	3. Do not resort to splicing by welding of reinforcement unless permitted or detailed on the drawing.
4. Use non corrodible (material) devices for positioning.	4. Do not tack weld cross bars for assembly of reinforcement.
5. Adopt splicing of reinforcement at non critical section; the percentage not to exceed 33.	5. Do not permit welding of reinforcement at site unless adequate facilities, equipment etc to produce and maintain uniform quality at par with that in shop welding is attainable.

Do's	Don'ts
6. Get the welded lengths of reinforcement tested for strength. 7. Follow the working drawing and bar bending schedules and match detailing and construction. 8. Support fusion bonded epoxy coated reinforcement with chairs of same steel.	6. Do not prolong gap between assembling of reinforcement and casting of concrete. 7. Do not heat the bars to facilitate straightening. 8. Do not re-bend or straighten an already bent HYSD bar to a diameter less than 6 times the diameter of bar. 9. Do not allow movement of workmen or trolley directly on fusion bonded epoxy coated steel while concreting. 10. Do not use fusion bonded epoxy coated reinforcement without touching up cut ends and damaged portions with repair patch up material.

1002: STRUCTURAL STEEL

A Methodology

A1 General

1. Provide finished rolled material which is free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. Ensure that it has a smooth and uniform finish and is straightened in the mill before shipment and is also free from loose mill scale, rust, pits or other defects affecting its strength and durability.

2. Use high tensile steel rivets conforming to IS:1149 only for members of high tensile steel in conformity with IS: 961 and not for members of mild steel.

3. Ensure use of high tensile friction grip bolts complying with requirements of IS: 4000 in bolted connections.

4. Do not use cast iron in any part of the bridge structure except where it is subjected to direct compression.

A2 Fabrication

a. General Requirements

1. Ensure that all parts of an assembly fit accurately together and carry mark number and item number and if required, serial number.

2. Use templates, jigs and other appliances made of mild steel for ensuring the accuracy of the work and where specially required, bushed with hard steel. Make all measurement by means of steel

tape or other device properly calibrated. Allow use of bridge materials which have been used as templates for drilling only after prior inspection and approval.

3. Provide all steel members and parts with straight edges and blunt surfaces and which are free from twist. Straighten or flatten them if necessary, by pressure unless they are required to be curvilinear forms without damaging the materials. Do not permit hammering for the purpose of straightening or flattening. Ensure that adjacent surfaces or edges are in close contact or at uniform distance throughout.

4. Obtain the programme of work containing the proposed system of identification and erection marks together with complete details of fabrication and welding procedure from the contractor for approval at least 15 days before commencement of fabrication.

5. Obtain shop drawing for fabrication from the contractor showing clearly complete information regarding the location, type, size and extent of all welds with clear distinction between shop and field welds, before start of work approval.

b. Preparation of Edges and Ends

1. Use shearing, cropping, sawing or flame cutting and accurate grounding, where required, to bring all structural steel parts to the specified dimension and shape.

2. Adopt any of the following prescribed methods for End/edge planning and cutting or leave as rolled.

   i. Shearing, cropping sawing, machining, machine flame cutting.

   ii. Hand flame cutting with subsequent grinding to a smooth edge.

3. Carry out preparation of edges and ends in conformity with clause 1003.2 of MORD Specifications for Rural Roads.

c. Preparation of Holes

1. Drilling and Punching

   i. Make holes for rivets, black bolts, high strength bolts/ rivets (excluding close tolerance and turn fitted bolts) either by punching or drilling. Provide diameter of holes 1.5 mm larger for bolts/rivets less than 25 mm diameter and 2 mm larger diameter holes in case of bolts/rivets of more than 25 mm diameter.

   ii. Provide all holes by drilling except in secondary members such as floor plates, hand rails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for materials conforming to IS: 226.

iii. Sub drill or sub punch the holes to a diameter of 3 mm less than the required size through material of more than one thickness or through main material thickness exceeding 20 mm for steel conforming to IS:2062 or 16 mm for steel conforming to IS: 961,IS:8500 and then ream to the size specified. Carry out reaming of material more than one thickness after assembly.

iv. Where practicable, connect the several plates or sections forming a compound member by clamps or tacking bolts and drill the holes through the group in one operation. Is it Alternatively, and in case of repetition work, drill the plates and sections separately from jigs and plates. Check jigs and templates at least once in 25 operations and remove all burrs.

2. Block Drilling

Where the number of plates to be riveted exceeds three or the total thickness is 90 mm or more, drill out the rivet holes in place 3 mm all round after assembling, unless they have been drilled through steel bushed jigs.

3. Size of Holes

Provide the size of holes in conformity with Sub para i of Para A2 c1.

4. Close Tolerance Bolts and Barrel Bolts

i. Keep the diameter of the holes equal to the nominal diameter of the bolt shank minus 0.15 mm to 0.0 mm in case of close tolerance or turn fitted bolts.

ii. Firmly hold together the members to be connected with close tolerance or turn fitted bolts by service bolts or clamps and drill through all thicknesses in one operation. Ream subsequently to required size within specified accuracy as specified in IS: 919 tolerance grade H8.

iii. Drill to smaller size the holes which are not drilled through all thickness in one operation and ream them after assembly.

5. Holes for High Friction Bolts

i. Drill all holes after removal of burrs. Where the number of plies in the grip does not exceed three, provide diameter of holes 1.6 mm larger than those of bolts.

ii. In case number plies in the grip exceed three, provide the diameter of holes as below:

In outer plies -1.6 mm larger than diameter of bolts

In inner plies - not less than 1.6 mm and not more than 3.2 mm larger than diameter of bolts.

6. Removal of Burrs

Take apart the work after drilling and completely remove all burrs left by drilling and the sharp edges of all rivet holes.

d. Rivets and Riveting

1. Show the diameter of rivets on the drawings as the size before heating. Provide each rivet with sufficient length to form a head of the standard dimensions as given in IS hand book on steel sections, part I and under side free from burrs.

2. When countersunk head is required, fill the countersunk hole by the head and where necessary ground off projection after counter sinking. Included angle of the head shall be

   i. For plates over 14 mm thickness -90 degrees

   ii. For plates up to and including 14 mm thickness-120 degrees

3. Conform tolerance on the diameter of rivets as per IS: 1148 for high tensile steel rivets and on minus side.

4. Carryout riveting in conformity with clause 1003.4 of MORD Specifications for Rural Roads.

e. Bolts, Nuts and Washers

Provide black bolts, close tolerance bolts, turned barrel bolts, high strength friction bolts and bolted connections, washers, studs, service bolts and drifts and carry out tightening of bolts as per clause 1003.5 of MORD Specifications for Rural Roads.

f. Pins and Pinholes

1. Pins

i. Provide the pins with a smooth surface free from flaws and of sufficient length to ensure that all parts connected thereby have a full bearing on them and are parallel throughout. Where the ends are threaded, turn them to a smaller diameter at the ends for the thread and provide with a pilot nut where necessary, to protect the thread when being drawn in place.

ii. Use forged and annealed pins when length or diameter of pins is more than 175 mm.

2. Pin Holes

i. Bore pin holes true to gauge, smooth, straight at right angles to the axis of the member and parallel to each other with the tolerance in the length of tension members from outside to outside and of compression members from inside to inside of pinholes of 1 mm. Carry out the boring in built-up members after riveting or welding of members.

ii. Specify the minimum diameter of the pin hole such that the resulting clearance between the pin and the hole is neither less than 0.5 mm nor more than 1.0 mm.

g. Shop Erection and Match Marking

1. Before dispatch, temporarily erect the steel work in the fabrication shop, either wholly or in such part as is considered necessary for the inspection to ascertain the conformance of both the alignment and fit of all connections as per the requirement. For this purpose, employ sufficient number of parallel drifts and tightly screwed up service bolts. Ensure that all parts fit accurately in accordance with the drawings and specifications.

2. Assemble full truss or girder temporarily, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly is specified.

3. Assemble the field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame. Check the alignment and accuracy of holes and only there after take up the reaming of sub-sized holes of specified size.

4. After approval of the work and before dismantling, carefully mark each part for re-erection with distinguishing marks and durable stamp markings. Obtain drawings showing these marks correctly from the contractor.

5. In cases where close tolerance or turned barrel bolts are used and interchangeability is not insisted upon, erect each span and mark its members distinctly.

h. Welding

1. Ensure that all welding is done with prior approval and of workmanship conforming to the specifications of IS: 823 or other relevant Indian Standards as appropriate.

2. For material thickness in excess of 20 mm, take special precautions like preheating as laid down in IS: 823.

3. Provide surfaces and edges to be smooth, uniform and free from fins, tears, cracks and other discontinuities. Make the surfaces also free from loose or thick scale, slag rust, moisture, oil and other foreign materials.

4. Ensure that the surfaces within 50 mm of any weld location is free from any paint or other material which may prevent proper welding or cause objectionable fumes during welding.

5. Follow provisions of clause 1003.8 of MORD Specifications for Rural Roads for carrying out welding.

6. Welding of stud shear connectors

i. Carry out welding of stud shear connectors in accordance with manufacturer's instructions including preheating.

ii. Make the stud and the surface to which it is to be welded free from scale, moisture, rust and other foreign material. Do not carry out painting, galvanizing or cadmium plating of the stud base.

iii. Ensure that the weld is free from cracks and capable of developing at least the nominal ultimate strength of studs.

iv. Carry out procedural trial for welding the stud, where specified.

1004 Erection

a. General

1. In case of execution of substructure and superstructure through different agencies, provide the substructure, constructed to correct lines dimensions and elevation finished properly and establish the lines and elevation required for erection purposes.

2. Ensure that the agency entrusted with the work of superstructure erects the structural steel, removes the temporary construction and does all work required to complete the construction as specified.

b. Organization and Equipment

1. Obtain from the contractor erection plans prepared by the fabricator showing the method and procedure of erection compatible with the details of fabrication. Accord approval to the methodology of erection and the number and character of tools and plant.

2. Prepare a detailed scheme showing stage wise activities, with complete drawing and working instructions based on detailed stage wise calculations considering the specification and capacity of erection equipment machinery, tools and tackles to be used and temporary working loads as per codal provisions.

3. Ensure that the scheme takes into account site conditions such as hydrology, rainfall, flood timings and intensity, soil and subsoil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space.

4. Further, ensure that it also indicates precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection and working drawings show clearly the temporary jigs, fixtures, clamps, spacer supports etc.

5. Ensure deployment, by prior approval, of a competent engineer or foreman in charge of the work with adequate experience in steel erection during execution of work.

6. Follow provisions of clause 1004.2 of MORD Specifications for Rural Roads for organizing the work and equipment there for.

c. Formwork

Ensure the provision of formwork that is properly designed, substantially built and maintained for all anticipated loads and where necessary, by prior approval.

d. Straightening Bent Material

1. Carry out straightening of plates, angles and other shapes by methods not likely to produce fracture or injury.

2. Allow use of heating only in special cases and restrict the heating to a temperature not higher than that produces a dark cherry red colour. Follow heating of metal by as slow cooling as possible.

3. Inspect carefully the surface after straightening of a bend or buckle for evidence of fracture, if any.

e. Assembling Steel

1. Accurately assemble the parts as shown on the drawings following the match marks. Carefully handle the material so that no part is bent, broken or otherwise damaged. Do not resort to hammering that will injure or distort the members.

2. Clean all bearing surfaces or surfaces to be in permanent contact before the members are assembled. Clear all joint surfaces for bolted connection including bolts, nuts, washer of scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts.

3. Secure any connection to be riveted or bolted in close contact with service bolts or with sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Normally, make the joints by filling not less than 50 percent of holes with service bolts and barrel drifts in the ratio 4:1. Tighten the service bolts as soon as the joint is assembled. Complete the connections to be made by close tolerance or barrel bolts as soon as practicable after assembly.

4. Hold securely in position any connection to be site welded by an approved method to ensure accurate alignment, camber and elevation before welding is commenced.

5. Use only an approved method of correction for the rectification of any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting.

f. Field Inspection

1. General

i. Subject all materials, equipment and work of erection to the inspection as per provisions of clause 1004.7 of MORD Specifications for Rural Roads.

ii. Do not apply protective treatment to the work until the appropriate inspection and testing have been carried out.

iii. Carry out stage inspection for all operations so as to ensure correctness of fabrication and good quality.

iv. Finally check the girder dimensions and camber only after welding and heating operations are completed and the member has cooled to a uniform temperature.

v. Inspect the steel work for surface defects and exposed edge laminations during fabrication and blast cleaning. Use chipping, grinding or ultrasonic inspection to determine depth of imperfection

2. Inspection Requirement

i. Check the fabricated member/component made out of rolled or built-up section for compliance of the tolerances given in Table 1002.2. Carry out inspection of member/components for compliance of tolerances and check for deviations over the full length.

ii. Ensure that the surface irregularities do not influence the results while checking during inspection..

iii. Check out of plane deviation at right angle to the surface over the full area of plate in case of plate and in a longitudinal direction over a length equal to the depth of the section for the web of rolled beam or channel section. For the cross girder or cross frame, check the deviation over the middle third of its length between each pair of webs and at the end of member for cantilever.

3. Inspection Stages

Carry out the stages of inspection for compliance of tolerances as per but not limited to stages below:

i. For completed parts, component/members-on completion of fabrication and before any subsequent operations such as surface preparation, painting, transportation, erection.

ii. For webs of plates and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints- on completion of site joint.

iii. For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased on completion on site assembly.

1005 Painting

a. General

1. Give approved shop coats as well as field coats of painting to all metal work. Apply coating to only dry surfaces and do not expose coated surface to rain or frost before they become dry. Provide all

surfaces with coatings except shear connectors and inner surfaces of fully sealed hollow sections. Take care to ensure that primer is not applied on the shear connectors while coating adjacent surfaces.

2. Type of Paints

Use ordinary paints or chemical paints as specified, in conformity with clause 1005.1.1 of MORD Specifications for Road Works.

3. Paint surfaces which are inaccessible for cleaning and painting after fabrication as specified before being assembled for riveting.

4. Thoroughly clean and dip into boiling linseed oil conforming to IS:77, all rivets, bolts, nuts, washers etc. Coat properly all machined surfaces with a mixture of white lead conforming to IS:34 and mutton tallow conforming to IS:887.

5. In site painting, give whole of the steel work the second cover coat after passing and after touching up the primer and cover coats, if damaged in transit.

6. Quality of Paint

Use only paints which have been tested as per the specifications given in relevant IS Codes for the qualities as given below:

- Weight test (Weight per 10 litre of paint thoroughly mixed),
- Drying time
- Flexibility and adhesion
- Consistency
- Dry thickness and rate of consumption

7. Carry out all painting and protective coating work in accordance with IS: 1477 (Part 1).

b. Surface Preparation

1. Prepare the steel surface in a thorough manner to ensure complete removal of mill scale by any one of the following processes by prior agreement.

- Dry or wet grit/sand blasting
- Picking restricted to single plates, bars and sections

2. Apply primary coat as soon as practicable after cleaning and in case of flame cleaning, while the metal is still warm.

3. Remove all slag from welds before painting. Maintain the surface dry and free from dirt and oil. Avoid work out of doors in frosty or humid weather.

c. Coating

1. Use prime coat conforming to the specifications by prior approval. Treat metal coating as prime coat.

2. Apply prime coat to the blast cleaned surface before any deterioration is visible. In any case, ensure that the surface receives one coat of primer within 4 hours of abrasive blast cleaning.

3. Provide all coats which are compatible to each other. When metal based coatings are used, provide the under coat compatible with the concerned metal base. Adopt the under coat and finishing coat, preferably, from the same manufacturer.

4. Use successive coats of different shades or colours. Allow each coat to dry thoroughly before applying the next coat. Take particular care with the priming and painting of edges, corners, welds and rivets.

5. Follow the guidelines given in Annexure 1000/I for epoxy based paints and the conventional painting system.

d. Painting in the Shop

1. Paint all fabricated steel in the shop with at least one priming coat after inspection and acceptance, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. Do not apply primer to galvanized surfaces.

2. Where shop contact surfaces are specifically required to be painted, bring them together while the paint is still wet.

3. Paint the field contact surface and surfaces to be in contact with cement with primer only. Do not apply paint within 50 mm of design location of welds. Ensure that the paint is completely dry before loading and transporting of the fabricated steel work to site.

4. Provide full specified protective treatment before assembly to surfaces not in contact but inaccessible before assembly.

5. Do not apply paint or metal coat within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is likely to impair the quality of welds.

6. Protect adequately the exposed machined surfaced.

e. Painting at Site

1. Provide full specified protective treatment before assembly to surfaces which will be inaccessible after site assembly.

2. Apply a coat of paint (in addition to any shop priming) to surfaces which will be in contact after site assembly and bring them together while the paint is still wet.

3. Make good the damaged or deteriorated paint surfaces with the same type of coat as the shop coat.

4. Where steel has received a metal coating in the shop, complete this coating at site so as to be continuous over any welds, bolts and site rivets.

5. Complete the specified protective treatment after erection.

f. Method of Application

1. Conform the methods of application of all paints as per the written recommendation of the manufacturer. Allow spray painting provided it does not cause inconvenience to the public and is appropriate to the type of structure being coated.

2. For areas inaccessible for painting and areas shaded for spray application, carry out coating first by brushing.

3. Ensure the application of oil based red lead primers by brush only with due care to work in all corners and crevices.

4. Apply the primer, intermediate and finishing coat to provide smooth coating of uniform thickness. Do not permit wrinkled or blistered coatings or coatings with pier holes, sags, lumps or other blemishes.

g. Protective Coatings in Different Environment

For the use of various types of coatings in different environments, follow the guidelines for selection of types of protective coatings given in Annexure-1000/II.

B. Quality Control Requirements

1. Material

a) Structural Steel

All structural steel shall, before fabrication, comply with the requirements of the relevant Indian Standards for the type of structural steel as given in section 2000.

b) Materials for Castings and Forgings, Fasteners, Welding Consumables and Paints
Materials for Castings and Forgings, Fasteners, Welding Consumables shall meet the requirements of relevant clauses of MORD Specifications for Rural Roads given in Table 1002.1

TABLE 1002.1 MATERIALS FOR CASTINGS AND FORGINGS, FASTENERS, WELDING CONSUMABLES AND PAINTS

Material	Reference clause of MORD Specifications
Casting and Forgings	Clause 1002.3.2.1
Fasteners	Clause 1002.3.2.2
Welding Consumables	Clause 1002.3.2.3
Paints	Clause 1002.3.

c) Special requirements as stated in clause 1002.3.1 of MORD Specifications for Rural Roads shall be satisfied in respect of materials as relevant.

2. Handling and Storing of Materials

Locate suitable area for storage of structures and components near the site of work on firm, leveled ground. Keep the access road free from water logging during the working period and the storage.

Provide the store with adequate handling equipment viz. mobile crane, gantries, derricks, chain pulley blocks, winch of capacity as required. Plan the stacking area and have racks, stands sleepers, access tracks, etc., and proper lighting. Plan the storage to suit erection work sequence and avoid damage or distortion.

Store the fabricated materials with erection marks visible. Ensure that they do not come into contact with earth surface or water and are accessible to handling equipment.

Store all materials, consumables, including raw steel or fabricated material specification- wise and size-wise above the ground upon platforms, skids or other supports.

Keep them free from dirt and other foreign matter and protect as far as possible from corrosion and distortion. Store electrodes specification-wise and keep them in dry warm condition in properly designed racks. Store the bolts, nuts, washers and other fasteners in gunny bags on racks above the ground with protective oil coating. Store paint under cover in air-tight containers. Keep small hand tools in containers in covered stores.

Follow IS: 7293 and IS: 7969 dealing with handling of materials and equipment for safe working.

3. Tolerances

3.1 Approve the tolerances in dimensions of components of fabricated structural steel work specified on the drawings before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 1002.2.

For a machined bearing surface, where specified, carry out machining deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5 m.

TABLE 1002.2 FABRICATION TOLERANCES

INDIVIDIUAL COMPONENTS

1.	Length		
	a)	Member with both ends finished for contact bearing	±1 mm
	b)	Individual components of members with end Plate connection	0 mm -2 mm
c)	Other member of length		
	i.	Up to and including 12 m	± 2 mm
	ii.	Over 12 m	± 3.5 mm
2.	Width		
	a)	Width of built-up girder	± 3 mm
	b)	Deviation in the width of members	+ 0 mm
		required to be inserted in other members	- 3 mm
3.	Depth		
	Deviation in the depths of solid web and open		+ 3 mm
	Web girders		- 2 mm
4.	Straightness		
	Deviation from straightness of columns		L/3000 subject to maximum of 15 mm
	i.	In elevation	+ 5 mm -0 mm
	ii.	In plan	L/1000 subject to a maximum of 10 mm

5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surface	3 mm
6.	Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the members	0.005d subject to a maximum of 2 mm where d is depth of member
7.	Tilt of flange of plate girders	
	a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings	0.005b subject to a maximum of 2 mm where b is width of the member
	b) At other places	0.015b subject to a maximum of 4 mm where b is width of the member
8.	Deviation from squareness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagnol
9.	Deviation from squareness of fixed base plate (not machined) to axis of columns. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate	D/500, where D is the distance from the column axis to the point under consideration on the base plate
10.	Deviation from squareness of machined ends to axes of columns	D/1000, where D is as defined in 9 above
11.	Deviation from squareness of machined ends to axes of beams	D/1000, where D is as defined in 9 above
12.	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	1/600 of depth of member subject to a maximum of 1.5 mm

3.2 Other tolerances as specified in respective clauses of subsection 1002 of MORD Specifications for Rural Roads shall be maintained where required.

4. Quality Control Tests

4.1 Tests prior to Construction

The tests and checks to be carried out prior to construction are indicated in Table 1002.3.

TABLE 1002.3 QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/ Works	Test/check	Frequency
1.	Structural steel	Physical and chemical properties as per appropriate IS codes relevant to the type of structural steel as per Section 2000	As in relevant IS codes
2.	Castings and forgings, Fasteners, welding consumables	Physical and chemical properties as per appropriate IS codes relevant to the type of material as stated in clause 1002.3.2 of MORD Specifications	As in relevant IS codes
3.	Paints	- Weight (for 10 liters of paint thoroughly mixed) - Drying time - Consistency - Dry thickness and rate of consumption - As per relevant IS codes applicable to the type of paints stipulated in clause 1002.3 of MORD Specifications	As in relevant IS codes
4.	Fabrication of structural steel	Work programme for the fabrication of structural steel and shop drawings for the fabrication of members.	Before commencement of work

4.2 Test during Construction

The tests/checks to be carried out during construction are given in Table 1002.4.

TABLE 1002.4 QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material/ Works	Test/check	Frequency
1.	Temporary erection in the fabrication shop of the structural steel work or a part thereof	Alignment and fit of all connections	Regularly during execution
2.	Assembling of field connection of main members of structure	Alignment and accuracy of holes and camber	Regularly during execution

S.No.	Material/ Works	Test/check	Frequency
3.	Welding procedure for shop and site welds including edge preparation of fusion faces	Conformity with IS:9595	Regularly during execution
4.	Tolerances in dimension of components of fabricated structural steel work Other tolerances	As in Table 1002.2 As in respective clause of subsection 1002 of MORD Specifications	Regularly during execution
5.	Erection of steel work	- Deployment of a competent engineer or foreman in charge of the work with adequate experience in steel erection. - Methodology of erection and the number and character of tools and plants	Before commencement of erection work As above
6.	Field inspection of all materials equipment and steel work	Inspection of steel work, testing of material, connections, welds, stud shear connectors as per clause 1004.7 of MORD Specifications	As per clause 1004.7 of MORD Specifications
7.	Prime coat and Methodology application of all paint coatings	- Conformance to approved specifications of primers - Conformance to the written recommendation of the manufacturers	Regularly during execution As above

4.3 Quality Control Checks by AE/EE

The quality control checks to be carried out by AE/EE are given in Table 1002.5

TABLE 1002.5 QUALITY CONTROL CHECKS BY AE/EE

S.No.	Test/check	Frequency/stage	Designation of Inspection Officers
1.	Work programme for fabrication of structural steel	Before commencement of work	Approval by EE
2.	Shop drawings for fabrication of members	Before commencement of work	Approval by AE/EE
3.	Welding procedure for shop and site welds including edge preparation of fusion faces	Before commencement of welding work	Check by AE/EE

S.No.	Test/check	Frequency/stage	Designation of Inspection Officers
4.	Temporary erection of steel work or a portion thereof and field connections of main members of structure	Regularly during execution	Approval by AE/EE
5.	Tolerances in dimensions of components of fabricated structural steel work shown on the drawings	Before commencement of fabrication work	Approval by AE/EE
6.	Methodology of erection and the number and character of tools and plants	Before commencement of erection of work	Approval by AE
7.	Method of storage and handling steel/ fabricated steel	Before commencement of work	Check by AE
8.	Correction method for rectification of any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of reaming and slight chipping or cutting	As and when required	Approval by EE
9.	Field inspection of all materials, equipment and work of erection of structural steel	Regularly during execution	Check/Approval by AE/EE
10.	Specification of prime coat and methods of application of all paint coatings	Before commencement of painting work	Approval by AE/EE
11.	Deployment of a competent engineer or foreman in charge of the work with adequate experience in steel erection.	Before commencement of steel erection work	Approval by EE

C. Do's and Don'ts

Do's	Don'ts
1. Straighten the finished rolled material in the mill before shipment. 2. Provide mark number and item number to all members/parts and if required a serial number after fabrication. 3. Make holes by drilling only, except in secondary members such as floor plates, hand rails etc. 4. Carry out driving of rivets when hot so as to fill the hole completely.	1. Do not use cast iron in any part of the bridge structure except where it is subjected to compression. 2. Do not allow hammering for straightening or flattening of members/parts for fabrication. 3. Do not use drifts of size larger than the nominal diameter of hole. 4. Do not allow welding when the air temperature is less than 10 $^{\circ}$ C, when the surfaces are wet, during periods of strong winds and in snowy weather, unless the work and the welding operators are adequately protected.

Do's	Don'ts
5. Before being dispatched, erect the steel work temporarily, either wholly or in such portion as necessary, in the fabrication shop for inspection. 6. Check the alignment, accuracy of holes and camber by assembling the field connections of main member of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame. 7. Carefully mark each part of the approved work with distinguishing marks and stamp with durable markings for re-erection. 8. Ensure deployment of an approved competent engineer or foreman in charge of the work with adequate experience in steel work erection. 9. Locate suitable area for storage of structures and components near the site of work on firm leveled ground. Ensure that the access road is free from water logging during the working period and the storage. 10. Rectify any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight clippings, cutting by a prior approved method only. 11. Use all coats which are compatible to each other. When metal based coatings are used ensure that the under coat is compatible with the concerned metal base. Preferably, use the under coat and finishing coat from the same manufacturers. 12. First make good the damaged or deteriorated paint surfaces with the same type of coat as the shop coat while painting at site. 13. Ensure that the paint is completely dry before loading and transporting of the fabricated steel work to site. 14. Use spray painting only if it will not cause inconvenience to the public and is appropriate to the type of structure being coated. 15. Apply oil based red lead primers by brush only, taking care to work into all corners and crevices.	5. Do not carry out painting, galvanizing or cadmium plating on stud base prior to welding. 6. Do not permit heating of the metal for the straightening of bent material except in special cases. 7. Do not allow hammering which will injure or distort the members while assembling steel. 8. Do not provide any protective treatment to the work until the appropriate inspection and testing have been carried out. 9. Do not impose any load or external restraint on the member/component during inspection. 10. Do not expose coated surface to rain or frost before they are dry. 11. Do not apply primer on the shear connectors while coating adjacent surfaces. 12. Do not allow wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes. 13. Do not apply paint or metal coat within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is likely to impair the quality of welds. 14. Do not apply paint within 50 mm of design location of welds.

Annexure-1000/I

Typical Guidelines for Epoxy Based Paints and the Conventional Painting System

Typical Guidelines for Epoxy Based Paints and the Conventional Painting System for bridge as given below may be complied with:

a) Epoxy Based Painting

i. Surface preparation: Remove oil/grease by use of petroleum hydrocarbon solution (IS: 1745) and grit blasting to near white metal surface.

ii. Paint system: 2 coats of epoxy zinc phosphate primer = 60

micron: Total 5 coats = 200 micron

b) Conventional Painting System for areas where corrosion is not severe

Priming Coat:

One coat of ready mixed, zinc chrome primer conforming to IS: 102

Or

One coat of ready mixed, zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS: 2074.

Or

Two coats of red oxide zinc chrome conforming to IS: 2074

Finishing Coats:

Two cover coats of red oxide paint conforming to IS: 123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

c) Conventional Painting System for areas where corrosion is severe

Priming Coat:

Two coats of ready mixed, red lead primer conforming to IS: 102

Or

One coat of ready mixed, zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS: 2074.

Finishing Coats:

Two coats of aluminum paint conforming to IS: 2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

SECTION 1100

PIPE CULVERTS AND VENTED CAUSEWAYS

1100: PIPE CULVERTS AND VENTED CAUSEWAYS

A. Methodology

1100.1 Pipe Culverts

a. Excavation for pipes

1. Lay the pipe 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 diameter of pipe above bed level, construct the embankment to the level above top of the pipe (equal to external diameter of pipe) and width not less than five times the diameter of pipe. After the construction of embankment, excavate the trench for laying the pipe.
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 boulder strata is met with, take down excavation to at least 200 mm below the bottom level of pipe, remove all loose material and fill the space with approved earth.

b. Loading and Unloading of Pipes

1. Make arrangement 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.

c. Bedding for Pipes

1. Provide Type A bedding 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.
2. 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 percent of its overall height. The compacted thickness of the granular bedding layer shall not be less than 75 mm.
3. For expansive soils, provide a layer of sand/ moorum or non-expansive material of minimum 450 mm thickness under the bedding.

d. 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 diameter of pipe and height 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. The pipe should be laid as per the specified longitudinal slope.

4. When two or more pipes are laid adjacent to each other, place them separated by a distance equal to half the diameter 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, keeps 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 mm x1000 mm upto ground level should be constructed.

e. Jointing

1. Jointing 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.

4. Keep the width of collars 150-200 mm and caulking space between 13 mm and 20 mm according to diameter of pipes.

f. Back Filling

1. Back fill trenches after the pipes have been laid and after jointing material has hardened. On top of pipe up to 300 mm, thoroughly ram, tamp or vibrate the soil in two layers. Thoroughly consolidate the materials under the 'haunches' of pipes using light mechanical tamping equipment.

2. Carryout filling of the trench simultaneously on both sides of the pipe, such that unequal pressures do not occur.

3. The back fill of soil shall be clean from boulders, 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. When minimum specified cushion cannot be provided over the pipe, encase the pipe in M 10 concrete with cover of minimum 100 mm.

g. Headwalls and Other Ancillary Works

Construct headwalls, wing walls, aprons and connected works as per details shown on the drawing.

1100.2 Vented Pipe Causeways

1. Choose vented pipe causeway to cater to low flow through circular vents which overtop during monsoon. Use RCC pipes (NP3 or NP4) for providing circular vents of specified diameter.
2. Follow the same methodology for excavation for pipes, loading and unloading of pipes, bedding for pipes, laying of pipes, jointing and back filling as detailed for pipe culverts vide subsection A1of this section.
3. Construct headwalls, apron, pitching of slope and other associated work as per details indicated on the drawing.
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. The face walls should cover the whole bed width of the water course and should be rising up to the top of the protected bed.
6. Provide cement concrete pavement with minimum 200 mm thick plain cement concrete slab in minimum M 30 grade concrete or as specified in the drawings. It will have cross slope of 2.5 percent sloping down towards downstream side. Space contraction joint in cc pavement not more than 4 m apart and seal as specified.
7. Adopt reinforced cement concrete M 25 grade guide posts of 250 mm diameter and specified height with full embedment in concrete pavement. Use stone wherever available in place of RCC. Provide the stones of size 225 mm x 225 mm x 300 mm (above road level). Keep the spacing of guide posts/stones at 1500 mm centre to centre. Paint the guide post/stones with alternate black and white bends with ordinary paint.

1100.3 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 superstructure heavy to withstand drag, uplift and lateral force due to overflow and upstream pressure.
2. Anchor the superstructure with piers and abutments by using stainless steel anchor rods.
3. Fix the location and levels of pier cap, abutment cap, pedestals and anchorage arrangement to ensure proper alignment.

4. Give streamline slope to pier cap, abutment cap and pedestals.
5. Carryout foundation and substructure works as per Section 1200, super structure as in Section 1400, protection works as per Section 1300 and Ancillary Items as stated in para 1100.4.
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 diameter (with PVC pipes) to reduce the uplift pressure on superstructure during submergence, their minimum number being, three per span in both directions.
8. Provide debris arresters on upstream side to prevent damage to submersible bridges due to floating trees and branches.

1100.4 Ancillary Items (Wearing coat, Railing, Kerbs, Warning signs, Flood gauges) for Vented causeways and Submersible bridges

1. Provide 75 mm thick C C wearing coat (not monolithic with the deck) in M 30 grade with a cross slope of 2.5 percent towards downstream side of deck in submersible bridge.
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 diameter bars @150 mm c/c at mid depth of wearing coat reducing to 75 mm c/c in both in a length of 1m near the expansion joint, provide additional reinforcement of 8mm diameter bars in both directions to make the spacing as 75 mm c/c.
4. Use open type or filler joint with appropriate nose protection.
5. Use metal railing of collapsible or removable or tubular type for submersible bridge.
6. Use discontinuous kerb with 300 mm wide gap opposite to each other at 1.8 m c/c on both sides, the continuous length of each piece being 1.5 m. Provide streamline shape to the outer face of the kerb.
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, causeways and submersible bridges, regarding depth of flow above road level and bridge deck.

B. Quality Control Requirements

1. Materials

i. Use all materials in conformity with provisions of Section 2000.

ii. Use NP3 or NP4 type reinforced concrete pipes, conforming to section 2000.The internal diameter shall not be less than 900 mm except in exceptional situation, when it may be 600 or 750 mm.

2. Components/ works

All works shall conform to the relevant specifications and as specified in the contract.

i. Earthwork shall conform to Section 300.

ii. Brick masonry work shall conform to Section 600.

iii. Stone masonry work shall conform to Section 700.

iv. Cement concrete work shall conform to Section 800.

v. Reinforcement for reinforced concrete work shall conform to Section 1000.

vi. Foundation and Substructure shall conform to Section 1200.

vii. Protective works shall conform to Section 1300.

viii. Superstructure, bearings, expansion joints wearing coat, shall conform to Section 1400.

ix. CC pavement shall conform to Section 1500.

x. Flood gauges shall be as per IRC: 67.

xi. Stainless steel bars (rust, acid and heat resistant) shall be as per IS:6603.

xii. Painting of RCC posts/ stones shall be as per IS: 164.

3. Tolerances

a. The following tolerances are permitted for concrete pipes as per IS458

i.	Overall length	±1percent of standard length
ii.	Internal diameter	±10 mm
iii.	Barrel thickness	
	80-95 mm	+5 mm
		-2.5 mm
	Over 95 mm	+7 mm
		-3.5 mm

b. For execution of works, tolerances as given in the relevant work sections are applicable.

4. Quality Control Tests

The quality control test/ checks for construction of pipe culverts, vented pipe causeways and submersible bridges are given below:

4.1. Tests prior to construction

The quality control tests to be carried out prior to construction are indicated in Table1100.1.

TABLE 1100.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency
1.	Bricks	As in Table 600.4	As in Table 600.4
2.	Stone	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
4.	Concrete Materials	As in Table 800.13	Table 800.13
5.	Stainless Steel bars (For submersible bridge)	Rust, acid and heat resistance (IS:6603)	Before procurement
6.	Steel reinforcement	As in Table 1001.3	Table 1001.3
7.	Plant equipment for production of concrete	As in Table 1200.5	Table 1200.5
8.	Pavement Materials	a) sub-base (Table 401.2) b) WBM(Table 405.6) c) Cement concrete (Table800.13)	Table 401.2 Table 405.6 Table 800.13

4.2. Tests During Construction

The Quality Control Tests / checks to be carried out during construction are indicated in Table1100.2

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 arrow or staggered columns. - Jointing of pipes	Before back filling

S.No.	Material/Work	Test/Check	Frequency
3.	Back fill	- Filling of trench on both sides (simultaneously) - Tamping/vibrating around pipe	During filling earth /granular material around pipe after laying
4.	Cushion over pipes	Thickness, Field density	While filling in layers
5.	Brick/Stone Masonry for	As in Table 600.5 or Clause 700.7	As in Table 600.5 or 700.7
6.	Side slopes on Head walls	- Slope - Stone pitching	Before construction of guard stones
7.	All concrete works	a) Workability (IS:1199) b) Cube strength (IS:516) c) Curing	As per Table 1200.6
8.	Concrete for foundation substructure and super-structure (For submersible bridge)	a) Dewatering b) Form panels c) Jointing	As per Table 1200.6
9.	Formwork	Erection, Strength, Stability, Camber, etc.	As per Table 900.3
10.	Reinforcement cage	Diameter, spacing, cover as per drawing	Before concreting
11.	Kerb, drain pipes railing/ parapets	As indicated in drawings	Before concreting/fixing
12.	Bearing & Expansion joint	Manufacture's Specification	Before installation
13.	Cement Concrete Pavement (Additional tests)	As per Table 1501.3(Items 5,6,7&8)	Table 1501.3 (Items 5,6,7&8)
14.	Equipment for handling pipes (prior to lowering)	- Adequacy of chain pulley block - Stability of Tripod arrangement etc.	Prior to lowering

4.3. 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.	Items/stage	Test/Check	Frequency	Designation of Inspecting Officer
1.	Headwalls/wing/Return walls	Plumbness	Random checking	AE
2.	Roadway	Camber, width tolerance in level	Random checking	AE
3.	Weep holes	Size and spacing	For each work	AE
4.	Cushion over pipes	Thickness of earthwork over pipes	Before laying of pavement course	EE
5.	General Workmanship	- Inlet and outlet gradient of pipes - Clear spacing between rows of pipes - Roadway alignment/camber	Random checking	EE
6.	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
7.	Wearing coat	Camber /tolerance/ levels	At the end of work	AE/EE
8.	Approaches	a) Gradient b) Pavement Surface	One check on each side of approach along centre line	AE/EE
9.	Protection works	a) Pitching of Slopes b) Thickness and Length of Apron c) Head, Face and Cut off walls	Before acceptance and onset of monsoon	AE/EE
10.	CC pavement	Width and thickness of pavement, surface levels, regularity and texture, joints(Refer Table 1501.4)	Before acceptance of work	AE/EE
11.	Equipment for handling pipes	Adequacy chain pulley block suitability of tripod arrangement etc.	Prior to lowering	EE

C. Do's and Don'ts

Do's	Don'ts
1. Carry out the work as per drawing which should be available at site. 2. Carry pavement crust, over pipe culverts. 3. Keep the trenches free from water until the pipes are installed and joints hardened. 4. Keep the trench in embankment on either side of pipe to about one-fourth diameter of pipe subject to a minimum of 150 mm but not more than one-third diameter of pipe or 300 mm. 5. Ensure that the longitudinal slope of pipe is not flatter than the bed slope. 6. Locate Causeways and submersible bridges far away from the confluence of streams. 7. Adapt submersible bridges which blend aesthetically in the environment. 8. Adopt guide post/stone of specified dimension and height embedded full depth in concrete pavement and in approach portion of causeway. Paint them with alternate black and white bands with ordinary paint. 9. Permit traffic on causeways and submersible bridges after sealing of construction joints and 28 days curing period of concrete. 10. Protect the stream bed on upstream and downstream of causeway by providing aprons and other protective works. 11. Anchor the superstructure of submersible bridges with piers and abutments by using stainless steel anchor rods. 12. At submersible bridges /causeways follow the same profile as flanking road section without any break in grade line. Provide properly designed vertical curves to avoid jerks.	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. 4. Do not choose submersible bridge if the mean velocity of stream is high (exceeding 6 m/sec). 5. Do not use composite type superstructure of steel girder with RCC slab decking for submersible bridges. 6. Do not use fixed type railings for submersible bridges. 7. Do not provide continuous kerb on the deck of submersible bridges. 8. Do not provide Guide posts/stones in submersible bridge portion and restrict their use to the approach portion of the bridge. 9. Do not adopt masonry substructure if the depth of foundation is more than 7 m. 10. Do not use dry rubble masonry in retaining walls/ breast walls and if necessary in approaches of submersible bridges. 11. Do not use metallic bearing for submersible bridges. 12. Do not provide gradients steeper than 1 in 20 on both ends of causeways.

SECTION 1200

FOUNDATION AND SUBSTRUCTURE FOR STRUCTURES

1200: FOUNDATION AND SUBSTRUCTURE FOR STRUCTURES

General

Before the commencement of construction of foundation and substructure for bridges having overall length of 30 m and above, obtain well in advance a method statement containing the information stipulated vide Annexure 1200/I from the contractor for approval of the Engineer.

A. METHODOLOGY

A1 Open Foundations

1. Set out plan dimension of the foundation at the bottom of the trench and check with respect to original reference line and areas.
2. Excavate for the foundation in accordance with the depth and plan dimensions of the structure with 300 mm extra on all sides.
3. For foundations resting on soil, provide a layer of M 10 concrete of minimum 100 mm thickness above the natural ground level to provide an even surface to support the foundation concrete. Before laying of lean concrete layer, clean earth surface of all loose material, compact and wet it.
4. For foundations resting on rock, clean the surface of rock of any loose material and then level it with a layer of concrete of the same grade as that of the foundation to provide an even surface.
5. Make up the extra depth of excavation made if any, with M 10 concrete in case of foundation resting on soil and with concrete of the same grade as that of foundation, in case of foundation resting on rock.
6. Before laying foundation concrete, clean the lean/leveling concrete or rock surface of all loose material and sprinkle water to wet. Provide side formwork as per required dimensions and height and place the reinforcement in position where provided.
7. Lay foundation concrete continuously to the required thickness up to the level of construction joint proposed.
8. Finish the concrete surface smooth with a trowel. Ensure proper curing.
9. Carry out dewatering where necessary for laying of concrete so as to keep the water level below foundation level with adequate provision/ precautions.
10. Where excavation in rock requires blasting, it shall be carried out as per Section 300.
11. Remove loose sand laid on foundation before commencement of back filling. Refill all spaces excavated and not occupied by permanent work with earth up to the surface of surrounding ground and compact. In case of excavation in rock, fill the annular space with M 15 concrete up to the level of top of rock for excavation up to 1.5 m ordinary rock and 0.6 m in hard rock. For deeper

excavation requiring further filling up to the level of top of rock, carry out the filling by grouted boulders with cement.

12. Complete the protective works, where provided, before the onset of monsoon.

A2 Pile Foundations

a. General

1. Carryout the complete subsurface investigations of strata in which pile foundations are proposed in advance along with in-situ pile tests to select the appropriate piling system and diameter and length of piles.

2. Carry out the borings to the required depth as per Clause 1204.2 MORD Specifications for Rural Roads, and complete subsurface investigation in accordance with IRC:78.

3. Obtain the information regarding pile type, method of installation of piles including details of the equipment from the contractor before commencement of work for approval of the Engineer.

b. Test Piles

1. Ensure installation of all test piles with the same type of equipment that is to be used for piling in the actual structure.

2. Conduct in-situ pile test in accordance with and on test piles conforming to requirements of section 1200 of MORD Specifications for Rural Roads.

3. Remove the test piles which are not to be incorporated in the completed structure to at least 600 mm below the proposed soffit level of pile cap. Back fill the remaining hole so formed with earth or other suitable material.

c. Concrete Piles

1. Provide concrete for both precast and cast in-situ piles conforming to requirement at the time of placement for concrete piles given in Table 1200.2.

2. Provide concrete piles of Minimum diameter of 1 m for river/marine bridges and 750 mm for bridges beyond the water zone and bridges on land.

d. Cast In-Situ Concrete Piles

1. Carryout boring using rotary equipment. Use percussion type equipment only where permitted. Allow only properly located liner or bore hole that does not show partial collapses that would affect the load carrying capacity of the pile.

2. Ensure that the diameter of the finished pile is not less than the specified diameter. Keep a continuous record of the volume of concrete placed in relation to the length of pile that is cast.

3. Remove defective piles or leave in place as considered convenient without affecting the performance of adjacent piles or pile cap. Provide additional piles to replace defective piles.

4. Concreting

i. Place concrete in a clean dry hole where practicable. Clean the pile shaft of all loose material prior to placing of the reinforcement cage. Ensure that no debris remain at the bottom of the shaft before starting the concreting of the pile.

ii. Lower the reinforcement of the pile tied in place to form a cage in the pile shaft. Provide spacers to maintain required cover. Do not provide L bends to the reinforcement at bottom to avoid interference with cleaning of pile base.

iii. Use internal vibrators for the compaction of concrete in top 3 m of pile where concrete is placed in dry and casing is present. In case of cohesive soils, where casing is withdrawn to form the cost in-situ pile, take necessary precautions to minimize the softening of soil by excess water. Do not allow the casing of cast in-situ piles to be withdrawn where mudflow conditions exist.

iv. Take care to prevent the segregation of concrete during concreting and to avoid displacement or distortion of reinforcement during concreting and while extracting the casing.

v. When concrete is placed inside precast tubes or consists of precast sections, ensure that these are free from cracks or other damage before being installed.

vi. Provide concrete that is properly graded, self compacting and does not get mixed with soil, excess water or other extraneous matter. Take special care in silty clays and other soils which have tendency to squeeze into the newly deposited concrete and form necking. Maintain sufficient head of green Concrete to prevent inflow of soil or water into the concrete.

vii. Place concrete in continuous process from toe level to the top of the pile. To ensure compaction by hydraulic static heads, maintain a minimum rate of placing concrete in the pile shaft as 6 m length of pile per hour.

5. Casing

i. Install a temporary casing to sufficient depth to ensure that fragments of soil from the sides of the hole do not drop into the concrete as it is placed during concreting of the pile. When the borehole is stabilized using drilling mud, provide temporary casing only near the top.

ii. Provide metal casing of sufficient thickness and strength to hold its original form without showing any harmful distortion while driving or when adjacent casings are driven.

iii. Use properly designed detachable shoe at the bottom of the casing for the installation of cast in-situ concrete driven piles. Provide a minimum 2 m length of top of bore with casing to

ensure against loose soil falling into the base. In cases in which the side soil can fall into the hole and side of the bore is not stabilized with drilling mud, provide suitable steel casing.

iv. Provide permanent steel liner of minimum 6 mm thickness at least up to maximum scour level. Provide permanent liner for the full length of pile in situation where:

a. Surrounding soil is marine clay,

b. Soft soil is present,

c. Surrounding soil has sulphate content equal to or more than 1 percent,

d. Surrounding water has sulphate content equal to or more than 2500 ppm, and

e. Leakage of sewage is expected.

v. Drive casing/liner for bored cast in-situ piles open ended with a pile driving hammer capable of achieving penetration of the liner to the required depth. Remove material inside the casing progressively by airlift, grab or percussion equipment or other approved means.

vi. In case of bored cast in-situ piles, keep the bottom of the casing sufficiently in advance of the boring tool and maintain the water level in the casing at the natural ground level to prevent entry of soil into the casing leading to formation of cavities and settlement into the adjoining ground. Make the joints of the casing as leak tight as possible to minimize in flow of water or leakage of slurry during concreting.

vii. Ensure that the diameter of the bore hole is not more than the inside diameter of the liner when the liners are installed before boring and diameter of liner + 2 mm when the liners are installed after boring.

6. Use of Tremie

Ensure that the concrete is poured through a tremie with funnel so as to deposit the concrete in the hole without segregation. Fulfill strictly the requirements for concreting done by tremie given in Annexure 1200/II

7. Removal of concrete above cutoff Level

i. Remove the concrete above cutoff level before it is set in order to prevent the damage of the good concrete below the cutoff level resulting from chipping by percussion method. Keep the removal of concrete within ± 25 mm, preferably on the minus side, from the specified cutoff level. After removal of such concrete, carry out the compaction of the concrete with spikes or vibrator.

ii. When concrete is not removed before setting, make a groove on outer perimeter by rotary equipment before chipping by percussion method.

iii. Provide minimum 50 mm embedment of cast in-situ concrete pile into pile cap. Cut away any defective concrete at the head of the completed pile and make good with new concrete. Ensure clear cover of 25 mm above the top of the pile for bottom reinforcement of pile cap. Expose the reinforcement in the pile for full anchorage length without damaging the rest of the pile to provide adequate bond into the pile cap.

e. Timber Piles

1. Use timber piles only for temporary bridges/structures. Stamp each pile on the butt with a stamp that makes a readily legible impression.

2. Inspect the treated timber piles after treatment. Drive treated timber piles within 6 months after treatment. Use untreated timber piles as test piles.

3. Provide protection to timber piles with approved tip protection suitable for use on timber piling of the size to be driven and steel straps. Place 2 separate steel straps within 600 mm of the butt of each pile after it is square cut and within 300 mm of the tip of each pile. Place additional intermediate steel straps at a maximum interval of 3 m measures along the pile.

4. Cutoff separately the timber piles which are to be capped to obtain true bearing on each pile. Replace inaccurately cutoff piles. Do not permit splicing of timber piles.

f. Pile Driving

1. Use any type of drop hammer to drive piles or their casings with the weight of power of the hammer sufficient to ensure a penetration of at least 5 mm per blow unless rock is met with. Employ the heaviest hammer practicable and limit the stroke to avoid damage to the pile. Provide a hammer of minimum of 2.5 Tonne for cast in-situ concrete piles and in case of precast concrete pile, use hammer of mass not less than 30 times the mass of 300 mm length of pile.

2. Ensure provision of boiler or air compressor of capacity of at least equal to that specified by the manufacturer of the hammer and equipped with an accurate pressure gauge at all times. Maintain the valve mechanism and other parts of steam, air or diesel hammers in first class condition so as to obtain the length of stroke and number of blows per minute as per the design of hammer.

3. Driving Procedure

i. Obtain details of equipment and the method proposed for driving for approval of the Engineer before start of the work. Carry out installation of piles from firm ground or from temporary supports or from fixed platform providing sufficient rigidity to ensure accuracy of pile driving under all conditions of tide, stream flow or hammer drop.

ii. Protect the top of pile by providing a helmet of substantial steel construction and providing uniform bearing across the top of the pile and holding the pile centrally under the hammer.

iii. Drive the piles from a fixed frame of sufficient rightly to ensure accuracy of driving within specified tolerances by directing the force of the hammer centrally and axially during driving. Avoid application of forces which may result in producing undue bending or torsional stresses in plies during driving.

iv. Limit the stroke of a single acting or drop hammer to 1.2 m and use a shorter stroke in case of danger of damaging the pile.

v. Guide effectively and hold the piles on line during the initial stages of driving without being bent or sprung into position. Carry out the checks soon after commencement of driving and at regular intervals during the driving operation to ensure that the pile frame does not exert any undue lateral forces on the pile due to restraint within the helmet.

vi. Stop driving on that pile which indicates finishing beyond the specified tolerances. Withdraw the pile, fill the hole and re-drive the pile thereafter.

vii. Carry out the pile driving continuously without any deliberate stop in later stages to avoid premature set-up or increased resistance to driving after stoppage of driving.

viii. Repair or replace a pile damaged in any way during driving. In the event of head of a pile getting damaged during the driving to the extent that further driving is not possible, cut off the head and continue the driving. In case the pile becomes too short due to such cutting of head, supply and splice on sufficient pile length to restore the pile to its correct length.

ix. Drive the pile to the specified minimum acceptable penetration by resorting to pre-boring and/or water jetting, where required. Carry out the pile driving to the lowest toe elevation based on nominal refusal or required dynamic capacity or top level of pile as specified. Nominal refusal is to be taken as equivalent to 25 mm total penetration for the final 20 blows using a hammer of specified driving energy. Do not allow severe driving which causes an average set per blow less than 0.5 mm.

x. When hard drilling is encountered due to dense strata or obstruction located above the pre-determined pile tip level, do not consider nominal refusal to have been achieved until the total number of blows, as the average driving resistance specified for nominal refusal, indicates that further driving is not going to advance the pile through dense strata or obstruction.

xi. Ensure that the pile is driven as accurately as possible to the vertical or to specified batter. In the event of any deviation from the proper alignment is to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile tips, replace such a pile or supplement it by an additional pile as considered appropriate.

xii. Take care not to damage by over driving. Note any sudden change in the rate of penetration which cannot be attributed to the nature of the ground and ascertain its causes, if possible, before continuing with the driving.

xiii. Give due consideration to the possibility of damaging any other pile while withdrawing a casing used in the construction of cast in-situ pile. Bore or drive any pile within 3 m of a newly cast pile only after 24 hours of completion of its installation.

xiv. For driving piles in a group in case of loose sand or stiff clay, proceed outward from the centre to avoid difficulty in driving the inner piles to the same depth as others. Driving may proceed from outside to inside to restrain the soil from flowing out during driving operations in case of very soft soil.

xv. In the event of a major variation between the depth at which adjacent foundation piles in a group meet refusal, take a boring nearby to ascertain the cause of this difference. If the boring shows the presence of highly compressive material below the level of the shorter file, enforce penetration of all the piles to a level below the bottom of the zone which shows such pockets.

4. Pre-boring and Jetting

i. Use pre-boring holes or water jets or both to assist the driving of piles when permitted, essentially to achieve the minimum specified penetration not reachable under normal driving conditions. Details of the arrangement for jetting shall be got approved from the Engineer in advance.

ii. Restrict the diameter of the hole to 100 mm less than the diagonal dimension of the pile. Provide pre-boring hole with such maximum depth that the specified set (or less) is obtained when the toe of the pile is at founding level. Carry out the pre-boring only up to 1 m above the founding level so that the pile is driven for at least one metre below the pre-bored hole. To ensure proper lateral support to the pile in the hole, back fill any space remaining around the pile after the completion of driving with approved granular material.

iii. Attach at least two jets symmetrically to the pile when water jetting is used. Carry out water jetting to such maximum depth that the specified set (or less) is obtained when the toe of the pile is at founding level so that the pile is driven for at least one m below the pre-bored hole.

iv. Make provision for collecting and draining away of the water to avoid endangering the stability of the piling plant when water comes to the surface due to the use of large quantities of water for jetting.

v. Stop jetting before the completion of driving which is to be finished invariably by ordinary methods. Any tendency shown by the pile tips to be drawn toward the pile already driven due to the disturbance of the ground, stop jetting.

g. Raker (Inclined) Piles

The maximum permissible rake in piles is given in Table 1200.3.

h. Pile Tests

1. Initial Load Test

i. Conduct required number of initial tests taking into consideration the bore log and soil profile, design length, pile diameter and design pile capacity subject to a minimum of two tests for each category.

ii. Carry out initial load test for axial capacity including uplift capacity, if required, as per procedure laid down in IS:2911, Part IV for a test load not less than 2½ times the design load. Conduct cycle load test for piles deriving strength from end bearing and side friction and maintained load test in case of end bearing piles not relying on friction and for piles socketed in rock.

iii. For taking the benefit of higher pile capacity in excess of 25 per cent of capacity calculated by static formula if so desired, carry out another two load tests to confirm the earlier value. Consider the minimum of the three values as initial load test value.

iv. Estimate the lateral load capacity of the pile by conducting lateral load test as per IS:2911, Part IV and taking permissible deflection as per IRC:78.

2. Routine Load Test

i. Perform routine load test at actual foundation locations of the bridge to reconfirm or modify the allowable loads. Conduct lateral load tests on two adjacent foundations.

ii. Do not use results of routine load test for upward revision of design capacity of pile. Conduct minimum number of routine load test as given in Table 1200.4.

iii. Permissible Overload:

Allow as over load up to 10 per cent of the capacity when the capacity of one of the piles in a group of piles is found to be deficient while conducting a routine load test (based on the settlement criteria of 12 mm for piles of diameter up to and including 600 mm and 2 per cent of the pile diameter for piles of diameter more than 600 mm at 1.5 times the design load).

iv. When specified, conduct strain dynamic tests after establishing co-relation using results of load tests as per detailed guidelines given in IRC:78, for a quick assessment of pile capacity. Do not use results of strain dynamic tests for upward revision of design capacity of pile.

v. Where specified, conduct pile integrity test as per detailed guidelines of IRC:78 to ascertain the quality of concrete and construction defects like voids, discontinuities etc.

i. Pile Cap

1. Provide reinforced concrete pile cap at a level higher than low water level unless functionally required to be below water level.

2. Lay pile cap concrete in dry conditions. Resort to dewatering in case of pile cap is below low water level to allow concreting in dry conditions. Provide a minimum off set of 150 mm beyond the outer face of the outer most piles. Cast the pile cap over a minimum 80 mm thick leveling course in M 15 nominal mix concrete if it is constructed with earth at bottom.

3. Protect the pile cap in marine conditions or areas exposed to the action of harmful channels with coating such as bituminous based coal tar epoxy or epoxy based paint or with suitable anti corrosive paint. Do not use high alumina cement for the concrete in marine environment.

4. Strip off concrete in a portion of pile top and anchor the pile reinforcement into the cap. Use manual chipping three days after casting of pile and chipping with pneumatic tools only after seven days after casting of pile. Ensure that the top of pile projects at least 50 mm into pile cap after stripping.

5. Ensure good quality of concrete at cut off level by bringing the pile top above cut off level and removing laitance and weak concrete before laying of pile cap.

j. Important considerations, Inspection/Precautions for Different Types of Piles

Pay attention to important considerations, inspection and observe precautions for different types of piles as brought out in Annexure 1200/III to facilitate installation of required quality of Piles.

A3 Well Foundations

a. Setting out and Preparations for Sinking

1. Fix the reference points to mark X-X axis along the direction of Traffic and Y-Y axis normal to the direction of traffic away from the zone of blow-ups or possible settlements resulting from well sinking operations. Connect these reference points to the permanent stations with the base line on the banks, and mark the centre line of individual wells with reference to these stations.

2. Prepare the bed for wells located on the banks of the stream/river or in dry area by excavating the soil up to 1.5 m, followed by leveling and dressing before placing.

3. For well to be located in water up to 5 m depth, construct a sand island for laying the cutting edge and well curb. Fix the plan dimensions and top level of the sand island in such a way that a minimum working space of 2 m all round the steining of the well is available and it is not affected by wave action. Ensure that the sand island is held in position and protected against scour by means of properly braced wooden ballies or sheet piles.

4. Adopt floating caissons when depth, of water is more than 5 m or in fast flowing rivers or for locations where soil is too weak to sustain Sand Island.

5. Ensure availability of equipment for construction of well foundation as indicated in Annexure 1200/IV.

b. Cutting Edge

1. Fabricate the cutting edge of structural steel with minimum weight of 40 kg per metre at site or in the shop. Erect the parts of the cutting edge on level firm ground about 300 mm above prevailing water level.

2. Anchor the cutting edge properly into the well curb as shown on the drawing. Keep cutting edge of inner walls about 300 mm above that of the outer walls for wells with two or more compartments.

3. Fix the bottom ends of vertical bond rods of steining securely with the cutting edge with check nuts or by welds.

c. Well Curb

1. Provide Reinforced concrete well curb of shape and dimensions as shown in IRC:78. Keep the internal angle of the curb at 30 to 37 degrees depending upon geotechnical data of the strata through which the well is to be sunk.

2. Reinforce the well with minimum reinforcement of 72 kg per cum of volume of concrete excluding bond rods.

3. Carry out concreting of well curb with steel forms in one continuous operations.

4. In case blasting is anticipated, protect the inner face or well curb with steel plate not less than 10 mm thickness up to top of well curb. Where considered necessary, also protect the inner face of steining with 6 mm thick steel plate up to height of 3 m above the top of well curb.

5. Ensure provision of additional hoop reinforcement of 10 mm diameter bars at 150 mm spacing in the curb and 3 m height of steining above the curb. Provide additional hoop reinforcement in the steining for further height of 3 m above the steel plates to avoid cracking due to sudden change in effective section.

d. Floating Caissons

1. The contractor shall prepare and furnish to the Engineer a method statement covering fabrication, floating and sinking operations with details such as total tonnage of steel involved, fabrication and welding specifications, list of materials and plant and a description of operations and manpower required for the work.

2. Carry out the fabrication of floating caissons at or near the banks or dry land or in dry docks. Fabricate the caisson structure from structural steel with absolutely leak-tight joints.

3. Fix the reinforcement of the curb and steining of the well inside the shell by welding and check the caisson structure against leakage before being floated and towed to site.

4. To maintain the stability of the shell under the action of water current, wave pressure and wind while being towed and kept in position, provide the shell with ballast in the form of water filling up to required level or filling with small amount of concrete. Ensure that the draught of the floating caisson is always less than the available depth of water for smooth hindrance free movement while being towed.

5. Plan the height of caisson such that at least 1 m of the shell is always above water level at any given time. Increase this height suitably for locations affected by the action of waves to avoid water spilling into the caisson. In case the bed has soft soil, provide an additional height of 3 to 5 m to cater for the self sinking of the caisson after grounding in bed. Provide appropriate additional height of caisson to accommodate local scour in sandy stratum especially with strong water current.

6. Hold the floating caisson in position with anchoring in minimum three directions to prevent unacceptable longitudinal and lateral movement. Ensure that the anchoring system permits small movements to facilitate correct positioning of the caisson at the exact location of the well and until the stage when it is just getting grounded. Special care is necessary in tidal zones where variation in water level is frequent.

7. Commence concreting of floating caisson after it is held in correct position with the concrete mixed in the batching plant through concrete pumps or tremie. Ensure that the concrete has a slump of 150 to 200 mm as vibration inside the shell is not possible. Alternatively, use self compacting concrete Place the concrete uniformly all around the caisson so that it settles vertically without any tendency to tilt.

e. Well steining

1. Use shaped and suitably stiffened MS Sheets as formwork for concreting of the well steining. Permit use of timber forms lined with plywood or MS Sheets only.

2. Restrict the maximum height of first lift of steining above the well curb to 2 m and that for subsequent lifts to the diameter of the well or the depth of well to be sunk below the bed level at any time.

3. Cast the first lift of steining only after sinking the well curb at least partially. Carry out the concreting in the subsequent lifts of about 2 to 2.5 m. Try to minimize the construction joints.

4. Build the steining of the well in one straight alignment from bottom to top such that in the event of tilting of well, the next lift of the steining can be aligned in the direction of the tilt.

5. After completion of a sinking stage, repair properly the damaged portions of steining at top before the next stage construction.

6. Mark minimum 4 gauges to measure the height of steining in the form of 100 mm wide strip painted on the steining with zero at the bottom of the cutting edge. Distribute the gauges equally on the outer face of the well, two in traffic direction and two normal to traffic direction.

f. Well Sinking

1. Ensure that the well is not placed in a pre-dredge hole. Sink the well by excavating the material uniformly from inside the dredge hole using cranes and grab buckets of required capacity. Observe precautions during sinking as stated in Annexure 1200/V. Sink the well true and vertical through all types of strata.

2. Resort to pneumatic sinking where obstacles such as tree trunks, large size boulders etc. are met with or when there is hard strata which cannot be removed by open dredging.

3. Start loading of the well with kentledge for sinking only after curing of the steining for at least 48 hours.

4. To minimize sand blowing, keep the level of water inside the well higher than the water table and also add heavy kentledge.

5. Maintain complete history of sinking of each well giving details of concreting, sinking and problems met if any, in the format given in Annexure -1200/I-1 and 1200/I-2 of MORD Specifications for Rural Roads.

6. Water Jetting

i. When required, adopt water jetting to facilitate sinking of wells through Clay/hard strata. Obtain a method statement from the contractor covering various aspects of the work including the number capacity and location of the high pressure pumps and other ancillaries required for executing the work, for approval of the Engineer.

ii. Use Steel pipes of 40 to 50 mm diameter tapering down to nozzle of 6 mm diameter at the bottom for carrying out water. Keep the steel pipe at least 1 m above the top of each steining lift to facilitate extension before casting of next lift of steining.

7. Jack Down Method

i. For adoption of jack down method of sinking where required, obtain a method statement for approval of the Engineer, giving full details of construction of ground anchors, fabrication of pressurization girder, type, number and capacity jacks to be used, method of dredging and application of jack down forces and all other relevant aspects for proper execution of the work.

ii. Take down the drill holes of 150 mm diameter along with casing to a minimum 20 m below the founding level of the well for housing the pre-stressing strands of ground anchors. Create a sump of 1 m inside the well by dredging before applying pressure from hydraulic jacks of at least 500 Tonne Capacity.

8. Use of Explosives

i. Where specified and required, use mild explosive as an aid for sinking of the well following strictly all prevalent laws concerning handling, storage and use of explosives. Take all safety precautions as per IS: 4081.

ii. Carry out any blasting only after the concrete in the steining is sufficient hardened and more than 7 days old. After completion of blasting operations, examine the well curb and steining for any cracks and required remedial measures, if any.

iii. Cover the blasting holes with rubber mats before detonating the charge to minimize damage due to flying debris in case of rock blasting is done for seating of the well.

iv. Make a minimum sump of 1 m depth before resorting to blasting. Use large charges, 0.7 Kg or more under expert direction only. Limit the burden of the charge to 1 m and the spacing of holes to 0.5 m to 0.6 m.

9. Use of Divers

i. Use divers if required, for removal of obstructions during sinking, carrying out rock blasting and inspection under water. Take all safety precautions as per any acceptable code or any statutory regulation in force, when divers work under water in the well.

ii. Employ only trained diving personnel after being certified fit for diving by an approved doctor and ensure they work under expert supervision. Control the raising of divers from the bottom of the well so as to keep decompression rate in conformity with the rate in the relevant regulations.

iii. Use diving and other equipment of acceptable standard and certified by an approved independent agency. Maintain them as per requirements for safe use.

iv. Ensure arrangement for adequate supply of low pressure clean cool air through an armoured flexible hose pipe and sand by compressor to cover the contingency of break - down of the compressor.

v. Provide separate high pressure connection for use of pneumatic tools and electric lights at 50 volts maximum.

g. Tilts and Shifts

1. Limit tilt of the well to 1 (horizontal) to 80 (vertical) and shift of the well to 150 mm in any resultant direction. Record tilt and shift of the well regularly during sinking operations in the format given in Annexure 1200/ II of MORD Specifications for Rural Roads.

2. Whenever any tilt is noticed, take adequate corrective measures like placing eccentric kentle edge, putting strutting, anchoring or depositing more dredged material outside the tilted face. A drop of water getting before further sinking. Adjust the jack down pressure on side to control the tilt in case of sinking by jack down method. Remove and dispose of dredged material sufficiently away from the affected well after correction.

3. Introduce timber struts between the steining of a pair of wells close to each other to prevent their tendency to move closed during sinking operation.

4. To control the tilt occurring in a well during sinking in dipping rock strata, support the curb suitably on the down slope side.

h. Seating of Wells

1. Ensure uniform seating of the well on the founding strata. Ascertain that the properties of the soil at foundation level and up to a depth of one and a half times the well diameter, are identical to that adopted in the design by conducting test borings.

2. Adopt in pneumatic methods of sinking to seat the well evenly in case of seating of well in hard rock strata, where the rock profile is steeply sloping.

3. Make a sump of 1.5 m to 2 m less diameter than that of the dredge hole with 300 mm depth in hard rock or 600 mm in ordinary rock inside the well by chiseling or blasting as required.

4. After the well is evenly seated on good hard rock, make arrangements for proper inspection in dry and visible condition before laying the bottom plug.

i. Bottom Plug

1. Provide a concrete bottom plug having top level minimum 300 mm above the top of the curb after making suitable sump below the level of cutting edge. Ensure removal of all loose material from the bottom of the well and thorough cleaning of inside faces of curb and steining before concreting the bottom plug.

2. Use concrete mix with a minimum cement content of 330 kg per cum and slump of about 150 mm to permit easy flow through tremie to fill up all cavities. Lay concrete with cement content not more than 330 kg per cum inclusive of all mineral admixtures, where added, by tremie under still water condition for concreting under water.

3. Carry out concreting of the bottom plug in one continuous operation till the dredge hole is filled up to the required height and causing least disturbance to the water inside the well. Take soundings thereafter to check that the concrete has been laid to the required height.

4. Ensure that the concrete after placing is not disturbed in any way for at least 7 days and any dewatering is carried out only 7 days after casting of bottom plug.

5. Check whether there is any rise in the level of bottom plug by taking soundings at the close of concreting and once every day for the next 3 days.

6. Test the soundness of the bottom plug by dewatering the well to a level of 5 m below the surrounding water level and checking the rise of water which should not be more than 10 cm per hour. Measure the depth of dewatering by 5 m from the still water created inside the well by the construction of false steining in case of foundations subjected to artesian pressure.

j. Sand Filling

1. Use and compact the sand which is clean, free from earth, clay clods, roots boulders, shingles etc. Commence sand filing 7 days after laying of bottom plug. Verify the top level of the bottom plug before starting sand filling. Provide sand filling to the required level.

2. Lay 300 mm thick M 15 grade concrete top plug over the sand filling.

k. Well Cap

1. Provide a reinforced cement concrete well cap over the top of the steining. Lay bottom of the well cap as low as possible but above the LWL in the active channel. Raise top of the well cap and keep it 1 m below existing ground level where the bed level is higher than the LWL.

2. Prepare formwork conforming to the shape of well cap. Anchor bond rods of steining into the well cap. Lay concrete of the well cap directly on leveled sand filling in case it has been carried up to the top of the well cap. Provide suitable shuttering support otherwise.

   Carry out well cap concreting in dry condition. To ensure that the well cap is laid in dry condition, provide properly designed false steining, where required.

A4 Substructure

This item covers piers, abutments, wing walls, return walls, pier and abutment caps and RCC dirt wall.

1. Adopt either brick masonry or Coursed Rubble (CR) masonry or plain or Reinforced concrete masonry for piers, abutments and wing/return walls. Use Random Rubble (RR) masonry in case of return/wing/toe walls of height less than 5 m. Adopt Dry Rubble masonry in case of wing/return/toe walls of heights up to 3 m which are not subjected to flood/stagnated water.

2. Before commencing masonry/concrete work, scrub the top surface of the foundation/well cap/pile cap with wire brush and remove all loose material and wet the surface.

3. Prefer the use of slip form for the concreting of tall piers and abutments.

4. Make provision of weep holes in case of solid (non spill through) abutments, hollow piers and wing/return walls as per Section 600 in case of plain/reinforced concrete or brick masonry structures. For structures in stone masonry, follow Section 700 for the provision of weep holes.

5. Provide the back fill behind the solid abutment wing and return walls and minimum 600mm thick filter median over the entire surface behind the abutment wings or return walls in conformity with provisions of IRC:78.

6. In case of abutments liable to considerable movement on account of earth pressures from back fill and settlement of foundations, take up casting of super structure resting on abutment only after filling up embankment in layers to full height.

7. Provide 20 mm vide vertical expansion joint filled with suitable asphaltic, bituminous board between abutments and wing/return walls and at every 10 m interval in wing/return wall.

8. Cast cantilever return wall monolithic with the dirt wall.

9. Provide coping for wing/return wall in brick masonry or stone masonry as per section 600 and 700 respectively.

10. For submersible bridges, provide substructure in plain or reinforced concrete if the height above foundation level is more than 7 m. Dry Rubble masonry is not to be used in wing/return/breast walls, if required, in approaches of submersible bridges.

11. In case of submersible bridges, check carefully the locations and levels of pier cap/abutment cap, pedestals, anchorage arrangements between superstructure and pedestals/pier cap/abutment cap, side bearing pad between superstructure and raised portion of pier cap (thrust wall) and stainless steel rods in pedestal/bearings to ensure alignment in accordance with the drawings.

12. Ensure provision of streamline shape to pier cap including raised portion/stopper (thrust) wall, abutment cap and pedestals of submersible bridges.

A5 Raft Foundations

This item covers reinforced cement concrete raft foundation with attached reinforced concrete cutoff wall or plain cement concrete detached cutoff wall launching apron on upstream and downstream side placed in open excavation.

1. Excavate for cutoff walls to accommodate leveling course of 100 mm thickness. Carryout such extra excavation of 100 mm just before laying lean concrete below cutoff walls. Make up extra depth of excavation if any, by M 10 concrete.

2. Cary out excavation for raft foundation in accordance with depth and plan dimensions on all sides. Make up extra depth of excavation if any with M 10 concrete.

3. Set out the plan dimensions of longitudinal and cross cut off walls and check with respect to original reference line and axis.

4. Provide a layer of M 10 concrete of 100 mm thickness below cutoff walls by using necessary formwork for providing even surface and proper quality of concrete.

5. Cast the longitudinal and cross cut off walls monolithically. Lay concrete in cut off walls by providing suitable formwork and in layers to facilitate proper compaction. Finish top of cut off wall to match with top of raft in case of RCC detached cutoff walls. Terminate the concreting of attached RCC cutoff wall at a pre-decided level below the haunch and keep the top surface suitably rough to ensure proper bond between old and new concrete.

6. Start gradual removal of formwork of cutoff walls ensuring filling of soil with adequate compaction on both sides. In case of filling by sand, resort to flooding to ensure compaction. Carry out the filling of trench after gradual removal of formwork is such a manner that the cutoff wall is subjected to uniform earth pressure from both sides up to about 1.20 m below the raft top level.

7. Remove the soil in between the cutoff walls for a required depth without damaging the cutoff wall and fill up by granular material for 0.90 m depth and compact properly. In case of sandy bed up to such a depth, compact the existing sandy bed suitably.

8. Lay 100 mm thick M 10 lean concrete over the compacted sand/granular layer to provide even surface to support raft slab. Mark the locations of pressure relief holes between piers and pier and abutment and place 100 mm diameter asbestos//PVC pipes in position.

9. Mark the locations of piers and abutment on the lean concrete to facilitate laying and binding reinforcement for raft slab. Provide anchor rods/pins for connecting pier/abutment with raft slab. In case of piers and abutments with nominal or design reinforcement, erect such reinforcement of piers/abutments and tie the same to raft reinforcement.

10. Provide necessary formwork for raft slab concrete in case of attached RCC cutoff wall. Before laying concrete in raft, clean lean concrete of all loose material and moister lightly. Provide only design mix concrete for raft slab and complete the concreting in one stretch. In case of long rafts, provide construction joint at specified location.

11. Finish the concrete surface smooth with trowel. Ensure proper curing.

12. Carry out dewatering where necessary for laying of concrete so as to keep water level below foundation level with adequate provision/precautions.

13. In the event of termination of raft work due to monsoon, provide extra cross cut off wall to protect the part raft already cast.

14. Remove loose sand laid on raft slab before commencement of backfilling. Refill all spaces excavated and not occupied by permanent work with earth up to the surface of surrounding ground and compact.

15. Complete protective works before the onset of floods.

16. Ensure that the raft slab completely rests on flexible foundation. Remove out crops of rock if any, so that the raft slab does not come in contact with the hard localized spots.

B QUALITY CONTROL REQUIREMENTS

1. Materials

Physical requirements of all materials and storage of materials shall conform to the provision of Section 2000.

2. Execution of works

2.1 Construction of structures/components shall meet the requirements for the relevant type of construction given in Table 1200.1.

TABLE: 1200.1 REQUIREMENTS FOR WORKS

S.N.	Type of Construction	Governing Section
1	Brick Masonry	Section 600
2	Stone/Block Masonry	Section 700
3	Plain/Reinforced Concrete	Sections 800, 900 and 1000
4	Structural Steel	Section 1000

2.2. For both precast and cast in-situ piles, the grade of concrete, minimum cement content, water cement ratio and slump at the time of placement are given in Table 1200.2.

TABLE 1200:2: REQUIREMENTS FOR CONCRETE IN PILES

Item	Cast in-Situ Concrete by tremie	Precast Concrete
Grade of Concrete	M 35	M 35
Minimum Cement Content	400 kg/cum	400 kg/cum
Minimum Water Cement Ratio	0.40	0.40
Slump as Measured at the time of Placement	150 -200 mm	50-75 mm

2.3. Maximum Rake in Piles

The maximum rake to be permitted in the raker piles shall not exceed the value given in Table 1200.3.

TABLE: 1200.3 MAXIMUM RAKE IN PILES

Type of pile	Maximum permissible rake
All bored piles	1 in 6
Cast-in situ piles	1 in 6
Precast driven piles	1 in 4

2.4. Minimum Number of Pile Tests

i. Initial Load Test

Minimum two load tests shall be conducted to assess the capacity of pile under each category.

ii. Routine Load Tests

Minimum number of routine load tests to confirm the pile capacity shall be conducted as given in Table 1200.4.

TABLE: 1200.4 MINIMUM NUMBER OF ROUTINE LOAD TESTS

Total number of piles for the bridge	Minimum number of test piles
Up to 50	2
50 to 150	3
Beyond 150	2 % of total piles (fractional number rounded to next higher integer number.

3. Tolerances

Permissible values of tolerances for different types of foundations and substructure are given below.

3.1. Open 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 plan 15 mm

d. Surface irregularities measured with 3 m straight edge 5 mm

e. Variation of levels at top ± 25 mm

3.2. Pile Foundations

i. Precast Concrete Piles

a. Variation in cross sectional dimensions +5 mm

b. Variation in length ± 25 mm

c. Surface irregularities measured with 3 m straight edge 5 mm

d. Bow for total length of pile in mm 1mm/m length of pile limited to20 mm

ii. Driven Piles

a.	Variation in cross sectional dimensions	+50 mm, - 10mm
b.	Variation from vertical for vertical piles	1 in 150
c.	For vertical piles deviation at piling platform level	75 mm
d.	Variation of level of top of piles	±25 mm

iii. Bored Piles

a.	Variation in cross sectional dimensions	+50 mm, - 10 mm
b.	Variation from vertical for vertical piles	1 in 150
c.	For vertical piles deviation at piling platform level	75 mm
d.	Variation of level of top piles	±25 mm

iv. Raker Piles

Variation from specified rake	1 in 25

v. Pile Cap

a.	Variation in dimensions	+50mm, - 10 mm
b.	Misplacement from specified position in plan	15 mm
c.	Surface irregularities measured with 3m straight edge	5 mm
d.	Variation of level of top of piles	±25 mm

3.3. Well Foundations

The permissible tilt shall not exceed 1 (horizontal) in 80 (vertical) and the shift of the base shall not be more than 150 mm in any resultant direction.

Well Steining and Well cap

a.	Variation in dimension	+50 mm, - 10 mm
b.	Misplacement from specific position in plan	15 mm
c.	Surface irregularities measured with 3 m straight edge	5 mm
d.	Variation of level at top	±25 mm

3.4. Sub structure (Concrete elements)

a.	Variation in cross-sectional dimensions	+10 mm, - 5 mm
b.	Misplacement from specific position in plan	10 mm
c.	Variation of levels at the top	±10 mm

d.	Variations of reduced levels of bearing areas		± 5 mm
e.	Variation from plumb over full height		± 10 mm
f.	Surface unevenness measured with 3 m Straight edge		
	i.	All surfaces except bearing area	5 mm
	ii.	Bearing areas	3 mm

3.5. Raft Foundations

a.	Variation in dimensions	+ 50 mm, - 10 mm
b.	Misplacement from specified position in plan	15 mm
c.	Surface unevenness measured with 3 m straight edge	5 mm
d.	Variation of levels at top	± 25 mm

4. Quality Control Tests

4.1 Tests prior to Construction

Quality control tests prior to construction are indicated in Table 1200.5

TABLE: 1200.5 QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/Work	Test	Frequency
1.	Cement Fine/Coarse aggregates water, concrete admixtures and Concrete for Structures	Test as in Table 800.13	As in Table 800.13
2.	Steel Reinforcement	Test as in Table 1001.3	Test as in Table 1001.3
3.	Plant & Equipment and other arrangements for concrete production	a. Working condition of concrete mixers including standby 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	Check by AE before commencement of concreting

S.No.	Material/Work	Test	Frequency
		f. Tools and equipment for finishing and curing. g. Formwork (As per Table 900.2)	
4.	Structural Steel	As per section 1000.	As per section 1000.
5.	Plant and equipment for installation/driving of piles and arrangement for jetting	As in Table 1200.7	As in Table 1200.7
6.	Initial load testing of piles	As in sub para A2 h1	As in sub para A2 h1
7.	Equipment and methodology for adoption of floating caissons, water jetting and jack down method for well sinking	As in Table 1200.7	As in Table 1200.7

4.2 Tests during construction

The Tests/Checks to be carried out during construction are indicated in Table 1200.6.

TABLE:1200.6 QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency/Stage
1.	Concrete for Structures	For constituents including concrete admixtures. As 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 foundations/substructures separately.
4.	Formwork	Tests as in Table 900.3	As in Table 900.3
5.	Reinforcement cage	a. Diameter and spacing of Reinforcements in cage as per drawing b. Size and placement of briquettes for supporting the	Before commencement of concreting As above

S.No.	Material/Work	Test/Check	Frequency/Stage
		reinforcements i.e. to provide bottom and side coverts c. Cleaning rust on reinforcements with wire brushing d. Other checks as per Table 1001.4.	Before placement and compaction 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	Pile Test	Routine load tests to confirm pile capacity	As in Table 1200.4.

*** Refer Table 800.14 also*

4.3 Quality Control Checks by AE/EE

The quality control checks to be carried out by the AE/EE are indicated in Table 1200.7.

TABLE: 1200.7 QUALITY CONTROL CHECKS BY AE/EE

S.No.	Material/Work	Test/Check	Frequency/Stage	Designation of Inspecting Officer
1.	Foundations	Dimension and levels	For each foundation	AE
2.	Substructures	-do-	Each supporting member	AE
3.	All concrete components	- Soundness of concrete - Honey combing, finishing - Tolerances - Workmanship - Cube strength (Review of test results)	As per Table 800.15	AE EE
4.	Pile foundations	Details of equipment and method for installation of piles. Details of equipment and method for driving of piles.	Before commencement of work As above	EE EE

S.No.	Material/Work	Test/Check	Frequency/Stage	Designation of Inspecting Officer
		Use of pre-boring and jetting to assists the pile driving including details of the arrangement for jetting.	-do-	EE
		Number, methodology and details of initial and routine pile load tests for verticals, lateral and uplift load capacity of the pile.	Every load test under each category of pile capacity	EE
		Treated timber piles after treatment.	Each pile	AE
		Tip protection of timber piles.	Each pile before driving	AE
5.	Well Foundations	Top level of sand island	Each well before laying the cutting edge	EE
		Detailed method statement covering fabrication, floating and sinking operations of floating caisson.	Before commencement of work	EE
		Method statement covering all aspects of the work including the number, capacity and location of the high pressure pumps and other ancillaries for adopting water jetting method for sinking of the well.	As above	EE
		Method statement giving full details of construction of ground anchors, fabrication of pressuring girder, type, number and capacity of jacks to be used, method of dredging and application of jack down force and all other relevant aspects for the use of jack down method of sinking.	As above	EE
		Embedment of cutting edge and the uniform seating of well in rocks strata.	Each well before plugging	EE

C. DO'S AND DON'TS

Do's	Don'ts
1. Prepare the surface of foundation for gravity type masonry or concrete return/wing walls similar to that of abutments. 2. Complete the protective works of foundations before onset of monsoon. 3. Install all test piles with the same type of equipment that is to be used for piling in the actual structure. 4. Clean the pile shaft of all loose material before placing of the reinforcement cage and remove all debris from the bottom of the shaft prior to commencement of concreting of pile. 5. Compact the top 3 m of the pile concrete with internal vibrators when concrete is placed dry and casing is present. 6. Install a temporary casing to sufficient depth when concreting is carried for a pile to prevent falling of soil fragment from the sides into the concrete as it is placed. 7. Provide permanent steel liner at least up to maximum scour level. 8. Maintain the water level in the casing at the natural ground water level to prevent the entry of soil into the casing leading to formation of cavities and settlements in the adjoining ground while installing bored cast in-situ piles in soils liable to flow. 9. Pour the concrete for pile invariably through a tremie with funnel so that the concrete is properly placed in the hole without segregation. 10. Anchor the cutting edge properly into the well curb. Keep the bottom of the cutting edge of the inner walls 300 mm above the cutting edge of the walls. 11. Protect the inner face of the well curb with 10 mm thick steel plates and if considered necessary also protect the inner face of the steining up to the height of 3 m above the curb with 6 mm thick steel plates when blasting is anticipated. Provide additional troop reinforcement of 10 mm diameter bars 150	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. Do not provide any construction joint in the concrete footing. 3. Do not allow casting of super-structure resting on the abutment which is likely to experience considerable movement due to earth pressure from backfill and settlement of foundations before completion of back filling up to full height. 4. Do not provide L-bends to the reinforcement at the bottom of the pile to avoid interference in the cleaning of the pile base. 5. Do not withdraw casing of the cast in-situ piles where mud flow conditions exist. 6. Do not change the method of concrete deposition part way up the pile and place the concrete in the pile wholly by tremie to avoid entrapment of laitance within the pile. 7. Do not add two percent extra cement when the concrete is placed through tremie. 8. Do not take out tremie out of concrete under any circumstances in case of interruption of concreting. 9. Do not bend the pile or spring it into position but effectively guide the pile and hold on line during the initial stages of driving. Do not damage the pile by over driving. 10. Do not damage rest of the pile when exposing the pile reinforcement for anchoring into the pile cap. 11. Do not cast the first lift of steining until the well curb is sunk at least partially, for stability. 12. Do not allow any well to be placed in a pre-dredged hole. 13. Normally, do not use dewatering as a means for sinking of the well.

Do's	Don'ts
mm spacing in the well curb and the steining up to 3 mm height above the curb and for a further height of up to two times the thickness of the steining above the steel plates. 12. Ensure that the concrete in the shell of the floating caisson has a slump of 150 to 200 mm as vibration is not possible. Alternatively, use self compacting concrete. 13. Minimize the sand blows by maintaining water level in the well at a higher level than the water table and by adding heavy kentledge. 14. Follow strictly all prevalent laws concerning handling, storing and using of explosive and observe necessary safety precautions as per applicable safety code, whenever blasting is resorted to. 15. Allow 24 hours to lapse before laying the bottom plug if blasting has been done after the well has reached the design foundation level. 16. Employ only persons trained in diving operations as divers and certified fit for diving by an approved doctor. 17. Take all safety precautions as per any acceptable safety code or any statutory regulation force, when divers carry out work under water in the well. 18. Introduce timber struts between the steining of a pair of wells close to each other which have a tendency to come closer during sinking, to prevent such movement. Ensure to carry out the concreting of well cap in dry condition by constructing false steining, if required. 19. Use timber piles only for temporary bridges /structures. 20. In the event of termination of work of raft due to monsoon, provide extra cross cut off wall to protect the part raft already cast.	14. Do not resort to dewatering if there is a danger of sand blowing under the well. 15. Do not place the kentledge on the loading platform in a disorderly and unsafe manner which can cause interference in he excavation inside the dredge hole and damage to the steining of the well in any way. 16. Do not commence blasting before the concrete in the steining has hardened sufficiently and is more than 7 days old. 17. Do not disturb in any way the bottom plug of concrete after placing for at least 7 days and any dewatering requires is to be carried out only 7 days after casting of bottom plug. 18. Do not allow splicing of timber piles.

Annexure-1200/I

CONTENTS OF METHOD STATEMENT FOR FOUNDATION AND SUBSTRUCTURE FOR BRIDGES OF OVERALL LENGTH 30 m or MORE

1. Sources of materials
2. Design, erection and removal of form work
3. Production , transportation, laying and curing of concrete
4. Personnel employed for execution and supervision
5. Tests and sampling procedure
6. Equipment details
7. Quality Management system to be adopted including Quality Manual
8. Safety measures
9. Any other relevant formation

Annexure-1200/II

REQUIREMENTS OF CONCRETING BY TREMIE

1. The hopper and tremie should be a leak proof system.
2. Diameter of tremie shall be not less than 200 mm of use with 20 mm diameter down aggregate.
3. The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it or with a steel plate with adequate charge to prevent mixing of concrete and water. However, the plug should not be left in the concrete as a lump.
4. The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe. The tremie should be always full of concrete.
5. The pile should be concreted wholly by tremie and the method of concrete deposition should not be changed part way up the pile, to prevent laitance from being entrapped within the pile.
6. All tremie tubes shall be thoroughly cleaned after use.
7. For concrete placed through tremie, there is no need to add 10 percent extra cement.
8. Concreting of piles shall be carried out continuously. In exceptional cases of interruption of concreting, the tremie shall not be taken out of the concrete under any circumstances. The tremie pipe shall be raised and lowered slowly from time to time to prevent it from getting stuck n the concrete while ensuring its lower end does not come out of concrete. The concreting shall be resumed before final setting time of concrete, which shall be established before the start of the piling operation. For achieving longer setting time of the concrete, super plasticizers having retarding properties/retarders can be used. If any of these requirements are not met, the pile shall be rejected.

Annexure-1200/III

IMPORTANT CONSIDERATIONS, INSPECTION/PRECAUTIONS FOR DIFFERENT TYPES OF PILES

1. Driven Cast in-situ Piles

   i. Consult Specialist literature and the guidelines from the pile construction industry regarding the method of installation, equipment and accessories for pile driving and recording of data.

   ii. Check the final set of penetration per blow of hammer by taking an average of last 10 blows during installation of piles.

   iii. Use cast iron conical type or mild steel flat type shoe with double reams for proper seating of the removable casing tube inside the space between the reams.

   iv. Ensure that there is no ingress of water in the casing tube from the bottom before commencement of pouring of concrete. Exercise adequate control during withdrawal of casing so as to maintain sufficient head of concrete inside the casing tube at all stages of withdrawal. Cast concrete in piles up to a minimum height of 600 mm above the designed top level of pile and strip it off at the time of construction of pile cap.

2. Bored Cast in-situ Piles

   i. Avoid voids in concrete and maintain sufficient head of concrete to prevent inflow of soil or water into the concrete. Take necessary precautions during concreting to minimize the softening of soil by excess water. Do not allow uncased cast in-situ pile where mud flow conditions exist.

   ii. Maintain the drilling mud such as bentonite suspension at a level sufficiently above the surrounding ground water level throughout the boring process to ensure the stability of the strata which is being penetrated until the pile is concreted.

   iii. Prevent the contamination of bentonite slurry for clay and silt by carefully controlling the properties of the material at stages of mixing, supply to the bore hole and immediately before concreting when bentonite suspension is used to maintain the stability of the bore hole. Limit:

      a. The density of bentonite suspension to 1.05 gm/cc,

      b. The Marsh cone viscosity between 30 and 40,

      c. The pH values between 9.5 and 12,

d. The soil content less than 1 per cent, and

e. The liquid limit of bentonite not less than 400 per cent.

iv. Wash the bore by bentonite flushing to ensure clean bottom after completion of boring and prior to concreting after placing of reinforcement cage. Continue flushing of bentonite with fresh bentonite slurry till the consistency of inflowing and outflowing slurry is similar.

v. Use retarding plasticizer for very large diameter piles and conduct non-destructive pile integrity tests to evaluate the integrity of large diameter piles.

vi. Grout the base of the pile where possible, with cement slurry under suitable pressure after concrete in the pile attains the desired strength, by placing conduit pipes with easily removable plugs at the bottom end in the bore along with the reinforcement cage before concreting.

Annexure -1200/IV

CONSTRUCTIOIN EQUIPMENT REQUIRED FOR WELL FOUNDATION

1. Crane with grab buckets capacity 0.5 cum to 2.0 cum
2. Submersible pumps
3. Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.
4. Chisels of appropriate sizes
5. Aqua-header for cutting rocky strata
6. Diving helmets and accessories
7. Batching plants for concrete production
8. Equipment for transportation, placing and compaction of concrete.

Annexure-1200/V

PRECAUTIONS DURING SINKING

1. When wells have to be sunk close to each other and clear distance between them is less than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately, so that, the sinking proceeds uniformly. Simultaneous and even dredging shall be carried out in the wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Plugging of all the wells shall be done together.

2. During sinking of double D-shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally.

3. Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

4. Before seasonal floods, all wells on which sinking is in progress shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods.

5. All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

6. The dredged material shall not be allowed to accumulate around the well. It shall be dumped and spread, as far away as possible, and then continuously and simultaneously removed, as directed by the Engineer. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

7. Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter / least lateral dimension of the well in plan. Normally the depth of sump shall not exceed 3 m below the level of the cutting edge unless otherwise specially permitted by the Engineer.

8. In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

9. Dewatering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand-blow.

10. Sand blowing in wells can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

11. In soft strata prone to settlement/creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment, has been completed.

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.

A1 Apron

1. Provide minimum 600 mm thick boulders apron beyond curtain walls. Keep the length of apron not less than twice the depth of curtain wall.
2. Use stones of minimum 40 kg weight each in apron. Alternately, use CC blocks M 15 grade of equivalent weight.
3. 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.
4. 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.
5. For regular and orderly disposition of stones 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.
6. Use wire crates of galvanized steel wire of 4 mm diameter with mesh opening not more than 150 mm.
7. Use in-situ 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 or ready available factory made gabions conforming to IS 16014 as per the drawings or as specified.
8. Place the crates in position before filling in boulders as far as possible.
9. Fill the crates by carefully hand packing the boulders as tight as possible and not by merely throwing stones or boulders.

A2 Pitching on Slopes

1. Use quarry stones of minimum 225 mm thickness or 25 kg weight as pitching or as specified, and spalls of minimum 25 mm size to fill the voids. Alternatively, PCC blocks of equivalent weight in M 15 Concrete can be used for pitching.

2. Provide one or two layers of graded materials (filter medium) of 150 mm thickness 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 profile before laying the pitching. Fill the depressions and thoroughly compact beforehand. The gradation of filter material shall be as per Clause1302.3 of MORD Specifications for Rural Roads.

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 of the adjacent layers by means of sufficient number of pin headers extending from one layer to the other.

A3 Toe Protection

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 65 mm to 75 mm diameter from a distance of 1.2 m from wider end. Paint the entire length in coal tar.

3. Choose lengths between 1.2 m and 3 m and drive the ballies into the ground at close intervals of 150 mm c/c. Use at least 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.

5. Retaining wall/breast wall as toe protection shall conform to clause 1604 of MORD Specifications for Rural Roads.

A4 Rubble Stone/Brick flooring over Cement Concrete Bedding

1. Where specified, provide rigid flooring under the bridges and culverts and extend for a minimum distance of 1.5 m on upstream side and 3 m 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 M 10 grade, so as to commence paving work.

3. Where rubble stone is specified as flooring, carryout the work with flat stones 150 mm thick, which are bedded on a 25 mm thick layer of 1:5 cement mortar. Fill the joints with 1:3 cement 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.

A5 Dry Rubble/Brick Flooring

1. 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.

2. Provide rubble stone flooring of minimum 150 mm thickness made with one flat stone only.

3. 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.

4. 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.

A6 Curtain wall

Enclose flooring by curtain walls in cement concrete (M 10) or stone/brick masonry in cement mortar 1:4 and take to a depth of at least 1.5 m on upstream side and 2 m on downstream side below the floor level. Ensure that the depth of curtain wall is not less than the normal scour depth.

A7 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 as far away as possible from an imaginary slope line of 4(horizontal):1(vertical) drawn from the top edge of the embankment or alternatively the open drain should be lined with stone/ brick masonry or concrete.

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 flowing from upper reaches and guide such flow into culverts. Cumulative discharge from several catch water drains with its increasing momentum may cause immense erosion. It is therefore desirable to provide lined chutes in such situations to lead the discharge to catch pit of culvert or to a natural drainage channel. Box type stepped chutes of stone masonry have been found to be more appropriate due to their stability and long life.

5. Refer to IRC:SP: 42 'Guidelines on Road Drainage' for more details and design of section.

B. Quality Control Requirements

1. Stones for Apron

The size and weight of stones for laying boulder apron shall conform to the requirements 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 2.5	300	40
3.0	380	76
3.5	510	184
4.0	670	417

Where stones of required size are not available, use cc blocks in M 15 grade weighing not less than 40 kg or stones in wire crates instead of isolated stones of equivalent weight.

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, use CC blocks in M 15 grade weighing not less than 25 kg or stones in wire crates instead of isolated stones of equivalent weight.

3. Wire Gabions

The galvanizing coating of gabions shall conform to IS: 4826 and that of annealed steel wire for wire crates shall conform to IS: 280. Ready available factory made gabions should conform to IS 16014.

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	Before procurement

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. 2. The minimum weight of stone in apron shall be 40 kg and that in pitching as 25 kg. 3. The stone shall be sound, hard and regular in shape. 4. When stones of required size are not available, use cement concrete block equivalent weight of M15 grade. 5. Fill the crates by carefully hand packing the boulders as tightly as possible. 6. Where cross fall and super elevation oppose each other in valley side curves, do ensure proper arrangement of drain layout. 7. Do provide catch water drains outside the periphery of slide/ unstable areas so that stability of hill slope is not further worsened. 8. The schedule of works should be so arranged that drains are completed in proper sequence with the road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drains.	1. Do not use stone which may suffer to marked deterioration by water or weather. 2. Do not adopt length of apron which is less than two times the depth of curtain wall. 3. Do not use round boulders in stone pitching. 4. Do not excavate the completed road works for construction of road side drains. 5. Do not fill the crates by merely throwing in stones or boulders.

SECTION 1400

SUPERSTRUCTURE, BEARINGS, EXPANSION JOINTS, WEARING COAT AND APPURTNANCES FOR STRUCTURES

1400: SUPERSTRUCTURE, BEARINGS, EXPANSION JOINTS, WEARING COAT AND APPURTNANCES FOR STRUCTURES

General

For bridges having overall length of 30 m and above, obtain a method statement containing details stipulated in Annexure- 1400 / I from the contractor for approval of the Engineer well in advance of the commencement of the construction of the superstructure.

1400.1 SUPER STRUCTURE

A. Methodology

I. Reinforced Concrete Construction

A1 Solid Slab

1. Where adjacent span of slab has already been cast in place, expansion joint and filler board abutting the already cast span shall form the shuttering for the adjacent span.
2. Cast whole of the slab in one go with reinforcement embedded for road kerb and railings/crash barriers.
3. In the case of slab continuous over two spans or more, cast in one go entire span of the first slab and the length of the slab in the next adjacent span up to the point of contra flexure. Repeat the same sequence of concreting for additional spans where provided. Do not allow any additional construction joint. Where permitted, provide longitudinal construction joint in very wide slabs.
4. Cast the portions of solid slabs near expansion joints along with reinforcement and embedments for expansion joints. For this purpose, where allowed, cast the portion of deck slab near expansion joints in a subsequent stage.
5. Provide wearing coat after the slab has been cast with the surface of the slab finished rough, but true to required lines and levels before the concrete has hardened.
6. Cover the top of the slab with clean moist stand as soon as the surface is hardened. Carry out curing as per Section 800.
7. Where provided, place bearing in position as per drawings before casting of slab.

A2 RCC T-Beam and Slab

1. Do not provide construction joint between the bottom bulb and the web.
2. Where position of construction joint is not specified, provide construction joint at the junction of the web and the fillet between the web and the deck slab with the approval of the Engineer.

3. Cast portion of deck slab near expansion joints along with reinforcements and embedments for expansion joints. For this purpose, where allowed, cast the portion of deck slab near expansion joints in a subsequent stage.

4. Finish the surface of the deck slab rough but true to required lines and levels before the cleaning of the concrete.

5. Take care to ensure alignment and setting of bearings as shown on the drawings.

A 3 RCC Box Cell

1. Construct the box section with a maximum of one construction joint located in the web below the fillet between the deck slab and web.

2. Carry out concreting operation continuously up to the construction joint. Use stiff brush for the brushing of concrete surface at the joint of the box after casting while the concrete is still fresh but has hardened slightly.

3. Prepare the surface of the already cast concrete before pouring of new concrete by

   i. Cleaning thoroughly the surface to remove debris and making surface rough in case of hardened concrete.

   ii. Treating the surface with wire brush followed by air jet for partially hardened concrete.

   iii. Soaking the old surface with water without leaving puddles immediately before start of the concreting to prevent absorption of water from newly poured concrete.

   iv. Compacting new concrete thoroughly in the region of joint.

4. Produce concrete in a power driven mechanical mixer of minimum 200 liter capacity. Also use a second mixer for continuous concreting, where required.

5. Ensure proper compaction of concrete in top slab of the box using screed or form vibrators. Use needle vibrators of appropriate specifications to ensure proper compaction of concrete in webs.

6. Keep bottom of the box 300 mm below the lowest bed level.

7. Provide protective apron and curtain walls as per Section 1300 and construct 400 mm thick plain cement concrete parapet on the top of deck slab of the box.

II. Prestressed Concrete Construction

A 4 PSC Girder and Composite RCC Slab

1. Provide as specified, precast or cast in-situ post tensioned or pretensioned PSC girders. Where precast construction is required to be adopted, include selection of casting yard and details of methodology and equipment for shifting and launching of girder in the method statement.

2. Ensure the sequence of construction including side shifting of girders, if required, and placement on bearings in accordance with the drawings.

3. Carryout concreting of the PSC girder constituting the top flange, web and bottom flange in a single operation without any construction joint.

4. Cast the portions of deck slab near expansion joints along with reinforcements and embedments for expansion joints. For this purpose, where allowed, cast portion of deck slab near expansion joints in a subsequent stage.

5. Finish the surface of the deck slab rough but true to required lines and levels before hardening of the concrete.

6. Take care to ensure correct alignment and setting of bearings as shown on the drawings.

A5 Box Girder

1. As specified, provide simply supported or continuous box girders. Provide approved minimum number of construction joints for simply supported box girders. In case of continuous box girders, ensure the sequence of construction and location of construction joints in conformity with the drawings.

2. Construct the box section with only one construction joint located in the web below the fillet between the deck slab and the web.

3. Cast the portions of deck slab neat expansion joints along with reinforcements and embedments for expansion joints. For this purpose, where allowed, cast portion of deck slab near expansion joints in a subsequent stage.

4. Finish the surface of the deck slab rough but true to required lines and levels before hardening of concrete.

5. Take care to ensure correct alignment and setting of bearings as shown on the drawings.

III. Cast In-Place Voided Slabs

A6 Reinforced / Prestressed Concrete Voided Slabs

1. As specified, provide either reinforced concrete voided slabs or prestressed concrete voided slabs.

2. Provide, as specified, voids of either circular or rectangular shape. Use void formers manufactured from steel sheets, fiber reinforced cement, expanded polystyrene, HDPE etc and generally corrugated to attain sufficient rigidity in order to prevent distortion or collapse during concreting and which are also leak tight.

3. In order to prevent flotation during concreting, tie down the void formers suitably.

4. Take care during placement of concrete to ensure that the concrete flows fully into the space below the void formers.

IV. Composite Type Construction

A7 RCC Slab with Steel Girder Composite Superstructure

1. Provide composite type of superstructure comprising longitudinal steel girders with RCC solid slab as decking for simply supported bridges only.

2. Ensure composite action between the steel girder and reinforced concrete deck by providing shear connectors as specified in the drawing.

3. Do not allow traffic on the bridge having composite type of superstructure prior to 28 days of concreting the deck for effective composite action.

4. Provide 150 mm x 150 mm haunches between top of steel girder and soffit of slab. Locate the sides of haunches outsides a line drawn at 45 degrees from the outside edge of the base of the connectors.

5. Protect all steel structural components of the composite type superstructure against corrosion by providing a minimum of three coats of paints or a metal coating followed by two coats of paint. Conform the painting and protective coating to IS: 1477.

1400.2 BEARINGS

A. Methodology

A1 General

1. Handle the bearings with care and store them under cover.

2. Exercise utmost care in setting and fixing all bearing in their correct positions and ensuring uniformity on all bearing surface.

3. When bearing assemblies or plates are specified to be placed (not embedded) directly on concrete, construct the concrete bearing area slightly above grade (maximum 12 mm) and finish by grinding.

4. Provide thin mortar pads of thickness not exceeding 12 mm in order to ensure that the bearings are set truly level and in exact position to have full and even bearing on the seats.

5. Ensure that the bottoms of girders to seat on the bearings are plane at the locations of the bearings and that the bearings do not get displaced while placing the girders.

6. Do not allow MS bearings sliding on MS plates. For sliding plate bearings, use either stainless steel surface sliding on stainless steel plate or PTFE surface sliding on stainless steel with mild steel matrix.

7. Use only full cylindrical rollers and do not allow use of segmental rollers. Ensure adequate width of base plate to accommodate the anticipated movements of the supporting structure.

8. Provide guides for components of rocker and roller bearings to prevent their dislodgement during earthquakes, in seismic zones IV and V.

9. Place the bearings at right angles to the longitudinal axis of the bridge for bridges with skew angle less than 20°. For bridges with skew angle greater than 20°, very wide bridges and curved bridges, ensure the location of bearings as stipulated on the drawings.

10. Make provision for easy access to the bearings for inspection and maintenance as also for jacking up the superstructure to facilitate repair / replacement of bearings.

A2 Steel Bearings

1. Workmanship

i. Ensure all work of steel bearings in conformity with clause 1402.3 of MORD specifications for Rural Roads and Section 1000.

ii. Take care to ensure that all parts of the bearing assembly fit accurately together.

iii. Machine knuckle pins, rolling surfaces of the rollers and bearing plates and make all bolt holes by drilling.

iv. In case of bearings which are to be grouted or bedded on a suitable yielding material, leave un machined any surface that is to be in permanent contact with the grout or the yielding material.

2. Construction Operation

i. Hold the bearings securely to prevent displacement of the component during concreting of girders. For this purpose, provide temporary connection between the top and bottom plates in case of fixed bearings and between top plates, base plate and saddle plate in case of roller- cum-rocker bearings or use any other suitable arrangement.

ii. In prestressed concrete construction involving launching of girders, avoid slipping or jumping of rollers due to vibration or jolts, and take adequate measures to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings at the launching end and place the beam on the rocker slightly in advance of placing on the roller.

iii. In precast prestressed girders, where recesses are left on the underside of girders to receive the anchor bolts, provide grout holes extending to the sides or top of the beam. Fill the grout hole with cement sand grout of mix 1:1 or with grout made of non-shrink high strength mortar. Alternatively, fit the precast girder with a template screwed or bolted into sleeves

already cast in the concrete, which can be removed and replaced by the top plate of the bearing at the time of erection of superstructure.

3. Installation

a. General

i. Place the bearing in position with all bearing surfaces in full contact and to the tolerances as specified.

ii. Place roller and rocker bearings such that their axes of rotations are horizontal and normal to the direction of movement of the members they support. Set upper and lower bearing plates horizontal in both directions.

iii. During installation, pre-set the bearings with respect to the bearing axis to account for the movement due to the following:

a. Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.

b. Shrinkage, creep and elastic shortening of prestressed girders.

iv. For bridges in gradient, place the bearing plates in a horizontal plane.

b. Placing

i. On supporting structures, provide pockets to receive anchor bolts with one side of the pocket projecting beyond the bearing plate. Fill the pocket with mortar and finish concrete bearing level by a thin and stiff mortar pad (of thickness not exceeding 12 mm) just before placing of bearing assemblies or bottom plate on the concrete seat. Use the mortar of mix 1:1 or of the non- shrink pre-packed type.

ii. In case of precast girders, make a recess of 6 mm on the underside with a level finish for housing the bearing plate. Provide a thin and stiff mortar pad with thickness not exceeding 3 mm over the top plate before lowering the precast beam in position in order to ensure full and even pressure on the plate surface.

iii. Ensure that while placing the girders, the bearings are in their exact positions as indicated in the approved drawing and not displaced there from.

iv. Carry out through cleaning and wetting of all concrete surfaces to be in contact with mortar for a period not less than 24 hours before placing mortar. Operations are to be carried out when the surface temperatures of the exposed bearings are the minimum practical.

v. Do not use any mortar that is more than 30 minutes old after completion of mixing.

vi. After placing and finishing the mortar, check the bearing for position and remove shims or other temporary supports and make the mortar made good. If the bearing has moved, lift the bearing, remove the mortar and repeat the whole procedure.

vii. Cure exposed faces of the mortar under damp hessian for 7 days.

viii. Placing of the bearing and mortar shall only be carried out in the presence of the representative of the manufacturer and the Engineer.

c. **Checking, cleaning and lubrication:** Before installation, each bearing shall be uncrated, disassembled and checked. Any damaged parts shall be made good for approval.

All bearings with sliding surfaces are to be cleaned and lightly lubricated with an approved lubricant immediately before installation.

A3 Elastomeric Bearings

1. Fabrication

i. Ensure that the elastomeric bearings are manufactured as per procedure and tolerances specified in clause 1402 of MORD Specifications for Rural Roads.

ii. Cast bearing with steel laminates as a single unit in a mould and vulcanize under heat and pressure.

iii. Do not allow casting of elements in separate unit and their bonding subsequently or cutting from large sized cast

iv. Produce bearings of similar size to be used in a particular bridge by identical process and in one lot as far as practicable. Resort to phased production only when the total number of bearings is large.

2. Installation

i. Use the bearing installed along a single line of support of identical dimensions.

ii. Place the bearings between true horizontal surfaces (maximum tolerance 0.2 percent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance + 3 mm).

iii. Ensure that concrete surfaces are free from local irregularities (maximum tolerance + 1 mm in height).

iv. Check the design for the actual inclination in seating if larger inaccuracies than those specified occur.

v. For cast-in-place concrete superstructure, where bearings are installed prior to concreting, use the forms around the bearings which are capable of easy removal and also fit the bearings snugly and prevent any leakage of mortar grout. Remove completely any mortar contaminating the bearings during concreting before setting.

vi. For precast concrete or steel superstructure elements, carryout fixing of bearing to them by application of epoxy resin adhesive to interface, after specified surface preparation with the approved specifications for adhesive material, workmanship and control.

vii. Take care to guard against faulty application and consequent behavior of the adhesive layer as a lubricant. Treat the bonding by the adhesive to be effective layer only as a device for installation and not to secure bearings against displacement for the purpose of design.

viii. As a measure of ample precaution against accidental displacement, place the bearings in a recess as per IRC: 83 (Part II).

A4 Pot Bearings

1. Manufacture

i. Follow the stipulations for manufacturing and manufacturing tolerances given in clause 1402.5 of MORD Specifications for Rural Roads.

ii. Produce the main components of a bearing casting / forging as a single monolithic body.

iii. In case the main components of the bearing are made from mild steel, they are to be machined to the required shape from a single piece of mild steel free of laminations.

iv. Do not permit welding for manufacture of the main components of the bearings.

2. Installation

a. General

i. Locate the bearings as to avoid the accumulation of dirt and debris on or around them. Ensure detailing of the structure in such a way that water is prevented from reaching the bearings.

ii. Normally do not dismantle the bearings after leaving the manufacturer's workshop. However, if for any reason, a bearing is required to be dismantled, carryout the same only under expert supervision for which the manufacturer's help may be sought.

iii. Do not allow transfer of load from the superstructure to the bearings until the bedding material has developed sufficient strength. Remove temporary clamping devices at the appropriate time before the bearings are required to accommodate movement. Fill the holes exposed on removal of temporary transit clamps with selected material. Where re-use

of these fixing holes may be required, carry out the filling of holes with material capable of being easily removed without damaging the threads.

iv. Make suitable temporary supporting arrangements under bearing base plates to accommodate thermal movement and elastic deformation of the incomplete superstructure. Remove such temporary supports if provided, once the bedding material has reached its required strength. Make good any voids left as a consequence of their removal using the same bedding material. Steel folding wedges and rubber pads are suitable for use as temporary supports.

b. Bedding

i. Select the bedding material keeping in view the type and size of bearing, construction sequence, load on the bearing and required setting time. Commonly used bedding materials are cementitious or chemical resin mortar and grout. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.

ii. Extend the bedding material, whether above or below the bearing, over the whole area of the bearing in order to ensure even loading. After installation, there shall be no voids or hard spots. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

iii. Use the bedding material capable of transmitting the applied load to the structure without being damaged. Prepare the surfaces to receive bedding mortar suitably so as to be compatible with the mortar chosen

c. Fixing of Bearings

i. Anchor the bearing in order to counter vibration and accidental impact. Anchorage should be accurately set into recesses cast into the structure using templates. The remaining space in the recesses should be filled with material capable of withstanding the loads.

ii. Ensure that the bearings that are to be installed on temporary supports are firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Fill the voids beneath the bearings completely with bedding material using the appropriate method.

iii. Fix the bearings directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location.

iv. If the structure is of steel, bolt the bearing directly onto it. Take care to ensure that there is no mismatch between the bolt holes of the structure and those of the bearing.

v. Tighten the threaded fasteners uniformly to avoid over stressing of any part of the bearing.

d. Bearings Supporting In-situ Concrete Deck

i. Where bearings are installed prior to casting of an in-situ concrete deck, seal the form work around bearings properly to prevent grout leakage. It is essential that the bearings and particularly the working surfaces are protected during concreting operations. Support the sliding plates fully and take care to prevent tilting, displacement or distortion of the bearing under the weight of green concrete. Remove completely any mortar contaminating the bearings before it sets.

ii. For bearings supporting precast concrete or steel beams, provide a thin layer of synthetic resin mortar between bearings and the beams. Bolt the bearings to anchor plates or sleeves embedded in precast concrete elements or to machined sole plates on steel elements.

1400.3 EXPANSION JOINTS

A Methodology

A1 General

1. Select the type of expansion joint to be provided on the basis of guidelines given in IRC: SP: 69.
2. Provide the expansion joint to cover the entire carriageway, kerb and footpaths, wherever provided and facia.
3. Expansion joint for foot path, if different from the carriageway expansion joint, should cater to all movements and rotations for which expansion joint for carriageway is designed and should be water tight.
4. Do not allow use of site fabricated expansion joints.
5. Procure only proven type of expansion joints from approved manufacturers.
6. Alternative type proprietary deck joints, where proposed, should meet the stipulations of clause 1403.2 of MORD Specifications for Rural Roads.
7. Provide expansion joints in conformity with the performance requirements given in Annexure-1400/II
8. Procure a minimum guarantee of 10 years from the contractor for satisfactory performance of all proprietary type expansion joints.

A2 Filler Joints

1. Components

Provide filler joint consisting of at least 2 mm thick corrugated copper plate placed slightly below the wearing coat, 20 mm thick compressible fiber board to protect the edges, 20 mm thick pre-

moulded joint filler filling the gap up to the top level of the wearing coat and sealed with a joint sealing compound.

2. Fabrication and installation

i. Construct the joint gap of width as specified. Thoroughly clean the surfaces of joint grooves with a wire brush to remove all loose materials and dirt and debris, then wash or jet them out.

ii. Do not place pre-moulded expansion joint filler in position until immediately prior to the placing of the abutting material. If the two adjacent surfaces of the joint are to be placed at different times, do not place this type of joint filler until the second face is about to be placed.

iii. Install sealants in accordance with the manufacturer's recommendations.

iv. Finish the sealants approximately 3 mm below the upper surfaces of the joint.

v. Remove the joint materials spilt or splashed onto finished surfaces of the bridge during joint filling operations and make good surfaces as required.

vi. Do not allow to seal any joint without prior approval.

A3 Reinforced Elastomeric joints

1. Components

Provide reinforced elastomeric joint comprising steel inserts anchorages, fixing bolts, elastomeric plugs, adhesives and sealants and necessary spacer bars as stipulated in clause 1403.5.1 of MORD Specifications for Rural Roads.

2. Fabrication

i. Sand / shot blast to SA1/2 all surfaces of the steel inserts and anchorage including the surfaces to be in contact with or embedded in concrete and provide with a coat of epoxy primer enriched with metallic zinc. For surfaces not to be in contact with or embedded in concrete, provide with an additional coat of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per paint manufacture's specification with a minimum total dry film thickness of 150 micron.

ii. Elastomeric slab units: Provide fully moulded elastomeric slab units to the required size in one single vulcanizing operation including the reinforcing plates and encasing layer as integral and homogenous part with rounded edges of reinforcing steel section. The elastomeric slab units are to be manufactured generally as per IRC: 83 (Part II). In order to ensure water tightness, provide adjoining portions of elastomeric slab units with suitable male-female groove.

iii. Ensure tolerances of fabrication as follows:

a. Plan dimension: ±5 mm

b. Total height: ±3 mm

A4 Single Strip / Box Seal Joint

1. Components

Provide single Strip / Box Seal Joint consisting of edge beam anchorages and sealing element conforming to clause 1403.6.1 of MORD Specifications for Rural Roads.

2. Fabrication (pre-installation)

i. Ensure long enough rolled steel profile for edge beams to cater for the full carriageway width. Cut these to size of actual requirements by means of a mitre box saw. Align cut-to-size steel profiles in accordance with the actual bridge cross-section on work tables. For this purpose, stretch the contour of bridge cross-section onto these tables. After the steel profiles are aligned, chuck them to the tables by means of screw clamps and tack by arc welding.

ii. Cut anchor plates to the required size by gas cutting and weld these to the edge beams.

iii. Bend the anchor loops to the required shape and weld to anchor plates.

iv. Clamp the finally assembled joints and transported to the work site.

A5 Asphaltic Plug Joint

1. Components

Provide asphaltic plug joint comprising a polymer modified bitumen binder, carefully selected single size aggregates, closure / bridging metallic plate and heat resistant foam caulking / backer rod as specified vide clause 1403.7.1 of MORD Specifications for Rural Roads.

2. This joint shall consist of a polymer modified bitumen binder, carefully selected single size aggregate, closure /bridging metallic plate and heat resistant foam caulking / backer rod.

3. Use asphaltic plug joint to cater for a maximum horizontal movement up to 25 mm and maximum vertical movement of 2 mm. This shall be certified by the manufacturer / supplier of the joint.

4. Ensure that the joint is capable of performing satisfactorily, within the temperature (ambient) range of -5 to 50°C.

A6 Compression Seal Joint

Components

i. Provide compression seal joint consisting of steel armoured nosing, anchorages and a

sealing element in conformity with provisions of clause 1403.8.1 of MORD Specifications for Rural Roads.

ii. This joint shall consist of steel angle nosing at two edges of the joint gap anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of reinforcing bars and anchor plates. Sealing element shall be a preformed continuous chloroprene/closed cell foam joint sealer compressed and fixed into the joint gap with a special adhesive binder.

iii. Provide the seal continuous over the full length of the joint required for carriageway, kerb and footpaths, if any. Ensure that the seal is capable to cater for a horizontal movement up to 40 mm and vertical movement of 3 mm.

A7 Installation of Expansion Joints

1. General procedure

i. Install expansion joints under thorough supervision of the manufacturer's / supplier's engineer in order to ensure the quality of installation so that expansion joints function as intended during their entire life span. Procure detailed installation manual from the manufacturer, of the expansion joints .

ii. Establish the dimensions of the recess in the decking in accordance with the drawings or design data of the manufacturer, taking the width of gap for movement of the joint into account.

iii. Carry out the presetting of expansion joint by means of an auxiliary construction.

iv. Lay the road surfacing / wearing coat before commencing installation of joint. Before laying wearing coat, fill the recess portion with sand and lay wearing coat in a continuous manner over the deck slabs and recess portion. Prior to the installation of the joints, remove portion of wearing coat over the recess by a suitable method e.g. saw cutting and the infill sand shall be removed subsequently.

v. Follow the general procedure laid down in clause 1403.9.1 of MORD Specifications for Rural Roads. for the preparation of the recess, shuttering, placing in the recess, connection and concreting during installation of expansion joint.

2. Specific Procedure

In addition to the general procedure, fulfill the requirements of specific procedure for installation of respective expansion joints stipulated in MORD Specifications for Rural Roads as indicated in Table 1400.2.

TABLE 1400.2 SPECIFIC PROCEDURE FOR INSTALLATION OF EXPANSION JOINTS

Expansion Joint Type	Reference Clause of MORD Specifications
Asphaltic plug joint	Clause 1403.9.2
Compression seal joint	Clause 1403.9.3
Single strip / box seal joint	Clause 1403.9.4
Reinforced elastomeric joint	Clause 1403.9.5

1404.4 WEARING COAT AND APPURTENANCES

A Methodology

A1 Wearing Coat

a. Bituminous Wearing Coat

1. Provide 20 mm thick premix carpet with seal coat as bituminous wearing coat on culverts having earth cushions and carry the pavement over such culverts.

2. On minor bridges and culverts without cushion, provide 40 mm thick Bituminous Macadam (BM) covered with 25 mm thick Semi Dense Bituminous Concrete (SDBC) as bituminous wearing coat.

3. For major bridges, provide bituminous wearing coat of any of the types given in Table 1400.1.

TABLE 1400.1 BITUMINOUS WEARING COAT ON MAJOR BRIDGES

Designation	Specification
Type 1	Bituminous concrete 50 mm thick laid in single layer
Type 2	Bituminous concrete 40 mm thick over laid with 25 mm thick Mastic Asphalt
Type 3	Stone Matrix Asphalt 50 mm thick laid in single layer
Type 4	Mastic Asphalt 50 mm thick laid in single layer

4. Clean the deck surface thoroughly and apply tack coat before laying wearing coat.

5. Ensure the construction operations and bituminous mixes as per Section 500 for the culverts and minor bridges and conforming to Section 500 of MORTH specifications in case of major bridges.

b. Cement Concrete Wearing Coat

1. Lay 75 mm thick cement concrete wearing coat in minimum M 30 grade separately over the bridge deck.

2. Reinforce the wearing coat with 8 mm diameter bars at 150 mm centre to centre in both directions at the mid depth of the wearing coat. Provide additional reinforcement of 8 mm diameter bars in both directions to make the spacing as 75 mm centre to centre in a length of 1 m near the expansion joint.

3. Conform the cement concrete and steel reinforcement to Section 800 and Section 1000 respectively.

4. In order to avoid formation of shrinkage cracks in hot weather, commence curing of wearing coat earlier than what is generally required.

5. Ensure non- skid characteristics for all carriageway and footpath surfaces.

6. Keep the cross slope in the deck as 2.5 percent.

7. In order to achieve camber / super elevation in wearing coat for the structures with flat deck surface, provide.

   i. Profile corrective course of the same material as of wearing coat before laying of wearing coat in case of bituminous wearing coat.

   ii. Provide profile corrective course along with the wearing coat in single layer in case of cement concrete wearing coat.

8. Do not allow overlay on the existing wearing coat on bridge decks. Either carry out repairs to the damaged wearing coat or remove and replace the same.

A 2 Railings, Crash Barriers and Kerbs

a. General

1. Do not construct railings/ crash barriers until the centering false work for the span has been released and the span is self- supporting.

2. Provide type of railing / crash barrier as specified and in conformity with IRC: 5 and IRC:6

3. Erect the railing / crash barrier true to line and grade. Ensure posts to be vertical with a tolerance not exceeding 6 mm in 3 m.

4. Exercise care in assembling expansion joints in the railing / crash barriers to ensure they function properly.

b. Metal railing / crash barriers

1. Galvanize or paint all complete steel rail elements, pipe terminal sections, posts, bolts nuts, hardware and other steel fittings.

2. Ensure that all galvanized elements of the railing / crash barrier are free from abrasions, rough or sharp edges and not kinked, twisted or bent. Carry out straightening if necessary, only by approved methods.

3. Clean and re-galvanize, all damaged galvanized surfaces, edges of holes and ends of steel railing / crash barrier cut after galvanizing.

4. Carefully adjust the railing / crash barrier prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Drill holes for field connections with the railing / crash barrier in place in the structure at proper grade and alignment.

5. Apply one shop coat of paint and three coats of paint after erection in case sections are not galvanized, unless otherwise specified.

6. Ensure that railing / crash barrier does not follow any irregularity in the alignment of the deck and rail elements are curved before erection when shown so on the drawings.

7. Handle railing / crash barrier with care so that the material and parts are kept clean and free from damage. Store railing / crash barrier materials above the ground on platforms skids or other supports and keep free from grease, dirt and other contaminants.

c. Cast in-situ concrete railing / crash barriers

1. Construct the portion of the railing /crash barrier or parapet which is to be cast in place in accordance with the requirements for structural concrete in Section 800 and steel reinforcement in Section 1000.

2. Provide forms of single width board or lined with suitable approved material. Do not allow form joints in plane surfaces.

3. Ensure that all mouldings, panel work and bevel strips are constructed as detailed in the drawings and all corners in the finished work are true, sharp and clean-cut as well as free from cracks, spalls or other defects. Carry out concreting of posts in one single pour.

d. Precast concrete railing /crash barriers

1. Provide precast members for railing/crash barriers of reinforced cement concrete in M 30 grade conforming to Section 800 and Section 1000.

2. Restrict the maximum size of the coarse aggregate to 12 mm.

3. Remove precast members from the moulds as soon as practicable and keep then damp for a minimum period of 10 days. Protect the members from sun and wind during this period.

4. Do not allow use of any precast member that becomes chipped, marred or cracked before or during the process of placing.

e. Railings for Submersible Bridges

1. Railings

i. Provide as specified, metal railings of collapsible or removable type or tubular railings only. Do not allow fixed type railings consisting of RCC vertical posts and RCC / Tubular horizontal members or solid parapet type or post and chain type railings.

ii. Where it is required to put up the railings immediately when the bridge is open to traffic after a submerging flood has receded, provide collapsible railings. Use collapsible railings of such design that they fit well in their grooves and are not liable to be dislodged by floods.

iii. Adopt removable type railings when there is no danger to the traffic using the bridge for short period without railings. Use removable type of railings of such design which ensures that the various members are interchangeable and can be easily removed and refitted.

iv. Provide collapsible or removable railings which are strong enough to resist same forces as applicable for railing or parapets on high level bridges. Ensure that they have such arrangement which does not allow the railings to collapse on carriageway side.

v. Handle metal railings with care so that the material and parts are kept clean and free from damage. Store railing materials above the ground on platforms, skids or other supports and keep free from grease, dirt and other contaminants.

vi. Do not allow guide posts/ stones in bridge portion and restrict their use to approach portion of the submergible bridge.

2. Kerbs

i. Do not allow continuous kerb on the deck of submersible bridges.

ii. Provide discontinuous kerb with 300 mm wide gap opposite to each other at 1.8 m center to center (1.5 m continuous length) on both sides to allow free flow of flood waters. Give stream line shape to the outer face of the kerb, as specified.

iii. Construct the kerb including pockets for fixing railings as per provisions of Section 800 and Section 1000.

A3. Approach slab

1. Construct Reinforced concrete approach slab covering the entire roadway width with a minimum length of 3.5 m and 300 mm minimum thickness.

2. Provide M30 grade concrete and reinforcement of 12 mm diameter bars at 150 mm centre to centre in each direction both at top and bottom for the RCC approach slab resting on 150 mm thick concrete base in M 15 grade.

3. Conform cement concrete and reinforcement to Section 800 and Section 1000 respectively.

A4. Drainage spouts

1. Use minimum 100 mm diameter drainage spouts of corrosion resistant material such as galvanized steel with suitable clean out fixtures. Restrict the spacing of drainage spouts to 10 m maximum. Ensure that the discharge from drainage spouts is kept away from the deck structure.

2. Fabricate the drainage assembly from mild steel components conforming to IS: 226 by seam welding for water tightness and hot dip galvanize thereafter.

3. Apply two coats of bituminous painting to the galvanized assembly before placement. Place the whole assembly in true position, lines and levels as specified, with necessary cut-out in the shuttering for deck slab and hold firmly in place . Where the reinforcements of the deck are required to be cut, place equivalent reinforcement at the carvers of the assembly.

4. After setting of the deck slab concrete, seal totally the shrinkage cracks around the assembly with polysulphide sealant as per IS:1834 and trim the excess sealant to receive the wearing coat. Finish similar sealant to cover at least 50 mm on the wearing coat surface all round the drainage assembly after completion of the wearing coat.

B. Quality Control Requirements

1. Materials

Physical Requirements of all materials shall conform to the provision of Section 2000. Materials of different components of bearings and expansion joints shall be in conformity with Sub section 1402 and Subsection 1403 respectively of MORD Specifications for Rural Roads For bituminous work relating to wearing coat, clause 14044 of this section shall be applicable.

2. Tolerances

i. Cast in-situ Superstructure

a)	Variations in thickness of top and bottom: slab for box girders, top and bottom flange for T- girders	- 5 mm to + 10 mm
b)	Variation in web thickness:	-5 mm to + 10 mm
c)	Variation in over all depth on width :	-5 mm to + 10 mm
d)	Variation in overall length between bearings:	shall not exceed ±10mm or ±0.1 percent of the span length, Whichever is less
e)	Permissible surface unevenness in deck slab : when measured with a 3 m straight edge or template	5 mm

ii. Composite type Superstructure

a. Variation in overall depth or width : ± 5 mm

b. Variation in overall length: shall not exceed ±10 mm between bearings or ± 0.1 percent of the span length, whichever is less

c. Permissible surface irregularities when measured: with a 3 m straight edge or template : 5 mm

iii. Bearings and Expansion joints

Tolerances for manufacturing/fabrication/installation shall be as stipulated in MORD Specifications for Rural Roads vide Subsection 1402 for bearings and Subsection 1403 for expansion joints.

3 Quality Control Tests

3.1 Tests Prior to Construction

a) Material / Work

The tests and checks to be carried out prior to construction are listed in Table 1400.1.

TABLE 1400.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency
1.	Cement, fine/Coarse Aggregates, water, concrete admixtures and Concrete for Structures	Tests as in Table 800.13	As in Table 800.13
2.	Steel Reinforcement	Test as in Table 1001.3	As in Table 1001.3
3.	Prestressing Steel, Anchorages	As in Section 1000	As in Section 1000
4.	Structural Steel	As in Section 1000	As in Section 1000
5.	Plant & Equipment and other arrangements for concrete production	a) Working condition of concrete mixers including standby arrangement b) Measuring boxes / scales for cement, fine and coarse aggregates c) Standard measuring cans (½, 1, 2, 5 liter capacity) for water	Check by AE before commencement of concreting

S.No.	Material/Work	Test/Check	Frequency
		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)	
6.	Prestressing Equipment	Requirement of Work as in Section 1000	Before Use

b) Manufactured Items:

Other checks to be done on 'Manufactured items' prior to construction are indicated in Table 1400.2.

TABLE 1400.2 QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency
1.	Bearings i. Steel bearings	Testing of bearing and all materials used in their manufacture as per IRC:83 (Part I) Quality Control report regarding testing and acceptance of bearings as per clause 1402.3.1.9 of MORD Specifications to be furnished by the manufacturer	Before procurement
	ii. Elastomeric bearings	Testing of specially moulded pieces and complete bearings or sections as per IRC:83 (Part II) and clause 1402.8.1 of MORD specifications Quality control certificate as per clause 1402.4.10 and Inspection certificate as per clause 1402.4.9 of MORD Specifications to be furnished by the manufacturer	Before procurement

S.No.	Material/Work	Test/Check	Frequency
	iii. Pot bearings	Tests on raw materials as per IRC:83 (Part III) Quality control report of routine tests as per inspection and testing vide clause 1402.5.10 of MORD Specifications to be furnished by the manufacturer	Before procurement
2.	Expansion joints	Documents to be furnished by the manufacturer: Sufficient evidence of the reliability of the proprietary product Copy of the test report for single strip / box seal joints and reinforced elastomeric joints as per clause 1403.10.1 of MORD Specifications Quality control report in respect of routine tests as per clause 1403.10.2.1 of MORD Specifications	Before procurement
3.	Shear connectors (For composite bridges)	Tests as per IRC:22	Before procurement

3.2 Tests / Checks during Construction

The Tests / Checks to be carried out during construction are indicated in Table 1400.3

TABLE 1400.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material/Work	Test/Check	Frequency
1.	Concrete for structures	For constituents including concrete admixtures As in Table 800.14	As in Table 800.14
2.	Cube Strength Results	Analysis of Test results (Clause No 815 of MORD Specifications)	During construction of superstructure components.
3.	Formwork	Tests as in Table 900.3	As in Table 900.3
4.	Reinforcement cage	Tests as in Table 900.3	As in Table 900.3

S.No.	Material/Work	Test/Check	Frequency
4.	Reinforcement cage	a) Diameter 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 1001.5	Before commencement of concreting As above Before placement and compaction of concrete
5.	- 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.
6.	Prestressing works	As in Section 1000	Each span
7.	Structural steel works in composite construction	As in Section 1000	Each span
8.	Bearings	Correct positioning on abutment/ pier cap/pedestals as per Subsection 1402	Each bearing/Before concreting.
9.	Expansion joint assemblies	Installation as per clause 1403.9 of MORD Specifications	At each joint location
10.	Sealing elements	To be installed as per Manufacturer's specifications	After hardening of concrete
11.	Wearing coat	Thickness, camber, surface texture	Each span
12.	Kerbs, Railings/Parapets/Crash barriers / Drain pipes	- Separate formwork - Dimensions - Spacing	As and when work is taken up.
13.	Shear connectors	Diameter, length and spacing	Each Span, 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 1400.4

TABLE 1400.4: QUALITY CONTROL CHECKS BY AE / EE

S.No.	Material/Work	Test/Check	Frequency/Stage	Designation of Inspecting Officer
1.	Superstructure	- Dimensions/width of carriageway - Overall length/Length between bearings - Camber	Each span	AE
2.	Bearings	- Placement and installation as per Sub Section 1402 of MORD Specifications	Each bearing	AE/EE
3.	Expansion Joints	- Placement and installation as per clause 1403.9 of MORD specifications	At each joint location	AE/EE
4.	Wearing coat	- Thickness - Camber - Surface Texture	Each span	AE
5.	Railings/Kerbs/parapets/ crash barriers	- Irregularity in alignment - Dimensions	Each span	AE
6.	Drainage spouts	- Spacing - Finishing Sealants	After Hardening	AE/EE
7.	General workmanship	-	Each span	AE/EE
8.	All concrete component	- Soundness of concrete - Honey combing, finishing - Tolerances - Workmanship - Cube strength (Review of test results)	As per Table 800.15 Random	AE/EE
9.	Shear Connectors	- Diameter, length and spacing	Each span Before concreting	AE/EE

C. Do's and Don'ts

Do's	Don'ts
1. Cast the portions of deck slab near expansion joints along with reinforcements and embedments for expansion joints. 2. Rough finish the surface of deck slab before hardening, to ensure bonding of wearing coat later. 3. Construct the box section of box cell / box girder strictly as per sequence of construction stated in the drawings and with only one construction joint located in the web below the fillet between deck slab and web. 4. Lay concrete in the PSC girder constituting the top flange, web and bottom flange in a single operation without any construction joint. 5. Provide composite type of superstructure for simply supported bridges only. 6. Place the bearings at right angles to the longitudinal axis of the bridge for bridges with skew angle less than 20°. For bridges with skew angle more than 20°, very wide bridges and curved bridges, place the bearings as shown in the drawings. 7. Ensure that the bottom of girders to be seated on bearings is plane at the location of bearings and that the bearings are not displaced while placing the girders. 8. Make provision for easy access to the bearings for inspection and maintenance and also for jacking up the superstructure to facilitate repair /replacement of bearings. 9. Provide roller and rocker bearings with guides to prevent them from being displaced during earthquakes in case of bridges located in zones IV and V. 10. Cast elastomeric bearing with steel plates as a single unit in mould and vulcanize under heat and pressure.	1. Do not resort to layered construction of thick RCC solid slabs to avoid cold joints. 2. Do not provide any construction joint at the junction of web and fillet between web and deck slab for T-beam bridge. 3. Do not allow traffic on the bridge having composite type of superstructure prior to 28 days of concreting the deck for effective composite action. 4. Do not permit the type of bearings with MS plate sliding on MS plate. 5. Do not allow use of segmental rollers and provide only full cylindrical rollers. 6. Ensure that any material like reclaimed rubber or vulcanized wastes or natural rubber is not used for elastomeric bearings. 7. Do not allow use of synthetic rubber like materials such as Ethyl propylene Dimonomer (EPDM), Isobutane Isoprene copolymer (IIR) and chloro-Isoprene copolymer (CIIR) in making of elastomeric bearings. 8. Do not permit casting of elements in separate unit and their subsequent bonding as also cutting from large sized cast for the manufacture of elastomeric bearings. 9. Do not allow use of site fabricated expansion joints. 10. Do not allow welding for manufacture of main components of any pot bearings. 11. Do not drill holes for fixing bolts for expansion joint in the bridge deck area adjacent to expansion joint within 7 days of concreting in case of reinforced elastomeric joints. 12. Do not permit mechanical fastening of sealing element with the edge beam in case of single strip / Box seal joint.

Do's	Don'ts
11. Produce elastomeric bearings of similar size to be used in a particular bridge by identical process and in one lot unless the total number of bearings is large. 12. Manufacture the main components of pot bearings as a single monolithic body by casting / forging. In case these are made from mild steel, machine them to required shape from a single piece of mild steel free of laminations. 13. Procure expansion joints of proven type from approved manufacturers. 14. Provide expansion joint covering the entire carriageway, kerb and footpath, where provided, and following the profile including the kerb, footway and facia. 15. For filler joints, use joint filler consisting of only large pieces and avoid assembly of small pieces to make up the required size. 16. Ensure use of elastomeric slab units that are fully moulded to the required size in one single vulcanizing operation including the reinforcing plates and encasing layers as an integral and homogenous part in case of reinforced elastomeric joints. 17. Install sealing element of compression seal joint when the ambient temperature is between + 5°C and +35°C. 18. Provide sealing element continuous for full length of the expansion joint required for carriageway, kerb and footpaths, if any. 19. Commence the curing of cement concrete wearing coat earlier than what is generally required to avoid formation of shrinkage cracks in hot weather. 20. For submersible bridges, provide metallic railings of collapsible or removable or tubular type only. 21. Ensure that the discharge from the drainage spouts is kept away from the deck structure.	13. Do not install asphaltic plug joint when the ambient temperature goes below +5°C or above +35°C or while it is raining/snowing. 14. Do not lay cement concrete wearing coat monolithic with the bridge deck. 15. Do not allow over lay on the existing wearing coat on bridge decks. 16. Do not provide fixed type railings on submersible bridges. 17. For submersible bridges, do not allow guide posts / stones in bridge portion and restrict their use to the approach portion of the bridge. 18. Do not allow provision of continuous kerb on deck of submersible bridges.

Annexure-1400 / I

CONTENTS OF METHOD STATEMENT FOR BRIDGES OF OVERALL LENGTH MORE THAN 30 m

i. Sources of Material

ii. Design, erection and removal of form work

iii. Production, transportation, laying and curing of concrete

iv. Prestressing system, if applicable

v. Personnel employed for execution and supervision

vi. Testes and sampling procedure

vii. Equipment details

viii. Quality Management System to be adopted including Quality Manual

ix. Safety measures

x. Any other relevant information

Annexure- 1400 / II

PERFORMANCE REQUIREMENTS OF EXPANSION JOINTS

1. Performance requirement with respect to bridges

The expansion joint shall:

i. Withstand the imposed load including the impact load from live load and other sources.

ii. Allow expansion and contraction movement due to temperature, creep, shrinkage, prestressing and structural deformations.

iii. Permit relative rotation in elevation and due to the causes as noted above.

iv. Be waterproof. Bridge deck expansion joint seals play a critical role in preventing the degradation of the structural components of the bridge system. Without effective joint seals, water passes through the bridge deck and work harmfully to corrode steel components and cause deterioration of the concrete. Rain water gathers various corroding additives from the atmosphere and also from the carriageway.

v. Ensure sealing. In case bridge deck joints are not sealed, apart from loss of waterproofing, grit and other forms of road debris may enter the joint. Debris, when impacted with the joint can seriously restrict the movement instead of facilitating the same. In the case of proprietary joints being accepted for adoption, the sealing shall be as specified by them.

vi. Ensure long life by being resistant to corrosion,

vii. Be easy to install,

viii. Be easy to maintain. Re-placebility of expansion joint shall be one of the basic criteria for selection of type of expansion joint,

ix. Be resistant of the materials likely to collect / spill over the deck in its normal service.

2. Performance Requirement with respect to user

The expansion joint shall:

i. Provide smooth continuity at the top of the deck for riding comfort,

ii. Be of skid resistant surface,

iii. Be non-damaging to the rubber tyre,

iv. Make minimum noise during vehicular crossing,

v. Ensure that animal paws and hooves should not get entangled where bridges are used by animal drawn traffic,

vi. Permit passing of bullock cart steel tyre for bridges where bullock carts ply,

vii. Look good aesthetically.

3. Performance requirement for transition zone

It is zone of connection of joint assembly and the adjoining deck. The expansion joint shall:

i. Permit transfer of generated forces without distress, i.e., without getting uprooted. The purpose will not be served if the bonding is with the wearing coat only. Anchorage must be provided with the deck structural element.

ii. Ensure that surface in the transition zone stays undisturbed during long term service.

SECTION 1500

CEMENT CONCRETE PAVEMENTS

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. If the first trial is unsatisfactory, the contractor shall have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

The materials shall meet the quality requirements given in Para B.

(ii) The trial length will be constructed in two parts for a period of at least 2 days with a minimum 15 m length in a day. In manual construction trial length shall be constructed at similar rates that is proposed for the main work.

(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 flexural strength of concrete as specified in the Contract.

The cement content should not be more than 425 kg nor less than 350 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 270 kg/cum. The flyash content may be upto 30% by weight of cementitious material.

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. A slump value of 30 ± 10 mm is reasonable for paving work. Chemical admixtures / plasticiser as per IS 9013 may be used if needed 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. The CBR of the sub grade shall not be less than 4%. If it is less than 4% CBR, it will be improved by stabilization to a CBR value of not less than 10%.

3. Lay granular or WBM grading 3 or lime treated soil of thickness varying from 75 to 150 mm depending upon the volume and type of traffic. **The four days soaked CBR of lime treated soil after 3 days curing shall not be less than 15%.**

Traffic up-to 50 CVPD: *75 mm thick WBM Gr-III or 100 mm GSB or 150 mm thick cement / lime / lime flyash treated marginal aggregates / soil with 3 MPa strength at 7 days with cement or at 28 days with lime / lime flyash is recommended.*

Traffic from 50 to 150 CVPD: *75 mm thick WBM Gr3/WMM over 100 mm GSB or 100 mm thick cementitious granular layer having minimum UCS of 3 MPa at 7 days with cement or 28 days with lime/ lime flyash, over 100 mm thick cementitious naturally available material with minimum UCS of 1.5 MPa is recommended.*

Traffic from 150 to 450 CVPD: *150 mm thick WBM Gr3 / WMM over 100 mm of granular sub bases or 100 mm of cementitious granular layer with a minimum UCS of 3 MPa at 7 days with cement or 28 days with lime or lime flyash is recommended.*

4. Provide a separation membrane (125 micron thick PVC sheet) between sub-base and concrete slab. It should be laid with minimum creases. The separation can also be provided by spraying VG 10 bitumen @2 kg/sqm and applying a light coat of sand passing 4.75 mm and retained on 2.36 mm sieves.

5. **Joints:**

Mark the location of transverse joints by transferring from the drawings, on the sub base with red paint on either side. In pavements upto 200 mm thick, no dowel bars will be provided. All types of joints shall be sealed with bituminous sealant as per IS 1834.

All dowel bars shall be within (±) 5 mm in length . Normally, dowel bars are 500 mm long and spaced at 250 mm c/c or as specified. They shall be parallel to the longitudinal axis of the pavement.

(i) Provide dowel bars where specified. These shall be placed at mid depth of the slab within a tolerance of ± 20 mm supported on dowel chairs.

(ii) Contraction joints shall be mechanically sawn in a width of 3 to 5 mm and to a depth of 1/4 to 1/3 of the slab thickness. The joints will be spaced 2.5 m to 3.75 m c/c. 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 of laying of concrete depending on weather conditions. The joints shall be subsequently widened to 8-10mm width and 20 mm depth to house the hot poured bituminious sealant as per drawings and as per para 15 below Both ends of joints will be plugged with pieces of synthetic tar felt to prevent ingress of water.

(iii) 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. Both ends of joints will be plugged with pieces of synthetic tarfelt to prevent ingress of water. The joint shall be sealed as per (ii) above.

(iv) Expansion joints shall be provided near bridges and slab culverts and consist of a bitumen impregnated joint/ pre-moulded synthetic joint filler board. The joint filler board shall be of 12 mm thickness near slab culverts and 20 mm thick near bridges and shall comply with IS:1838. Dowel bars shall be provided at the expansion joints as per drawings. Both ends of joints will be plugged with pieces of synthetic tarfelt to prevent ingress of water.

(v) Longitudinal joints shall be provided for a pavement which is more than 4.5 m wide and tie bars shall be provided at mid depth of slab. The concreting in the entire width shall be done in one go and the joint shall be saw cut. It shall be 3.5 mm wide and of depth equal to 1/3rd of the depth of slab after curing period is over. The joint shall be widened to 6 to 8 mm to a depth of 12-15 mm and sealed with hot poured bituminous sealant.

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 or slightly less to accommodate the surface regularity of the sub-base. 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 **as per IS 4926** conforming to the specified properties of strength and workability may also be used.

8. Slump of concrete at paving site should be in the range of 30 mm ±10 mm. It will not be more than 20 mm for hill roads.

9. Concrete shall be placed between the side forms in a continuous manner and shall be levelled with rakes and shovels. In concrete panels having acute angles, a bar mat of 10 mm dia tor 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 Salitax or other pre-moulded board as per IS:1838 and bar mats before concreting. Such panels with openings shall have, bars mats of 10 mm dia tor steel at 150 mm both ways placed, 50 mm below the top of slab in the entire panel.

11. Compact concrete by a vibrating screed supplemented by two needle vibrators. The needle vibrator will be used specially in corners to ensure proper compaction of concrete. The screed vibrator will be moved slowly to ensure adequate compaction of the concrete. The bottom of the screed vibrator will be of the shape as per the cross profile of the slab road. The amplitude of the vibration will not be less than 1.5 mm and the speed of travel not more than 0.6m per minute The temperature of the concrete shall be between 5°C - 30°C.

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 hand handled steel brush. The depth of the texture shall be about 1.5 mm. The texturing shall be perpendicular to the centre line of the pavement. The textured surface shall be free from porous or other surface depression. The texturing brush shall be cleaned at suitable intervals and made free from hardened cement paste.

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 finishing operations, the entire 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 at the end of 24 hours, the slab shall be thoroughly wetted and then cured by ponding or covering with wet sand, occasionally sprinkled with water. The curing shall be continued for 21 days.

In case water is not available for curing, the newly built pavement surface will be sprayed with two coats of curing compound, so that even a pin hold is not visible which is not covered on the main surface and side. No traffic will be allowed for 7 days when such curing is under progress.

The concrete will be exposed only during the duration of saw cutting of each joint. The joint will be temporarily sealed with jute rope.

15. After minimum of 28 days after casting the concrete pavement, joint groove at contraction and construction joint shall be widened to 10 mm width and to a depth 18 to 20 mm and shall be sealed with bituminous sealant after inserting baker rope of coconut fiber. Before sealing the primer will be applied as per manufacturer's instructions. Hence traffic at slow speed with caution signs may be allowed once the sealant has cooled to ambient temperature.

16. Paving near culverts and bridges: the pavement slab shall be carried over the hume pipe ensuring adequate cushion. In case the pavement abuts the main desk slab, of a culvert or a bridge, a proper expansion joint as per para 5 (iv) above shall be provided. In case the pavement abuts the existing culvert / bridge expansion joint shall be provided by drilling holes at the required spacing in the existing deck slab. These holes shall be of diameter 2 mm more than the dia of the dowel bar. The

dowel bars will be fixed in these holes with epoxy resin. The exposed end of the dowel bar shall be covered with polythene sheating and shall be embedded in the fresh concrete of pavement slab.

B. Quality Control Requirements

1. Material

(i) Cement

Any cement of the following types capable of achieving the design strength may be used.

(a) Ordinary Portland Cement, 43 Grade, IS:269

(b) Ordinary Portland Pozzalana cement, IS:1489

(c) Portland Blast Furnace Slag cement, IS:455

(d) Ordinary Portland Cement (OPC), 53 Grade, IS:269, (to be used only when a part of cement is replaced by fly-ash.)

(e) 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.

Use of fly-ash not more than 30% by weight of cementitious material may be permitted in OPC with the approval of the Engineer.

(ii) Admixtures

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 part-1.

(iii) Aggregates

(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 of 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 (SO3) 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 31.5 mm. It shall not have a flakiness index more than 35% and water absorption exceeding 5%. The soundness test will be conducted if water absorption is more than 3%.

(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 : **1%**
- Coal and lignite : 1%
- Material passing Sieve No. 75 micron: **3%** in natural sand and **8%** in crushed sand.

(f) Coarse and fine aggregates, after blending shall conform to the gradation requirements given in Table 1501.1

TABLE 1501.1: AGGREGATE GRADATION FOR CONCRETE PAVEMENTS

S.No.	Sieve Designation	Percentage by weight passing the Sieve
1.	31.5 mm	100
2.	26.50 mm	85-95
3.	19.0 mm	68-88
4.	9.50 mm	45-65
5.	4.75 mm	30-55
6.	600 micron	8-30
7.	150 micron	5-15
8.	75 micron	0-5

(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/sqmm shall be used as dowel bars. These shall be free from oil, dirt, loose rust, scale, irregularities and burring.

(vi) Tie bars: the tie bars shall be tor steel as per IS:1786 having yield strength not less than 500 N/mm^2

(vii) Pre-moulded Joint Filler

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

(viii) 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

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

3. Surface Level

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

4. Surface Regularity

The maximum allowable difference between the pavement surface and a 3 m straight edge shall not exceed **6 mm** in both transverse and longitudinal direction.

5. Thickness: As per drawings. A tolerance of ± 10 mm is permitted.

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 1501.2

TABLE 1501.2 QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Type of tests	Frequency
1.	Cement	As in Table 2000.4
2.	Fine aggregates	As in Table 2000.9
3.	Coarse aggregates	As in Table 2000.10
4.	Water	Once for each source, subsequently, in case of doubt.
5.	Admixture - Chemical (workability) (IS: 6925 & IS: 9103) - Mineral (flyash) (IS:3812)	Manufacturer's Certificate before procurement -do- -do-
6.	Dowel bars (Plain steel) IS:432 (part -I)	Tests for 3 samples to determine yield strength
7.	- Tie bars tor steel IS 1786	-do-
8.	- Pre-moulded joint filler (IS:1838) or - Joint sealing Compound (IS:1834)	Manufacturer's Certificate -do-
9.	Plants equipment and tools	As per contract
10.	Concrete mix Design for cement content w/c ratio and dosage of plasticizers for the specified design strength	To be approved by EE
11.	Granular Sub base	Table 401.2
12.	Trial Length	To be approved by EE before regular work.

6.2 Tests during construction.

The quality control 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.	Sub grade and sub base	As in Tables 301.5 and 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 cum of concrete at paving site or one test for each dumper laid at plant site.
4.	Strength of concrete (IS:516)	Minimum 6 cubes and six beams (3 each for 7 days and 28 days 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	Check regularly
9.	Compaction equipment (needle, screed and plate vibrators)	For continuous working and standby arrangement
10.	Separation membrane (thickness and laying)	Prior to laying
11.	Levels and alignment	
	I) Level Tolerance	To be checked for each day's work regularly
	II) Surface regularity (transverse and longitudinal including camber / cross slope)	
	III) Width of pavement and position of paving edges	To be checked for each day's work regularly at grid points
	IV) Pavement thickness	To be checked for each day's work
	V) Alignment of joints	As above
	VI) Depth of dowels bars	As above
	VII) Texturing and edging	As above

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	At random	AE
	- Surface regularity	At random	AE
	- Surface texture	At random	AE
	- Transverse joints	Every Joint	AE
3.	Joints (Expansion / Contraction)		
	- Joint alignment, dimensions and 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

6.4. 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 1500 mm length; cumulative length of such cracks in each slab shall not exceed 2000 mm.

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.	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°C or less than 5°C at the point of placing and ambient temperature is greater than 35°C

Do's	Don'ts
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.	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 1501A.1. Roll the trial length as per rolling sequence given in Table 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 re-determined. Determine natural moisture content of aggregate on day to day basis, before production of the mix.

TABLE 1502.1: ROLLING SEQUENCE FOR ROLLER COMPACTED CONCRETE PAVEMENT

S.No.	Type of Roller	Number of Static passes	Number of vibrating passes	Remarks
1.	Tandem vibratory roller of 80-100 kN static weight	2	Nil	Breakdown rolling
		Nil	4-6	Vibratory rolling with amplitude 0.8 -0.4 mm
		1-2	Nil	smoothening
		OR		
2.	Single front drum steel roller with rear tyres of rubber	1	Nil	Breakdown rolling
		Nil	4-5	Vibratory rolling with amplitude descending from 1.8 to 0.4 mm
		1-2	Nil	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% reference density. 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. Remove and relay the trial length if the same does not comply with specifications. The main work will start only after approval of the trial length by the Engineer.

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 1501.23.5.1 of MORD Specifications. Check the homogeneity of RCCP from these cores.

Mix Design

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. The exact moisture content requirement in the mix shall be established after making field trial construction. If strength achieved is lower than the desired strength, the trial should be repeated after increasing the cement content till the desire strength is achieved.

   The mix design shall be based upon flexural strength which shall be not less than 3.8 MPa. The design mix shall be minimum of M30 grade.

6. Use flyash in RCCP not more than 30% by weight of cementitious material by replacement of cement is permitted. The concrete shall have zero slump. No flyash is to be blended in factory manufactured portland pozzolana cement or blast furnace slag cement.

7. The water content may be kept within 5 to 7 % of the weight of cement, aggregates and weight of the coarse and fine aggregates and cement. 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 350 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 270 kg per cum. Flexural strength of concrete shall not be less than 3.8 MPa.

   The design mix shall be minimum M30 grade.

Construction

9. Prepare the sub grade as per para A-2 of sub section 1501

10. Provide the sub base as per para A-3 of sub section 1501

11. Produce concrete near the site, using approved concrete mixers of at least 0.2 cum capacity. The concrete shall be zero slump concrete. Each batch shall be mixed for not less than 1.5 minutes.

12. Fix the side forms as per paras A-6 and A-9 of sub section 1501

13. At every 6 m nearly, camber templates or uni directional tapered templates having design slopes shall be placed. 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.

14. For placing of concrete by semi-mechanised methods, the concrete will be placed with 25% to 30% prodding (to be adjusted during field trial between the camber templates). The placement of concrete shall be done in a continuous manner.

Place the mix with wheel barrow/ steel pans with rotary motion and spread uniformly with shovels and rakes. Use a wooden screed 125 mm by 50 mm and 3 m long in a sawing motion to level the mix before rolling.

15. 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 tamping bars to give good initial compaction. The side forms will be in the form of channels or steel plates supported by jacks. The rolling near the edges of the pavement will be done at very low amplitude of the vibratory roller by giving more number of passes.

16. The rolling shall be carried out in sequence indicated in Table 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. If some hungry surface or honey combed surface appears, broom in cement sand mortar 1:4 in roll with 1 pass of static roller.

17. The final time of rolling shall not exceed 90 minutes from the time of mixing water when the temperature is between 25°C and 30°C, and 120 minutes when the same is less than or equal to 25°C. No concreting is to be done when the temperature is less than 4°C or more than 35°C. Chilled water should be used to bring the temperature of concrete to 30°C. Take precautions indicated in IRC:15 when ambient temperature is below 5°C or more than 35°C.

18. Carry RCCP over hume pipe culverts. In case of existing or new bridges/ culverts, RCCP shall abutt the deck/ approach slab and a construction joint should be provided as per clause 1502.5 of MORD Specifications.

19. No longitudinal joint shall be provided if the width of carriageway is less than 3.75 m. RCCP shall have only transverse contraction joints at 4 m centre to centre. These shall be saw-cut after 24 hours of laying. The width of joints shall be 6-8 mm and depth one-fourth of RCCP slab. These shall be filled with hot poured sealing compound as per paras 5-A and 15-A of sub section 1501.

20. 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.

21. 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 requirements 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 1502.2

TABLE 1502.2: AGGREGATE GRADATION FOR RCCP

Sieve Designation	Percentage by Weight passing the sieve
26.50 mm	100
19.0 mm	80-100
9.50 mm	55-75
4.75 mm	35-60
600 micron	10-35
75 micron	0-5

Fly-ash may be from anthracite 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 1502.3.

TABLE 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 sqm/kg by Blaine's permeability test,	320 sqm/kg minimum
2	Particles retained on 45 micron IS sieve	34% maximum
3	Lime reactivity average compressive strength	4.5 N/sqm
4	Soundness by autoclave test expansion of specimen	0.8% maximum
5	Drying shrinkage	0.15% maximum

2. 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-B** shall apply

3 Quality Control Tests

3.1 Tests prior to construction

The Quality Control tests to be carried prior to construction are indicated in Table 1502.4

TABLE 1502.4 QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Sl.No.	Type of tests	Frequency
1.	Material for concrete	As in Table 1501.2
2.	Concrete Mix Design (with and without fly ash)	Approved by EE for cement concrete w/c ratio and use of plasticizers
3.	Plants, equipment and tools	As per contract
4.	Trial Length before commencement of regular work	Approved by EE
5.	Granular sub base	As in Table 401.2
6.	Design parameters (grade of concrete width, thickness and details of joints)	As per construction drawings.

3.2 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

Sl.No.	Type/Check	Frequency
1.	Gradation and moisture content of aggregates	As inTable1501.3
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:2720-28)	Three tests for each 2000 sqm or part thereof.
5.	Sub grade and Sub base	As in Tables 301.5 and 401.3
6.	Strength of Concrete (IS : 516)	As in Table 1501.3
7.	Side forms	As in Table1501.3
8.	Transverse Contraction Joints (width and depth)	18-24 hours after laying

3.3 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	AE/EE
2.	Cumulative length of cracks	One check for every 100 m	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 fly ash as replacement of cement if Port land Pozzolana fly ash 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 **manufactured** using block manufacturing machine or semi mechanized means i.e. **vibrating table and surface vibrator** as per clause 1503.6 of M**O**RD Specifications.

2. Ensure a trial length of 30 m is laid for demonstrating the procedure and equipment for laying the main pavement. If trial found deficient it shall be re-laid.

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. If the soaked CBR of sub grade soil is less than 4 percent, it shall be improved by stabilisation to not less than 10%.

4. Sub base and base: Provide sub base with 100 mm thick GSB or, 100 mm WBM Gr. 1 and 75 mm WBM (Gr. 2 or 3) base extended by at least 150 mm beyond the edge of blocks, as per section 400 of the MORD specifications.

5. Lay 25 to 30 mm thick (compacted) bedding sand conforming to grading requirements indicated in Table 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. Lay the concrete paving blocks over the sand bedding. The pattern for paving blocks shall be stretcher type. The joints between stretcher bond shall be staggered by about half the length of stretcher.

7. The sizes of the paving blocks and restraint blocks shall be 450 mm x 300 mm x 150 mm size (L x B x H) and concrete shall have design mix of M 30 grade. The cement content shall be between 350 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 4 mm to 6 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 sqm

(ii) Spread a thin layer of joint filling sand as per gradation given in Table 1503.1on 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.B1**

(ii) Bedding and joint filling sand

Grading for bedding and joint filling sand shall conform to the requirements indicated in Table 1503.1.

TABLE 1503.1: RECOMMENDED GRADING FOR BEDDING AND JOINT FILLING SAND

IS Sieve Size	Percent passing	
	Bedding sand	Joint filling sand
10.00 mm	100	100
4.75 mm	90-100	95-100
2.36 mm	75-100	95-100
1.18 mm	55-90	90-100
600 micron	35-59	80-100
300 micron	8-30	15-50
150 micron	0-10	0-15
75 micron	0-3	0-5

(iii) Sub-base and base course

Granular sub-base and WBM be shall conform to sub-section 401 and 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 f_{ck}+3 MPa where f_{ck} is the design characteristic compressive strength.

(ii) The tolerance in surface levels shall be ± 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 of the road shall be not 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

Sl.No.	Type of tests	Frequency
1.	Material for concrete	As in Table 1501.2
2.	Concrete Mix Design	For Approval by EE
3.	Grading for bedding and joint filling sand	As per Table 1503.1
4.	Size and compressive strength of paving blocks	**As per drawings**
5.	Sub grade and sub base	As in Table 301.4 and 401.2
6.	Trial length before commencement of regular work	Approval by EE
7.	Design parameters (joint details, pattern of laying and end restraints)	As per drawing
8.	Manufacturing machine or semi mechanised method for blocks and vibrating plate compactor.	As per drawing

3.2 Tests during construction

The Quality Control Tests to be carried out during construction are indicated in Table 1503.3

1503.3 QUALITY CONTROL TESTS DURING CONSTRUCTION

Sl.No.	Type of tests	Frequency
1.	Sub grade and sub base	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.	Tolerance (Level tolerance and 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)	As above	AE / EE
3.	Performance of 30 m Trial length	For Each Work	EE
4.	General Workmanship	As above	AE / EE

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 IRC : SP : 63.

2. The minimum thickness of paving blocks shall be 60 mm for projected traffic upto 100 vehicles per day and 80 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

3. 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.

4. Ensure a trial length of 30 m is laid for demonstrating the procedure and equipment for laying the main pavement. **It will be re-laid if found deficient in any respect.**

5. Prepare the sub-grade as per sub section 1501 to the specified grades and cross-sections and uniformly compact to the design strength. Sub-grade shall have a camber of 3%.The soaked CBR of sub grade soil shall not be less than 4 %.

6. **Sub base course:** Lay a minimum 100 mm thick granular Sub base or 100 mm thick WBM grade -1 conforming to section 400.

7. Base coarse: Provide a minimum 100 mm thick granular / stabilised base course conforming to section 400. It shall extend at least 300 mm beyond the edge of restraints.

8. Lay bedding sand conforming to grading requirements indicated in **Table 1503.1** uniformly over the base course. **The bedding sand will be 25 mm (compacted) for 60 mm thick blocks and 30 mm (compacted) for 80 mm thick blocks.** 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.

9. Lay paving blocks over the sand bedding. The pattern for paving blocks shall be stretcher. The joints between stretcher bond shall be staggered by about half the length of stretcher.

10. 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 Table 1503.1 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 IRC : SP : 63.

(ii) Grading for bedding and joint filling sand for interlocking concrete block pavement shall meet the requirements indicated in Table 1503.1

(iii) surface level : The dimensions and tolerances of paving blocks shall conform to the requirements indicated in Table 1504.1.

2. The tolerance in surface levels in transverse profile shall be + 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 be 12 mm.

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 80mm	±3 mm
4	Aspect Ratio L/T	Maximum: 4.0	+0.2
5	Chamfer (Arris)	Minimum: 5mm Maximum: 7mm	±1 mm
6	Plan Area	Maximum 0.03m^2	+0.001m^2
7	Wearing Face Area	Minimum 75% of plan area	-1%
8	Squareness	NIL	±2 mm

TABLE 1504.2: CORRECTION FACTORS FOR THICKNESSAND 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

4. Quality Control Tests

4.1 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

Sl.No.	Type of tests	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 Tables 401.2 and 400.6
5.	Trail 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.

4.2 Tests during construction

The Quality Control tests to be carried out during construction are indicated in Table 1504.4

TABLE 1504.4 QUALITY CONTROL TESTS DURING CONSTRUCTION

Sl.No.	Tests / Check	Frequency
1.	Sub grade and sub base	As in table 301.5, 401.3 and 400.3
2.	Dimensions and tolerance of paving blocks	As specified. At random
3.	Paving pattern	Approval by EE before commencement of work
4.	Compaction of paving blocks	Regularly
5.	Surface regularity i) tolerance for lines, levels and grades ii) longitudinal and transverse profile	Random check
6.	Compressive strength of concrete of blocks	As specified

4.3 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	EE
3.	Water absorption and Compressive Strength (5 out of 500 blocks selected at random)	For each work	AE / EE
4.	General workmanship	For each work	AE / EE

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, sub-base, 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 handbook. 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 other sections. Hill Road Construction should be taken up after carrying out necessary geo-technical investigations since drainage, erosion and slope stability aspects assume significance in hill roads.

A. Methodology

1. Site Clearance

Carry out the site clearance to the requirements of Section 200. Ensure that reference pillars constructed by the Engineer are taken over and maintained by the Contractor.

2. Setting Out

Set out the alignment 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 of 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.

(vi) Width of roadway in hilly terrain is inclusive of parapet and hill side drains. Extra widening at curves shall be provided as per drawings. On roads subjected to snowfall, width of roadway shall be increased as shown on drawings.

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 minimise 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 should 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 be random rubble dry masonry conforming 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 as per the drawings 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 sub-section 303 and construct sub-base, base and specified surfacing in accordance with the requirements of the respective sub-sections.

7. Drainage

Carry out excavation for drains along with hillside cutting conforming to the shape, size and grades as shown on the drawings.

(i) Provide lining and guideposts along the edges as specified.

(ii) Locate catch water 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 as per details shown on the drawings. Ensure a minimum cushion of 600 mm over corbelling, conforming to Clause 1606.5.4 of MORD Specification.

(ii) Construct causeways as per drawings and conforming to the requirements of Section 1100.

(iii) Construct pipe culverts conforming to requirements of Section 1100.

9. Protective Works

Catchment protection works such as Apron, Pitching on the Slopes, Rubble Stone/ Brick Flooring/ Curtain Walls, etc should be conforming to the Drawings and Section 1300.

10. Safety Devices and 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 of explosives during rock blasting. Other precautions have been outlined in Sub-section 304.

11. Hill Slope Protection and Removal of Landslide Debris

i) Take necessary measures against soil erosion and sedimentation in conformity with the requirements of section 300 of MORD Specifications.

ii) Landslide debris should be removed immediately to clear the roadway and to keep the traffic moving.

iii) The debris should be removed by manual labour (in case of small quantity) and by machinery (bull dozer, etc) in case of large quantities. Under no circumstances, such debris should be pushed down the valley side of the slope as this will damage the vegetation and may lead to fresh slides besides increasing sedimentation problems.

12. Bio-Engineering Measures for slope Stabilisation and Protection

Bio-engineering measures involving use of living plants should be undertaken in conjunction with engineering solutions for stabilisation and protection of road side slopes. Shallow slope failures (up to 0.5 m deep) can be tackled by bio-engineering measures. Failures deeper than this and failures arising due to geological and drainage conditions would require additional engineering measures.

i) The timing of bio-engineering measures is of critical importance. Activities such as planting should be carried out within identified few favourable weeks in a timely manner so that bio-engineering measures become effective.

ii) The Contractor shall plant grass, shrubs and trees as specified in the contract in a manner as shown in the drawings or as directed by the Engineer by supplying all necessary materials, resources, man power and facilities which may be required.

iii) Slopes should be prepared for sowing / planting operations as per MORD Specifications clause 1612.2.

iv) All plantings stock shall be of species indigenous to the area unless otherwise specified. The species of grass and type of hardwood cuttings can be respectively as per Table 1600.1 and sub-section 1612.3.5.2 of MORD Specifications for Rural Roads.

v) Using appropriate tools such as tape measure and spirit level, planting lines should be marked out with a string. Spacing should be as shown in drawings.

vi) Planting of grass slips and hardwood cuttings should be taken up simultaneously. Under no circumstances should new plants be walked on or otherwise disturbed.

vii) Carry out brush layering / Palisades/ Fascines work as shown on drawings. The hardwood cuttings for brush layering are normally 30 mm in diameter and 450 to 600 mm long. The hardwood cuttings for palisades are normally 30 mm in diameter and at least 600 mm long. The hardwood cuttings for fascines are normally 30 mm in diameter and minimum 1000 mm long.

viii) Brush layering and fascine work should be started from the bottom of the area to be treated. Palisade construction work should be started from the top of the area being treated.

ix) About 2/3rd of the hardwood cuttings for brush layers are buried at an angle of 30 degrees to the slope. About 2/3rd of the hardwood cuttings for palisades are inserted directly into the soil upright. Bundles of hardwood cuttings (fascines) are buried completely in soil.

x) If the soil is dry and there is no rain within 16 to 24 hours after planting, the site should be watered carefully with a fine spray. The Contractor shall water the site for first two weeks after planting in case of inadequate rainfall.

B. Quality Control Requirements

1. Materials

(i) Stone Masonry Work: Conforming to Section 700

(ii) Sub-base and Base Course: Conforming to Section 400

(iii) Bituminous Construction: Conforming to Section 500

(iv) Cement Concrete for structure: Conforming to Section 800

(v) Pitching/Apron: Conforming to Section 1300

(vi) 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%to (-)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.

5. In case of bio-engineering works, seed selection and cutting preparation, planting and care for cuttings shall be done as per best agricultural practices. Guidance from horticulture / agriculture Department should be taken up for executing this work.

6. Regular monitoring of the work (at least once a day) by AE is required to ensure that work is being carried out as per specifications and drawings. EE may inspect the work randomly once in three or four days.

C. Do's and Don'ts

Do's	Don'ts
1. Take precautions for safe guarding the environment (Clause 110 of MORD Specifications). 2. Take appropriate measures to ensure stability of slopes during construction. Provide the necessary protective measures for safety against erosion, subsidence and recurrent slips and slides. 3. Ensure that safety measures including traffic signs, guideposts, railings, parapets, etc are provided at appropriate places. 4. Identify areas for proper disposal of debris and waste materials before commencement of the work. 5. At hairpin bends, pave the entire roadway width to avoid erosion. 6. 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. 7. Carry out the back fill behind retaining wall/breast wall only after the masonry work of wall has been approved by the Engineer. 8. 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 Sub-base or drainage layer or as per desired specifications. 9. Construct the cross drainage works like scuppers or small culverts along with the formation cutting work. Excavation for catch pit should also be done simultaneously.	1. Do not throw debris from excavation / blasting haphazardly down the hill slope. 2. Do not carry out blasting operation indiscriminately. 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. Do not stack serviceable stones over roadway so as to allow free flow of traffic. 5. Do not allow bumps or steep grades in longitudinal section of hill roads. 6. 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 walls into segments to avoid their bulging tendency. 7. Do not take up planting of cuttings until levelling, making trenches of required dimensions, etc have been carried out and surface has been well prepared. 8. Do not allow planting stock of lower quality (species which have not been specified, saplings which are too old or too young, saplings which are unfit for planting, etc) as otherwise vigorous growth of plant cover cannot be ensured. 9. Do not damage bark while making hard wood cutting. While taking hard wood cuttings for planting, do not remove more than 60 per cent of any single plant.

Do's	Don'ts
10. Do ensure that Contractor carries out bio-engineering measures strictly according to time schedule in the most favourable periods identified. 11. Do ensure that while preparing slope for bio-engineering works, no damage is done to existing vegetation, unless Engineer specifically instructs for removal of certain plants. 12. Do ensure that cuttings made for planting are well cared (wrapped using wet jute cloth) and kept in shady moist conditions. 13. Do ensure that planting of grass slips is carried out in a manner similar to millet seedlings and hardwood cuttings are planted in a way similar to planting of horticulture cuttings.	

SECTION 1700

TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES

1700: TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES

A. Methodology

1701 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 fixed over Aluminium Composite Material(ACM).The ACM sheets used for sign boards is a sandwiched construction with a thermoplastic core of "Low Density Polyethylene(LDPE) between two skins/sheets of Aluminium with overall thickness of 3 mm. For Overhead signs, overall thickness of ACM substrate shall be minimum 4 mm. The Thickness of each aluminium skin will be 0.25-0.3 mm on both sides. Refer Clause 1701.3.7 of MORD Specifications.

3. Retro Reflective sheeting shall be used for the signs in accordance with clause 1701.3.8 of MORD Specifications. The type of sheeting shall be as specified in the contract or as directed by the Engineer.

4. The messages (legends, letters, numerals etc) and borders shall either be screen printed or of cut out for the cautionary/mandatory singn boards. For informatory and other sign boards, the messages and borders shall be cut out. Cut-outs shall be either made out of retro reflective sheeting or of durable transparent overlay except those in black which shall be non reflective 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. 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.

7. 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.

8. 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.

9. The signs and supports, except the reflectorised portion and GI posts, shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. The portion of mild steel post below ground should be painted with three coats of red lead paint.

10. 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.

11. The extreme edge of the Road Sign adjacent to the road should be at a distance of at least 2.0 m from the edge of the carriageway. In no case shall any part of the Road Sign come in the way of vehicular traffic.

12. The lowest edge of Road Sign shall not be less than 2.0 m above the crown of pavement.

1702. Road Markings

1. The road markings should be in conformity with the Code of Practice for Road Markings: IRC:35:2015.

2. Painting 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.

1706. Reflective Pavement Marker(Road Studs)

1. Road Stud shall be fixed at the site for night time visibility, as specified in the contract.

2. It shall be fixed to the road surface using the adhesive and the procedure recommended by the manufacturer. The road surface shall be dry and free of dirt, grease oil etc. for achieving an effective bond.

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.

(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 226 and 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) **Aluminium Composite Material (ACM) Sheets:** The ACM sheets used for sign boards is a sandwiched construction with a thermoplastic core of "Low Density Polyethylene(LDPE)

between two skins/sheets of Aluminium with overall thickness of 3 mm. For Overhead signs ,overall thickness of ACM substrate shall be minimum 4 mm. The Thickness of each aluminium skin will be 0.25-0.3 mm on both sides. Refer Clause 1701.3.7 of MORD Specifications.

(viii) **Retro Reflective Sheeting:** The sheeting for signs shall be in accordance with clause 1701.3.8 of MORD Specifications.

(ix) Shoulder mounted ground signs with a maximum side dimension not exceeding 600 mm shall not be less than 3 mm thick with Aluminium Composite Material. Its Support shall be such that it does not bend or deformunder the prevailing wind and other loads. All overhead signs made with Aluminium Composite Material shall be minimum 4mm thick to withstand wind and other loads without deformation.

(x) In respect of sign sizes not covered by IRC:67, the structural details (thickness, etc.) shall be as per the approved drawings or as directed by the Engineer.

(xi) Both the screen printed areas and cut-out sheeting and cut-out durable transparent overlay film shall be covered under the 5-Year warranty for Class A sheeting and the 7-Year warranty for Class B sheeting issued by sheeting manufacturer.

2. Road Markings

Materials for paints for road markings shall be in conformity with the requirements laid down in the code of Practice for Road Markings IRC:35.

3. Road Studs

1. Studs shall be made of plastic body with reflectors. The reflectors should have abrasion resistance protective coating in accordance with the Code of Practice for Road Markings-IRC:35.
2. Optical Performance shall meet the requirements specified in Clause 1701.4 of MORD Specifications.
3. Road Studs shall be covered by a two year warranty for satisfactory field performance.

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. 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. 3. Ensure that profile of the head of the stud is smooth without any sharp edges.	1. Do not keep the lowest edge of Road Sign less than 2.0 m above the crown of the road 2. Do not cause inconvenience to traffic while painting operations are in progress. 3. Do not use nails to fix the marker.

SECTION 1900

MAINTENANCE

1901. GENERAL

1. The following Sub- sections cover the road maintenance works as required to be carried out under the contract or as per the maintenance plan /programme or as directed by the Engineer.

2. The maintenance of rural roads is classified into three categories:

   (i) Routine maintenance: It is carried out on regular basis to keep pavement, shoulders, drains, cross-drainage works and other road components in good condition throughout the year. These are generally small-scale works but widely dispersed and can be efficiently carried out using simple tools, equipment or manual methods.

   (ii) Periodic renewal: The periodic renewals consist of providing a bituminous surfacing/granular surfacing (on WBM/gravel surfaced road) layer over the pavement periodically at the specified interval of time so as to improve the pavement riding quality and prevent deterioration of the pavement characteristics. The requirement and implementation of renewals can also be linked to the condition of the pavement instead of being carried out at a fixed periodicity.

   (iii) Emergency maintenance works: These include unforeseen events such as landslides, washouts, damages to pavement, structures, etc. The damages require immediate attention in order to keep the road open and ensure safety of the road users.

3. The various maintenance activities are carried out on the basis of the annual maintenance plan drawn up based on condition survey of the road and structures. The road condition survey is done immediately after the recession of monsoons.

4. Routine and scheduled inspections of the road and structures by the field officers are necessary to identify the extent and type of damages and maintenance needs so as to take prompt and timely action for their repairs and maintenance.

   The Junior Engineer shall inspect the entire road length under his jurisdiction at least once every week.

   The Assistant Engineer shall inspect the entire road length under his jurisdiction at least once every month.

   The Executive Engineer shall inspect all the roads under his jurisdiction at least once every three months.

   The following documents may be referred for guidance:

   IRC: 82- Code of Practice for Maintenance of Bituminous Road Surfaces.

   IRC: SP: 35 Guidelines for Inspection and maintenance of Bridges

MORTH "Manual for Maintenance of Roads"

5. All materials used for repairs shall conform to the requirements specified for the original construction as per the relevant Sub-sections.

6. Adequate arrangements for traffic management during maintenance operations shall be made in accordance with the requirements specified in Section 100.

1902, 1903, 1908, 1915 & 1917: MAINTENANCE OF EARTHWORKS, SHOULDERS, DRAINS & BIO-ENGINEERING WORKS

The maintenance of earthwork and related items of construction in these Sub-sections include restoration of rain cuts, maintenance of shoulders, embankment slopes, drains and bio-engineering works.

A. Methodology

I. Restoration of Rain Cuts

1. Clear the areas affected by rain cuts of all loose soil and then provide benching in embankment slopes. 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. For repair of rain cuts in shoulders, trim the edges of the rain cuts vertically bringing the outline of the affected area to a rectangular shape to the extent possible and remove all loose materials and clean the area.

2. Lay fresh material, meeting the requirements of a suitable fill material (as per Sub-section 301for embankment slopes and Sub-section 407 for shoulders) in layers not exceeding 250 mm loose thickness and compact at a moisture content equal to OMC ± 2 per cent. Carryout compaction using plate compactors/rammers or by suitable implements handled manually as directed by the Engineer.

3. Ensure that the finished work conforms to the specified alignment, embankment profile, levels and slopes.

II. Maintenance of Shoulders

1. For making up of an earthen/ gravel shoulder where extra material is required to be added, loosen the existing shoulder to receive fresh soil/ gravel. Make up the deficiency in layers of loose thickness not exceeding 250 mm. After ensuring the placement moisture in the loose soil layer at OMC ± 2 per cent, compact the layer to obtain 100 per cent of maximum dry density in accordance with IS:2720 (Part 7). For compaction, any of the equipment - 80 to 100 kN smooth wheel roller, vibratory roller, hand roller, plate vibrator or hand rammer can be used, provided the specified dry density is achieved. Depending upon type of compacting equipment being used, loose layer thickness would have to be suitably modified to achieve the specified degree of compaction.

2. Where earth is required to be excavated from the shoulder, remove high spots/excess earth either using equipment like tractor towed grader or by manual means using hand tools. The resulting surface should be conforming to specified camber and have a field density of at least 100 per cent of maximum dry density as per IS:2720 (Part 7), otherwise excavate/loosen the surface to a depth of 150 mm and compact to 100 per cent of maximum dry density as per IS:2720 (Part 7), making sure that the moisture content prior to compaction is at OMC± 2 per cent. The compacted layer should be finished to the required cross fall.

3. Vegetation, bushes, heaps of soil, debris etc. shall be removed, and disposed of to an off-road dumping place. This task should be performed while patching and restoring the shoulders and along with other tasks like 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 as directed by Engineer. 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, clear slopes, side drains, catch water drains of all growth of vegetation, debris, silt, etc.

2. Carry out reshaping, re-grading and deepening of ditches/drains to the required shape, cross-section and gradient preferably by tractor-towed grader, wherever possible, otherwise by manual methods as directed by Engineer. 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 shall be removed from the site and should never be spread over the road.

3. All objects which obstruct water flow shall be removed.

4. Repair drain erosion by replacing and backfilling the lost soil. In the case of recurring problem of erosion, permanent measures like lining of drain should be considered.

5. Check for any settled or damaged lining or precast drain sections, which should be removed and restored to original specifications. In the affected portion, the underlying soil shall be compacted after addition of fresh soil where required, the levels corrected and lining or precast drain restored to original specification..

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 its rate

of spread, fertilizer types and its rate of spread and most favourable season and weather for seeding. Suitable mulch along with jute or coir or geo synthetic netting can be provided for preventing the seeds from getting washed away before the seeds sprout.

IV. Cutting of Branches of Trees

Branches of trees extending above the roadway shall be cut or trimmed to provide a clear height of 5 m above the road surface and shoulders.

V. Maintenance of Bio-Engineering Works

This work shall cover maintenance of planted bio-engineering sites as directed by the Engineer.

1. Development of vegetation through bio-engineering works require about 12 months. Hence, contract for bio-engineering works should include comprehensive maintenance of plants for 12 months after planting.
2. Weeds and unwanted plants should be cut down periodically encouraging growth of plants required under bio-engineering specifications.
3. Plants should be watered at required intervals. They should also be mulched at all times but special care must be taken during spring time when soil moisture deficit is maximum.
4. Protection of the planted area by suitable fencing should be carried out to prevent damage from people or animals and such fencing should be properly maintained.
5. Contractor should replace failed, damaged, diseased and weak plants using fresh, healthy plants of same or similar species as directed by the Engineer. Replacing and enrichment works can be carried out using different species also if they are suitable and approved by the Engineer.

B. Quality control requirements

1. Materials

All soils/gravel and other materials used for maintenance shall satisfy all quality requirements for use in embankment slopes/shoulders, and in roadside ditches/drains, as laid down in the relevant sub-sections for original construction. Jute geotextile when adopted should conform to IS 14986, Coir geotextile should conform to IS 15869 and geosynthetic nettings should conform to IRC 56.

2. Surface Finish

All maintenance works shall be carried out to the finished surface standards laid down in original drawings.

3. Camber / Cross Fall / Side Slopes / Profile

Check that the maintenance work has been carried out to the specified camber/cross-section and side slopes, levels and profile.

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. 2. The deficiency in shoulder thickness should be made up in layers, ensuring the optimum moisture for compaction and achieving the specified density. 3. The compacted layers on the shoulder should be finished to the required cross-fall. 4. Do make provisions to maintain sufficient supply of tarpaulin or other water proof cloth during placement of concrete when rain is expected. 5. While reshaping/re-grading and deepening of ditches/drains, carefully check and correct the invert level and grading. 6. Before turfing or grass-seeding, get the needed advice from the local Agriculture Department. 7. While taking up removal of weeds, ensure that weeds and unwanted plants are not pulled out by roots since this may disturb the ground surface.	1. Do not use any soil for restoring rain cuts, which does not meet the requirements for suitability as a fill material. 2. Do not allow any obstructions to remain store main on the shoulders. 3. Do not spread the excess material over the road surface while reshaping, regrading and deepening of ditches. 4. Do not attempt turfing or seeding on soil type, which will not sustain plant growth, without providing topsoil. 5. Do not use any chemical methods or resort to burning to control road side vegetation. 6. Do not take up re-plantation work (replacement of damaged, diseased or weak plants by fresh healthy plants) during unfavourable climatic conditions.

1904: MAINTENANCE OF BITUMINOUS SURFACE ROAD

It is an essential requirement prior to undertaking any maintenance measures that a pavement condition survey is carried out to identify the type and extent of the distress. It is also to be ensured that the past record of performance and maintenance carried out and traffic data are available with the Engineer. Reference may be made to IRC: 82

A. Methodology

I. Routine maintenance and remedying defects

1. Based on the field inspection, identify the type of distress and the affected area. IRC: 82 provides practical guidance for identifying type and magnitude of the distress. Most common types of defects/ distresses observed in bituminous surfacing are:

(i) **Surface defects** like fatty surfaces, smooth surfaces, streaking and hungry surfaces

(ii) **Cracks-**hair-line cracks, medium and wide 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) In the case of large areas of fatty surface having irregularities, removal of the affected layer in the area and replacing it with a layer of a properly designed bituminous 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. Care should be exercised to ensure that the bitumen is sprayed uniformly. The manufacturer's instructions should be followed while using a mechanical sprayer.

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 urgent measure, a fog seal may be used. The oxidized and hungry surface may also be treated using liquid rejuvenating agent as specified in IRC 82.

3. Cracks

The sealing of cracks shall be carried our as per the procedure given in para A-3(b) of Sub-section 501.

The fine cracks (less than 3 mm in width) shall be sealed by Fog Spray or application of liquid rejuvenating material, which is a very light application of low viscosity Slow Setting Bitumen Emulsion as given in Appendix: A.

The medium and 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 bitumen emulsion (SS-2 grade) 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 (more than 6 mm wide), shall be cut and patched as per Section 501. Cracks of different types and severity level may also be repaired using rubberized bitumen as per IRC: 82.

4. Deformations

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 patch the area with premix material after applying 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 reconstruction. 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 material, 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/subgrade and reconstruct the affected layer 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 a 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°C 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 Aggregates

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 cut-back bitumen and covered with coarse sand, or a slurry seal can be applied. Where the ravelling has progressed far, it would be necessary to provide a renewal coat with premix material.

5.4 Pot-hole

Pothole repairs and patching shall be carried out as per para A-3 of Sub-section 501.Bituminous material for filling of potholes and for patching should be either a hot-mix prepared in plant or a

cold mix as per specifications. Storable cold mixes for repairing potholes may also be used. Storable pothole patching bituminous mixes may be prepared using cutback bitumen or bitumen emulsion as per specifications laid down in IRC: 116 or IRC: SP-100.

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 portion should be laid. The shoulder should have an adequate cross slope to drain away the water. A cross 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

1. Selection Criteria

Periodic surface renewal should be carried out when the pavement surface is due for renewal for providing a new surfacing as per the specified criteria. The specified criteria may include either periodicity of renewal say 5 to 7 years depending on traffic and climatic conditions or pavement condition (assessed on the basis of pavement condition survey) at which renewal should be applied. The latter criteria is more rational and is recommended in IRC: 82 which also suggests an objective criteria in terms of road roughness and condition rating of the pavement for applying renewal treatment. It suggests a roughness of 4000 mm/km for rural roads as a guide for providing renewal treatment. The pavement surface roughness is measured by Bump Integrator as per IRC: SP: 16.

In any case, irrespective of the criteria adopted, it is to be ensured that a pavement condition survey is carried out to evaluate the pavement condition for identifying the need for surface renewal. The sections which do not have adequate residual life and require strengthening should not be considered for renewal treatment.

2. Renewal Treatment

Normally the type of surface treatment depends upon the type of the existing surface, traffic and climatic conditions. It may include Surface dressing, 20 mm thick OGPC or a superior surfacing. The type of renewal treatment shall be as specified in the Contract.

3. Prior to laying the renewal treatment, the existing surface shall be prepared as per Sub-section 501.

4. Construction operations for laying the renewal surface shall be as per the relevant specifications for the original Construction.

B. Quality Control Requirements.

1. The work shall be carried out in conformity with the relevant specifications for the type of surfacing to the required levels, grades and lines using approved materials meeting the specified requirements and exercising specified quality control tests and checks given in the relevant Sub-sections.

1905 MAINTENANCE OF CEMENT CONCRETE ROAD

It is an essential requirement prior to undertaking any maintenance measures that a pavement condition survey is carried out to identify the type and extent of the distress and the past record of performance and maintenance carried out, traffic data and construction details are available with the Engineer.

1905.1 Repair of spalled joint grooves

The joint grooves along longitudinal joints, contraction joints, construction joints and expansion joints with passage of time get spalled due to plying of traffic.

A. Methodology:

1 Examine the general condition of joints.

1. Inspect the longitudinal and transverse joints in affected panels.
2. Assess the extent of damages to the edges of joint grooves
3. Check for gaps due to embrittled / lost sealant in the groove.
4. The spalled edges will be chiseled and given the rectangular shape with sharp edges as far as possible. The spall area shall be filled with joint sealing compound if the penetration of the spall in the concrete is upto 25 mm.
5. In case the spall has penetrated more than 25 mm, it will be deepened with the chisel and swept clean.
6. If the depth of spall is upto 65 mm, it will be filled with mortar of epoxy and sand / fine aggregates in ratio of 1:4 after priming as per manufacturer's instructions (IRC:SP:83).
7. A wooden plank of shuttering ply duly oiled with shuttering oil will be inserted in the groove of the joint.

8. In case the depth is more than 65 mm, the pit will be kept moist for 4 hours, with a moist cloth, then swept clean leaving no traces of water and painted with 1:1 cement, sand and slurry on sides and bottom. The water cement ratio of the slurry will be 0.62 (IRC: SP: 83).

9. A wooden plank of appropriate width and duly oiled, mentioned as above will be inserted in the joint groove. It will be filled with concrete of 10 mm down sizes aggregates and of the same grade as that of the concrete in the main slab. It will be tamped and leveled with mason tools, such as trowel, straight edge and brushes etc (IRC: SP: 83).

10. The plank will be taken out when the epoxy / concrete has partially set. This normally takes 2 hours.

11. The traffic will be allowed on the repaired portion after 4 hours in case of epoxy repairs and 3 days in case of repairs with concrete. The joint will be refilled with the joint sealant after 4 hours in case of epoxy concrete treatment and after 7 days in case of hydraulic cement concrete treatment.

B. Quality Control

(i) Mark the line of cut in the spall with colored 'chalk' so that each repair area is rectangular.

(ii) Examine the shelf life /expiry date of sealant materials and epoxy resin.

C. Materials

The type / grade of epoxy compatible with the coefficient of thermal expansion of concrete shall be used with fine aggregates or fine stone sand to prepare a dry mix.

1905.2 Repairs of Sealant

A. Methodology

1. The old sealant shall be raked out with the help of raker. The grooves shall be thoroughly cleaned.

2. Primer will be applied with brush.

3. When the primer has become 'tacky', hot poured bitumen sealant (IS 1834) will be poured to a depth leaving 3 mm from the top.

Repair of cracks

In CC pavements usually longitudinal, transverse, diagonal and corner cracks do occur. These are to be treated in the following manner:

A-I Methodology for repair of partial depth cracks

(i) Examine the crack thoroughly by visual inspection.

(ii) Measure the width and length of crack.

(iii) Find depth of crack from coring at one or two cracks.

(iv) If the crack is upto 1.5 mm wide, 10 mm dia holes are driven to a depth slightly more than the depth of the crack, at 300 mm interval on the alignment of the crack. The low viscosity flowing epoxy resin is injected. After 10-15 minutes the holes are again topped up as earlier epoxy resin flows into the cracks (IRC: SP: 83).

(v) If the width of the crack is more than 1.5 mm then the alignment of crack is given a saw cut with a small cutter saw so as to form V shape groove all along the alignment of the crack. The V-groove is washed with jet of water. It is allowed to dry. Low viscosity epoxy resin is poured into the V groove with the help of keep. Sand passing through 2.36 mm sieve is poured on the epoxy and the same is lightly tamped. The traffic is allowed after 4 hours (IRC: SP: 83).





Epoxy sealing (Source IRC : SP : 83)

B. Quality Control requirements

(i) Examine the shelf life of epoxy resin.

(ii) Examine the blade of saw cutter and keep sufficient blades as stand by.

(iii) Examine the working of water jet and air jet.

C. Materials and tools

(i) Epoxy resin, saw cutter with 150 mm dia blade, small 'keep' for facilitating the pouring of epoxy resin in the V-groove.

(ii) Small concrete drilling machine capable of drilling 10 mm dia holes.

(iii) Crack measuring gauge.

(iv) Coarse aggregates size 10 mm down.

(v) Sand crushed / natural meeting IS: 383 Specifications.

(vi) Cement, aggregates, and water as per section 1501.

(vii) Bituminous primer and sealant as per manufacturer's Specifications. Epoxy resin as per manufacturer's Specifications.

A-II Methodology for Repair of full depth cracks:

1. If a crack has penetrated more than 50% depth of slab, then it shall be repaired / replaced as under

(i) If the two halves along the crack are not rocking, fill the crack with low grade viscosity resin.

(ii) If the two halves along the cracked panel are rocking it shall be replaced.

a) In case there are no dowel bars, the following methodology will be followed.

(i) Cut the cracked slab along the existing joints on both sides.

(ii) Remove the debris and clean the surface

(iii) Restore and re-compact the sub base.

(iv) Restore DLC in the affected area, if the same is cracked.

(v) Keep the sides of the pit moist for 4 hours and then sweep clean with dry cloth.

(vi) Paint the sides of pit with cement sand slurry 1:1.

(vii) Pour the fresh concrete of the same grade as that of original design. Compact the concrete and texture as usual.

(viii) Saw-cut the construction joints on both sides in the new concrete after 6-18 hours.

(ix) Do the curing for at-least 7 days and then keep the moist sand on the new panel for further 7 days.

(x) Widen the construction joint by saw-cutting and seal with Bitumen sealant.

(xi) Open to traffic first three days at restricted speed and then at normal speed.

b) In case there are dowel bars (pavement thickness beyond 200 mm) in the existing panels, the following methodology will be followed.

(i) Cut the cracked slab upto bottom in a one metre width so as to encompass the transverse crack.

(ii) Remove the debris and clean the surface

(iii) Restore and re-compact the sub base.

Restore DLC below, if the same is cracked.

(iv) Keep the sides of the pit moist for 4 hours and then sweep clean with dry cloth.

(v) Drill 20 mm dia holes in the side walls of pit, 250 mm deep on both faces of the pit.

(vi) Paint the sides of pit with cement sand slurry 1:1.

(vii) Install 16 mm dia tie bars in the holes and epoxy grout the tie bars. Install dowel bar assembly.

(viii) After 4 hours, pour concrete and vibrate the same.

(ix) Saw cut the new transverse joint at appropriate time.

(x) Cure for seven days.

(xi) Seal the new transverse joint with bituminous sealant after application of primer.

(xii) Open to traffic first three days at restricted speed and then at normal speed.



Full Depth Repair with Grouted Tie Bar and new dowel assembly
Source (IRC: SP: 83)

Raveling/scaling:

This happens due to use of too much water or use of unsound and dirty aggregates and inadequate curing.

A. Methodology

1 Inspect the surface carefully

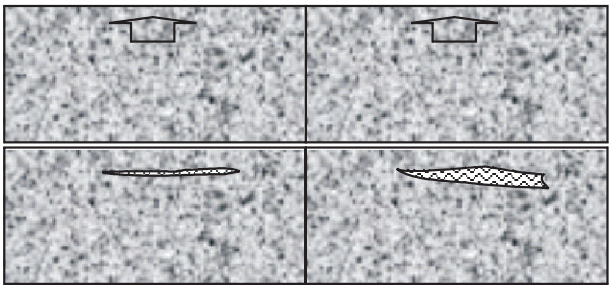
2 Remove the concrete up to 5-7 mm depth by chiseling.

3 Remove dust by air Jet.

4 Apply 5 mm thick epoxy: Sand mortar 1:4. The sand has to be 4.75 mm passing and well graded.

5 Texture with hand held long steel wire brush.

6 Open to traffic after 4 hours



Ravelling, Scaling (IRC: SP: 83)

Repair of Roller Compacted Concrete

A. Methodology

1 Cracks

(i) If the crack is less than 10 mm wide, no treatment is needed.

(ii) If it is 10 mm or more, clear and fill with bituminous concrete.

2 Blow-up in RCCP

(i) The portion blown up and beyond should be saw cut to full depth and in full pavement width and thrown away. The cut length along direction of traffic will be not less than 1.810 + 0.15 = 1.825 metre

(ii) Restore the GSB and roll to requisite density.

(iii) Pour the RCC mix level, with rakes and roll. Check the surface unevenness with 3 m straight edge.

(iv) Roll it properly, taking care that roller runs in transverse direction so that edges of old RCCP are not broken. Alternatively, it can be compacted with plate compactor.

(v) Do seven days curing.

(vi) The surface is ready to receive the PQC.

B. Quality Control requirements

1. Provisions of section 1502 will apply as this repair is actually re-construction of distressed and removed portion.

Quality control tests prior to construction and during construction and QC checks by AE / EE are same as those provided in section 1502.

2. Quality Control checks to be carried out by AE/EE for Repair works

All repair works will be got executed under direct supervision of AE.

(i)	Inspection of sealed surface	AE
(ii)	Depth of removal of sealed Concrete	AE
(iii)	Application of epoxy mortar	AE /EE
(iv)	Texture depth of repaired surface	EE

C. Dos and Don'ts

Do's	Don'ts
1 Do Check whether the two halves along the cracks are rocking or not.	1 Do not allow spilling of sealant on the surface of pavement.
2 Do Check the depth of crack by cores.	2 Do not roll the freshly laid RCC-mix in longitudinal direction.
3 Do Ensure the Air curing of sealant for 4-5 days	3 Do not delay the texturing of surface repaired with epoxy mortar / concrete.
4 Do Take the density while the RCC is still green.	4 Do not lay the RCC mix till the underneath GSB has been re-compacted.
5 Do Check the condition of sub grade below blown up RCC and repair of the same is needed.	5 Do not roll in L-direction as it will damage the vertical end of the existing RCC.
6. Do Take confirmatory course to see the homogeneity of concretec	6. Do not allow the work till all logistics are fully in place.

1906: MAINTENANCE OF GRAVEL ROAD

Maintenance of gravel roads is of crucial importance for its satisfactory performance. Even though gravel roads require frequent maintenance interventions than black topped roads, these interventions are relatively inexpensive and simple. Various maintenance operations on gravel roads can be classified into two categories (i) Routine maintenance comprising patch repairs, grading, dragging, applying dust palliatives, etc and periodic maintenance comprising of re-gravelling.

A. Methodology

Routine maintenance operations should be carried out preferably once or twice in a year (except dragging) or as directed by the Engineer.

I. Routine Maintenance Measures

1. Grading: To rectify defects like loss of shape, ruts, pot holes, corrugations, erosion gullies, etc grading is carried out using tractor towed grader. Operate the grader in such a way so that it cuts to the bottom of surface defects and loosens material for grading. After operating the grader, the surface should be compacted using 80 to 100 kN three wheeled road roller. During rolling operations, ensure that moisture content of gravel surface is at OMC± 2 per cent. Traffic intensity of more than 100 vehicles in a day may require more than 2 grading operations in a year.

2. Dragging: This operation smoothens out minor defects in the road surface and removes loose material from the surface, upto 25 to 30 mm. Dragging should be done using specially made drags (broom drag, timber drag or cutting drag) towed by a tractor. Drags should be towed at a speed of 5 to 10 km/hour and dragging operation should be carried out at frequent enough intervals as directed by the Engineer to smoothen the road surface.

3. Patching/ filling up of pot holes, depressions, erosion gullies, etc: This activity comprises of repairing all local depressions, ruts, potholes and erosion gullies by adding new gravel material of specified properties as per Sub-section 402 and then compacting the replaced/new gravel by using road roller. Before undertaking 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 OMC±2 per cent.

4. Use of dust palliatives: Dust generation is the main disadvantage of gravel roads. As per IRC SP:77, following four categories of dust palliatives seem to be suitable for Indian conditions - (i) Water (ii) Hygroscopic products (common salt, calcium chloride, etc) (iii) Organic petroleum products (bitumen emulsion, cutback, dust oils, etc) (iv) Clay additives (bentonite, montmorillonite, etc). Prior applying palliatives, surface defects should be rectified and surface compacted. The surface should be dampened except when applying cutback. Dust palliative should then be uniformly applied over the surface. After light compaction, traffic may be allowed if chlorides are used while for other products, some time may be required for the product to get absorbed before allowing traffic.

II. Periodic Maintenance - Re-gravelling

Re-gravelling should be taken up before any significant reductions in base thickness takes place. Re-gravelling may also be needed to rectify significant defects of loss of shape, pot holes, ruts, etc. Before re-gravelling, existing gravel surface should be graded, watered to bring its moisture content to OMC± 2 per cent and rolled. Fresh gravel material to achieve about 25 to 75 mm in loose thickness should then be spread using tractor towed grader and watered to bring its moisture

content to OMC± 2 per cent. The camber should be checked with a camber board at approximately 100 m or at closer intervals as directed by the Engineer. After correct camber has been achieved, rolling can be taken up to achieve specified density of compacted gravel layer as per Sub-section 402.

B. Quality Control Requirements

1. Materials

Any gravel used for routine maintenance repairs and for periodic re-gravelling should conform to the requirements as per Sub-section 402. Since worn out top layer is replaced while providing re-gravelling, re-gravelling work must be carried out using material specified for surface gravel.

2. Surface Finish

The surface finish after the routine maintenance repairs and periodic re-gravelling 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 as per Sub-section 402.

C. Do's and Don'ts

Do's	Don'ts
1. Do ensure that gravel used for repairs, whether as salvaged material or as fresh material, meets the specified requirements for use in the layer in question. 2. Do ensure that patching of large potholes and depressions is carried out and stagnant water is drained out before grading. 3. The grader operations should start from the edges of the road and work towards the center. 4. The surface of a gravel road should be improved by dragging with the use of an approved type of drag. 5. 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. 6. Normally 8 passes of roller is required for compacting gravel layer.	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. Do not use any scrapped gravel for repairs, if it does not meet the specified requirements. 3. Do not spread additional gravel for re-gravelling on the old surface without scarifying the old surface. 4. Do not start roller compaction unless the material to be compacted is at a moisture content equal to OMC ± 2 per cent. 5. Do not use manual methods for making up the loss of profile without the approval of the Engineer. 6. Dragging should not be done on roads which have deteriorated to such an extent where heavy grading or reshaping is required.

1907: 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. WBM roads are damaged due to traffic and adverse climatic conditions. In dry weather, dust is generated and during rains, mud and slush may be formed. Due to combined effect of traffic and rain water washing away the binder material from surface, stone aggregates get loosened and this may lead to ravelling and eventually to pot hole formation.

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 loss of binding material and ravelled surface.

2. Before filling up a pothole, remove all loose material from the pothole upto the firm base, cut the affected area into a 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. 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 portion of all loose material and sprinkle with water. Scarification and removal of stones shall be done to an approximate rectangular section with flat bottom and vertical sides. Fill the prepared rut portion with salvaged material, if found suitable and/or fresh suitable aggregates as may be required. Roll after addition of screenings, binding material and watering following the standard procedure as per Sub-section 405. After rolling, provide sand layer of about 6 mm thickness over the finished surface and lightly sprinkle with water.

4. Remove any damaged portions at the edges, replace by fresh material. Rolling the repaired edge and shoulder shall be carried out simultaneously and cross profile of the shoulder remedied by grading.

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 as per Sub-section 405 should be provided.

6. Fine hair cracks may sometimes be seen on the surface, which are indicative of ravelling taking place later. Loss of binder material due to traffic and rains, can lead to loosening of stones leading to ravelling. This can be remedied by blending with good binding material and sprinkling water on 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. Shoulder should be constructed simultaneously by adding additional earth / hard shoulder material as required.

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 Sub-section 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 Sub-section 405.

3. Camber / Crossfall

Camber/Cross fall 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 Sub-section 405. 2. While filling potholes, keep the surface slightly proud (about one cm higher) 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 thick layer of coarse sand should be provided and lightly sprinkled with water. 5. While undertaking surface renewal of WBM layer, the thickness requirement of WBM layer should be assessed and increased if necessary.	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 raveling 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.

1909, 1910 MAINTENANCE OF BRIDGES, CULVERTS AND CAUSEWAYS

I. Maintenance Inspection

i. Undertake regular maintenance inspection of all bridges, culverts and causeways as per the type, frequency and inspection procedure given in IRC : SP : 35 for maintenance and timely detection of distress / damages in various components of the structure and for the assessment and carrying out the required repairs.

ii. For guidance in conduct of inspection of bridges, culverts and causeways and record of observation during the inspection, reference may be made to IRC: SP:52 Bridge Inspector's Reference Manual.

a. Routine inspection of bridges, culverts and causeways

1. Carry out routine inspection of bridges, culverts and causeways at least once a year, but preferably twice a year before and after monsoon. For bridges located in hilly areas prone to landslides and bridges in severe exposure condition, routine inspection shall be carried out twice a year before and after monsoon.

2. Use inspection proforma vide Appendix 4 and conventional standard tools listed in Appendix 6 as given in IRC: SP: 35for conducting routine inspection.

3. Officers at the level of Assistant Engineers shall be responsible for routine inspection of minor bridges (overall length less than 60m), culverts and causeways. Routine inspection of major bridges (overall length more than 60m shall be the responsibility of the officer of the rank of Executive Engineer and above. A calendar of inspection of bridges, culverts and causeways under his jurisdiction shall be prepared by the officer responsible for inspection.

b. Principal Inspection of Bridges

1. Carryout principal inspection of bridges with the help of close visual assessment supplemented by instrumented aid for the close examination of elements of the structure. Include detailed inspection of the foundation and wherever appropriate under water inspection of the foundation.

2. Principal inspection shall be carried out by a senior level engineer of the rank of Executive Engineer and above against comprehensive check list of items related to the material, condition and situation of the structure as given in Appendix 5 of IRC:SP:35.

3. Conduct first principal inspection before the expiry of contract defect liability period but not later than 6 months after completion and opening of the bridge to traffic. This inspection shall be followed by subsequent principal inspections at a maximum interval of 3 years. In case routine inspection reveals any distress in the bridge structure, more frequent inspection shall be essential.

A calendar also for principal inspection of bridges shall be prepared by each officer responsible for such inspections.

c. Special Inspection of Bridges

1. Carry out special inspection of bridges after the occurrences such as strong earthquake, accidents, passage of unusual loads or floods, unusual settlement of foundation, substantial change of traffic pattern and major weaknesses noticed during routine or principal inspection.

2. When bridge of similar design and constructed almost at the same time show some distresses, subject such bridges to special inspections.

3. As special inspection requires lots of supplementary testing and structural analysis, deep involvement of design organization and experts in the relevant fields, who are senior level engineers, is necessary. Conduct special inspection taking guidance from possible instrument aided assessment methods listed in Appendix 7, use of standard tools listed in Appendix 6 and guidelines on field tests including tests of non-destructive and destructive type as given in Appendix 8 of IRC:SP:35.

II. Maintenance

1909.1 MAINTENANCE OF BRIDGES

A. Methodology

1. Approaches

Check the approaches in the vicinity of the bridge for unevenness, settlement if any, cracking of the pavement, camber, longitudinal gradient, proper functioning of the drainage facility, damage to guard rails, condition of approach slabs, erosion or damages to the embankment, settlement or disturbance of the slopes, etc. The approach slabs shall also be examined for any untoward cracking, movement away from the dirt wall and to see that no portion rests on the wing walls/cantilever returns.

2. Protective works

Examine the protective works like guide bunds, spurs, pitching around abutment, etc, during the floods to ascertain the HFL, scour depth, launching of apron, etc. and after floods to examine the condition of existing slopes and slope pitching and adequacy of the apron.

Look for aspects like launching of the apron, settling of the slope, piping action, improper drainage of the rain water causing the slope to be disturbed, impact of waves carrying away the smaller particles and thus disturbing the slope, any undue scour at the nose of the bund and/or at the toe of the pitching. Check the protection both during and after the floods to ascertain the extent of scour, cracking and damage of the floor if any, adequacy of the cut off walls and apron, etc.

3. Waterway

Check presence of obstruction, island formation, vegetation under growth etc. check any abnormal change inflow pattern, Look for signs of abnormal afflux, erosion of bank and check adequacy of water way.

4. Foundation

Check settlement, abnormal scour, tilting etc. observe general condition of the foundation to ascertain aspects like cracking, disintegration, decay, erosion , cavitations and damage due to impact of floating bodies, boulders etc.

5. Substructure (pier, abutments and wing/ return walls)

Check PCC or RCC pier abutments and wing/ return walls for damages due to impact, cracks, spalling or disintegration of concrete particularly at construction joints and at top where the super structure rests. Examine masonry piers, abutments and wing/ return walls for cracks due to settlement of foundation, the condition of pointing or plastering, condition of stones/ bricks, any possible bulging or movements etc. and the face of dirt wall of the abutments for any tilting, requisite expansion gap for movement etc. Look for presence of any moisture on the exposed faces of the abutments to ascertain proper function of weep holes and filter media forming the back fill.

6. Bearings

6.1 Metallic Bearings

Ascertain general condition like cleanliness, rusting of plates etc. Examine proper functioning of the bearings by observing excessive movement if any, unusual tilting of rollers, rollers jumping of the guides and condition of grease/ oil, when last greased and whether it needs to be replaced or not, check for any structural cracks in the supporting members like abutment/ pier cap, pedestal etc and effectiveness of anchor bolts whether in position and not loose.

6.2 Elastomeric Bearings

Check physical condition of the pads like oxidation, creep, flattering, bulging, splitting and displacement etc, observe general cleanliness of the bearings and their surroundings.

6.3 Concrete Bearings

Check any signs of distress like cracking, spalling, disintegration, staining, dishing etc and any excessive shifting, loss of shape and cracks if any in abutment/ pier cap or pedestal. Observe general cleanliness condition of the bearings.

In case of submersible bridges examine the condition of downstream stoppers.

7. Superstructure

7.1 Reinforced Concrete Members

Examine concrete decks for cracked, spalled, disintegrated honey combed, leached or stained areas and other signs of deterioration specially over the bearings. Observe for presence of significant cracks in the articulation of Girder Bridge, webs of girder, bottom of soffit slab of box girder structure and outside faces of girders etc, check signs of deterioration in the exposed reinforcement, especially in areas where deck is affected by saline water and sea breeze. Check accumulation of silt and debris on surface of deck or inside box girders in case of submersible bridges.

7.2 Prestressed Concrete Members

Check for loss of camber, excessive deflection, distress due to buckling, cracking and deterioration of concrete, cracking or spalling in the area around the bearings and at cast in place diaphragm, corrosion of reinforcement, sheathing and tendons, if visible. Examine area around anchorages for cracks, water tightness and corrosion of prestressing steel and excessive vibrations, if any,

Check accumulation of silt and debris on surface of deck or inside box girders in case of submersible bridges.

7.3 Structural Steel Members

Examine structural steel members like trusses, girders, stringers, railing etc for corrosion, cracking, condition and loosening of bolts, rivets, welds in connections. Check flanges and webs of all section for damage, misalignment, web stiffness for buckling and all components of truss members in respect of alignment and any kinks and bow in the members. Observe condition of paint to ascertain the extent of corrosion and excessive vibrations, if any.

7.4 Masonry Arches

Check the condition of masonry arch ring presence of cracks, mortar joints, pointing, plaster etc, flattening of arch profile, drainage of spandrel fill (bulging of spandrel wall), separation from arch ring and vegetation growth.

7.5 Timber Components

Examine all timber components for decay, rot, splits, evidence of failure etc, splice points for soundness in shear connection, condition and tightness of bolt. Check components submerged under water for decay and flooring in timber and steel bridges for loose and rotten members

8. Expansion Joint

Check proper functioning of the joint, adequacy of the expansion gap, cracks in wearing coat, condition of sealing material-splitting, oxidation, creep, flattering, bulging for neoprene seal

material and hardening, cracking for bituminous filler. Examine for secureness of joints, condition of top sliding plate and whether corroded or not, locking of joints specially finger type expansion joints, debris in open joints resulting in reduction in expansion gap and rattling of joints, if any.

9. Wearing Coat (Concrete/Bitumen)

Check cracks, spalling of concrete, disintegration, potholes to ascertain surface condition, examine riding quality with respect to slipperiness, bumps, unevenness etc and evidence of wear or additional thickness against the design thickness.

10. Drainage Spouts and Vent Holes

Check clogging, deterioration, damage, projection of drainage spouts on the underside affecting structural members.

Examine functioning of vent holes for submersible bridges.

11. Hand Rails/ Parapets/ Crash Barriers

Check expansion gaps, alignment, any missing part, damage due to collision and cracks, spalling, scaling and deterioration in the concrete of RCC hand rails/ crash barriers,.

Remove collapsible hand rails before floods in case of submersible bridge.

12. Footpaths

Check for concrete foot paths sidewalks for cracks, spalling, scalling or pot holes, any missing or damaged precast footpath slabs and cleanliness of ducts along foot paths.

13. Utilities

Check leakage of water/ sewage pipes, damage due to telephone and electric cables, condition of lighting facilities and damage due to any other utilities.

B. Quality Control Requirements

B-1 Maintenance/Repair Activity

1. Clean the carriageway, footpath, joints, gulleys, gutters etc of dust, litter by mechanical means or hands.
2. Remove silts, sand and debris on surface of the deck and silt and debris from inside the box girders of submersible bridges.
3. Clear the vent holes in the superstructure and drainage spouts of any clogging.
4. Remove foreign material such as trash or vegetation growth on any part of the structure without causing damage to that part of the structure.

5. Undertake repairs for damages caused due to cracking, spalling and erosion of flooring, apron, pitching and curtain walls etc.

6. Carryout repairs of masonry arches for cracking, loose joints, separation of arch ring and spandrel wall and removal of vegetation.

7. Carry out small restoration, re-pointing of stone/ brick masonry, replacement of missing stone/ bricks, sealing.

8. Repair cracked approach slab or replace settled or broken approach slab.

9. Undertake localized repairs to concrete/ bituminous wearing coat and water proofing, bituminous fillers in the expansion joints.

10. Repair, remove and replace damaged hand rails / parapets/crash barriers.

11. Carry out localized painting operations for protection of steel members from corrosion and protective treatment such as lubrication and greasing operation on timber.

12. Undertake sealing of cracks in brick, stone, reinforced or pre stressed concrete structure by injection of cement grout or epoxy resin into cracks.

13. Repair the damaged, spalled, honey combed concrete by the use of cement mortar (gunite/shotcrete), sound water tight concrete, epoxy mortar/polymer mortar.

14. Carryout maintenance of expansion joints by periodic cleaning and removal of debris. Repair the expansion joint by replacing damaged sealant filler, sealing element and cracked concrete in the zone of anchoring the joint or replace the damaged expansion joints depending on their types.

15. Undertake maintenance of bearing such as cleaning, graphiting, painting etc (metallic bearing) and repair of unusual tilt or excessive shift of the bearing elements or replacement of cracked/ deformed elastomeric bearings by raising the deck of the bridge.

B-2 Materials

1. Carry out repairs on cement based components / parts with cement mortar / cement concrete except required otherwise.

2. Adopt brick or stone masonry for repair of components made of same materials unless necessary otherwise.

3. Use materials conforming to the requirements of section 2000 for the repairs of component /structure.

4. Epoxy resin for use in epoxy grout and epoxy mortar and polymer to be used in polymer mortar shall be procured from the reputed manufacturers only.

5. Materials not covered in Section 2000 shall conform to specifications of the manufacturer and shall be tested for conformance to these specifications in an independent laboratory.

1909.2 MAINTENANCE OF CULVERTS

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 asses 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, abutment, wing/return walls, springing of arches, headwalls, cut off walls for any damage 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 of foundation and tilt of abutment, wing/return walls.
6. Check for condition of inlets, outlets and catch pits of pipe culverts/arches/boxes from inside and on outer face for growth of vegetation, erosion and chocking of culverts.
7. For concrete members, examine for signs of distress such as, cracking, spalling, exposure/corrosion of embedded steel.
8. Examine structural steel members like stringers, railings etc. for corrosion cracking, condition and loosening of bolts, rivets or welds in connection, etc.
9. Check timber components for decay, rot, splits and evidence of failure etc.
10. Examine parapets, railings, guard posts, guard stones for safety of pedestrians and animals.

B. Quality Control Requirements

B-1 Maintenance/Repair Activity

1. Clear and clean debris of sand and silt from culvert opening and catch water pit including growth of vegetation without causing damage to any part of the structure. Remove and dump waste material so obtained far away from the channel.
2. Carryout repairs for damages caused due to cracking, spalling and erosion to flooring, apron, pitching and curtain walls.
3. Undertake small restoration, re-pointing of stone / brick masonry replacement of missing stones/bricks, plastering of brick work, sealing of cracks etc in the masonry/concrete.

4. Carryout repairs of masonry arches for cracking, loose joints, separation of arch ring and spandrel wall and removal of vegetation growth.
5. Carryout localized painting for protection of steel members from corrosion and protective treatment such as lubrication and greasing for timber.

B-2 Materials

1. Carry out repairs on cement based components / parts with cement mortar.
2. Use cement slurry for sealing of cracks and where necessary and specified, inject epoxy grout under pressure following manufacturer's specification.
3. Carryout repairs to approaches and banks periodically with local soil.
4. Use brick or stone masonry for repair of components made of the same material.
5. Use materials which are in conformity with Section 2000 for the repairs. For materials not covered in section 2000, follow manufacturer's specification for execution of work and testing to check conformance to specifications.

1909.3 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 cause 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 face walls and head walls for loosening of material.
5. Check the condition of guideposts / guard stones / 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 gauges of causeways and submersible bridges before onset of monsoon.

B. Quality Control Requirements

B-1 Maintenance/Repair Activity

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.

B-2 Materials

1. Carryout repairs to concrete components or cement plaster with the same material.
2. Use stones / bricks for replacement of parts or to repair local damage to masonry.
3. Use local soil if suitable, for repairs to embankments approaches etc.
4. Conform all materials to Section 2000.

B. Do's and Don'ts

Do's	Don'ts
1. Carry out routine inspection of all bridges, culverts and causeways atleast once a year preferably twice before and after monsoon. 2. Undertake principal inspection of bridges at a maximum interval of 3 years or earlier if required, based on the results of routine inspection. 3. Prepare a calendar of inspection of bridges, culverts and causeways and follow the same for timely and regular inspection. 4. Undertake maintenance activities like cleaning and clearing the deck of silt sand, trash, debris removal of vegetation growth, cleaning and de-clogging drainage spouts, vent holes regularly. 5. Carry out dismantling and removal of any component/structure using appropriate tools and equipment. 6. In removing parts/of components like kerbs, railings, parapets, crash barriers, catch basin, inlets etc where portions of existing construction are to be retained, remove the same to an existing joint or cut and chip to a true line with face perpendicular to the surface of the existing surface ensure sufficient removal to provide for proper grades and connection with the new work. 7. Dismantle the existing wearing coat before laying fresh wearing coat on the bridge decks. 8. Engage only specialized agencies having expertise and previous experience of such works for repair works involving injection of cement grout/epoxy resins, guniting shotcreting ,use of epoxy/polymer mortars, repair or replacement of proprietary type of expansion joints and rectification of defects/replacement of bearings by lifting of deck of the bridge etc.	1. Do not dump the debris, silt sand, vegetation etc and any surplus material after removal, in the vicinity of water channel. 2. Do not cause any damage to any part of structure while clearing and cleaning it of the debris, silt sand and vegetation. 3. Do not disturb or damage any adjacent component/ structure, pavement or any other work to be left in place during dismantling or removal of any part of the structure. 4. Do not provide overlay on existing wearing coat on the bridge decks. 5. Do not cause damage to the existing structure including concrete, reinforcement, prestressing anchorages for cables if any, located in the deck slab when dismantling the wearing coat.

1911: 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 along with 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 along with 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 signs.

B. Quality Control Requirements

1. Materials

The material for repair/fabrication of signs shall conform to subsection IRC: 67

1912, 1913 & 1914 MAINTENANCE OF MARKINGS & APPURTENANCES

A. Methodology

1. All road markings shall be maintained so as to be clearly visible to the driver. A 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 the Code of Practice for Road Markings: IRC: 35.

3. Repainting and lettering on kilometre and 200-m stones shall be as per guidelines indicated in IRC:8 and 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.

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.

SECTION 2000

MATERIALS FOR STRUCTURES

2000 MATERIALS FOR STRUCTURES

A. Methodology:

1. Approve sources proposed by the contractor for procurement of materials prior to delivery.
2. Allow materials from approved sources only to be brought at site.
3. For manufactured items like cement, concrete admixtures, Steel reinforcement, prestressing strands and cement concrete pipes obtain the details of the source, testing facilities available with the manufactures and arrangement for transport and storage at site from the contractor.
4. Carry out tests on samples of materials from the sources for conformity to specifications. Ensure that the variation in test results of different samples is within acceptable limits.
5. Ask the contractor to identify new sources of acceptable materials in case the materials from the approved sources prove to be unacceptable at any time.
6. Store all materials at proper places to prevent their deterioration, intrusion of foreign matter and ensure their satisfactory quality and fitness for the work. Also ensure that the storage space permits easy inspection, removal and re-storage of the materials. Subject all such materials to acceptance test prior to immediate use even though stored in approved godowns /places.

B. Quality Control Requirements:

1. Materials:

i. Bricks:

Use first class bricks of any of the following two types in masonry works. The physical requirements of bricks are given in Table 2000.1.

TABLE 2000.1: PHYSICAL REQUIREMENTS OF BRICKS

Item	IS Code/Requirements
Burnt Clay bricks	IS:1077, IS:3495
Clay Flyash bricks	IS:13757, IS:3495
Flyash	Grade 1 or 2 IS:3812 Part I & Part II
Minimum compressive strength Burnt Clay bricks	8.4MPa for individual bricks and mean strength not less than 10.5MPa for a group of 5 specimens.
Clay Flyash bricks	Value specified on drawing or 7MPa whichever is higher.
Water Absorption	Not more than 20% by weight up to class 12.5 and 15% by weight for higher class (IS:1077 and IS:3495 Part -2)
Efflorescence	Moderate up to 50 % of exposed area of brick covered with a thin deposit of salt but unaccompanied by powdering on flaking of surface (IS:3495 Part 3)
Preferred Size	190 mm x 90 m x 90 m or 230 mm x 110 mm x 70 m

ii. Stones and Blocks:

a. Stones

Use stones which are hard, sound, free from cracks, decay and weathering. Do not use stones with round surface. The specifications and requirements of stones shall satisfy those given in Table 2000.2.

TABLE 2000.2: REQUIREMENTS OF STONES

Item	Requirement
Least Dimension (IS:1597 Part 1)	150 mm
Water Absorption (IS:1124)	Not more than 5 percent of its weight

b. Blocks

Use only normal weight solid concrete blocks made of cement and suitable aggregate conforming to requirements given in Table 2000.3 for bridge works.

TABLE 2000.3:- REQUIREMENTS OF BLOCKS

Item	Requirement
Concrete Block	IS:2185 Part 1
Minimum Compressive Strength IS:2185 Part 1	10.50 MPa
Minimum Dimension Thickness and width	200 mm
Minimum Density	2.20 Tonne/cum

iii. Cast Iron:

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

iv. Cement and Lime:

a. Cement of any of the following types shall be used meeting the physical requirements given in Table 2000.4.

TABLE 2000.4: CEMENT AND LIME

Type	Grade	IS code
Ordinary Portland cement	33	IS: 269
Ordinary Portland cement	43	IS: 269
Ordinary Portland cement	53	IS: 269

Type	Grade	IS code
Sulphate resisting Portland cement *	-	IS: 12330
Portland Pozzolana cement	Flyash based	IS:1489 (Part 1)
Portland slag cement	-	IS: 455
Rapid Hardening Portland cement #	-	IS: 8041
Low heat Portland cement	-	IS: 12600
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.*

 # Use only in precast concrete products with approval of the Engineer.

Carryout independent tests of samples drawn from the consignment at the site laboratory on in an independent laboratory approved by the Engineer immediately after delivery as given in Table 2000.5.

TABLE 2000.5: TESTS ON DELIVERY OF CEMENT

Property	Permissible Value			Tested as per
Setting Time *	Initial set > 30 minutes Final set<600 minutes			IS: 269 IS: 4031 (Part-5)
Compressive Strength	33 Grade	43 Grade	53 Grade	IS: 269
at 03 days	16 MPa	23 MPa	30 MPa	IS: 4031 (Part 6)
at 07 days	22 MPa	33 MPa	43 MPa	
at 14 days	33 MPa min	43 MPa min	53 MPa	
	48 MPa	58 MPa		

** 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.*

b. Lime

Use lime conforming to physical requirements given in Table 2000.4.

v. Concrete Admixtures:

a. Mineral Admixtures:

Mineral admixtures shall satisfy the requirement given in Table 2000.6.

TABLE 2000.6: REQUIREMENTS OF MINERAL ADMIXTURES

Type	Requirement
Flyash	IS:3812 (Part I & II)
Granulated slag	IS: 12089
Silica fume	IS: 15388

b. Chemical Admixture:

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

Chemical admixtures shall conform to requirements given in Table 2000.7.

TABLE 2000.7: REQUIREMENTS OF CHEMICAL ADMIXTURES

Item	IS Code/Requirement
Information required from the manufacturer.	Clause 2007.3.1 of MORD Specifications.
Physical and chemical requirement.	a. IS:9103
	b. Conformance to clause 2007.3.2 of MORD Specifications.
	c. All tests to be conducted periodically at an independent laboratory and results compared with the data given by the manufacturer.

vi. Fine Aggregates:

Natural sand, crushed stone sand or crushed gravel sand or a combination thereof shall be dense, durable, clean and free from deleterious substances and shall conform to the requirements given in Table 2000.8.

TABLE 2000.8:- FINE AGGREGATES

Material	IS Code
Sand (For masonry work)	IS:2116
Natural/Crushed stone/Crushed gravel Sand(for structural concrete work)	IS:383

Fine aggregates to be used in structural concrete shall conform to grading requirements given in Table 2000.9.

TABLE 2000.9: GRADING REQUIREMENTS OF FINE AGGREGATES

	Percent by weight passing the sieve for nominal size of		
IS Sieve Size	Zone 1	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

vii. Coarse Aggregates:

Corse aggregates for concrete shall consist of clean hard, strong dense, nonporous and durable pieces of crushed stone, crushed gravel or suitable combination thereof.

All coarse aggregates shall conform to IS: 383 and maximum nominal size of coarse aggregates for various structural components in plain and reinforced cement concrete (PCC and RCC) and prestressed concrete (PSC) shall conform to Table 2000.10.

TABLE 2000.10: GRADING REQUIREMENTS OF COARSE AGGREGATES

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

viii. Water:

a. Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts, sugar, organic materials or other substance that may be deleterious to concrete or steel The pH value of water shall not be less than 6. Potable water is generally considered satisfactory for mixing and curing.

b. Average 28 days compressive strength of at least three 150 mm cubes prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with the distilled water.

c. Samples of water for making mortar or concrete are tested for approval of source of supply once and subsequently in case of doubt.

d. The permissible limits for solids in water have to be tested in an approved laboratory as directed by Engineer as given in Table 2000.11.

TABLE 2000.11: LIMITS FOR SOLIDS IN WATER

Type of Solids	Tested As per	Maximum permissible limit
Organic	IS: 3025 (Part 18)	200 mg/litre
Inorganic	IS: 3025 (Part 18)	3000 mg/litre
Sulphates (as SO3)	IS: 3025 (Part 28)	400mg/litre
Chlorides (as Cl)	IS: 3025 (Part 32)	2000 mg/litre (For Plain Concrete)
		500mg/litre (For Reinforced/Pre-stressed Concrete)
Suspended matter	IS: 3025 (Part 17)	2000 mg/litre

ix. Cast Steel:

Use of cast steel shall be restricted to bearings and other similar parts. Steel for casting shall meet the requirements given in Table 2000.12.

TABLE 2000.12: REQUIREMENTS OF CAST STEEL

Material	Grade	IS Code
Steel for casting	280-520N	IS Code: 1030
Steel for casting	280-520W	IS Code: 1030
(In case subsequent welding in the relevant cast steel components is unavoidable)		

x. Steel for Prestressing:

a. The prestressing steel shall conform to any of the standards given in the Table 2000.13.

TABLE 2000.13: REQUIREMENTS OF PRESTRESSING STEEL

Prestressing Steel	IS code
Plain hard drawn steel wire	IS: 1785 (Part I) and IS:1785 (Part II)
Cold drawn indented wire	IS: 6003
High tensile steel bar	IS: 2090
Uncoated stress relieved strands	IS: 6006
Uncoated stress relieved low relaxation seven ply strand for prestressed concrete	IS: 14268

b. Obtain data in respect of modulus of elasticity, relaxation loss at 1000 hrs, minimum ultimate tensile strength, stress strain curve etc from the manufacturer. Subject the prestressing steel to acceptance test as per relevant IS code for the type of prestressing steel, prior to actual use in the works.

xi. Reinforcement /Untensioned Steel:

a. Reinforcement/Untensioned steel shall consist of grades of reinforcing bars indicated in the Table 2000.14.

TABLE 2000.14: GRADES OF REINFORCING BARS

Grade Designation	Bar Type conforming to Governing IS Specifications	Characteristic Strength fy MPa	Elastic Modulus GPa
Fe 240	IS: 432 Part I Mild steel	240	200
Fe415	IS: 1786 High Strength Deformed Steel bars	415	200
Fe 500 or Fe 500D	IS: 1786 High Strength Deformed Steel bars	500	200
Fe 550 or Fe 550D	IS: 1786 High Strength Deformed Steel bars	550	200

Wire fabrics conforming to IS:1566 can be used as reinforcing steel.
Where specified, Fusion Bonded Epoxy coated reinforcement conforming to IS:13620 shall be used.
Hot dipped galvanized reinforcing steel with coating conforming to IS 12594-1988 shall be used, where specified.

b. All reinforcement steel shall be procured from original producers manufacturing billets directly and rolling the billets to make the steel conforming to IS: 1786 requirements. No rerolled steel shall be incorporated in the works.

c. In case of any doubt regarding quality of the steel supplied by the original producer, get the material tested in NABL accredited laboratories as a third party check to conform the test results shown in the certificates.

xii. Structural Steel

All structural steel, before fabrication, shall satisfy the requirements of respective Indian standards as mentioned against each structural steel type in Table 2000.15.

TABLE 2000.15 REQUIREMENTS OF STRUCTURAL STEEL

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

xiii. Timber:

For structural purposes, timber conforming to IS: 883 shall only be used.

xiv. Reinforced and Prestressed Concrete Pipes:

Reinforced concrete pipes and pre-stressed concrete pipes used for highway structures shall conform to requirements given in Table 2000:16.

TABLE 2000.16: REQUIREMENTS OF REINFORCED AND PRE-STRESSED CONCRETE PIPES

Pipe	Type	IS Code
Reinforced Concrete Pipe	NP3, NP4	IS: 458
Prestressed Concrete Pipe	NP4	IS: 784

2. Storage of Materials:

The stacking and storage of materials such as bricks, fine aggregates, coarse aggregates, cement, lime and reinforcing steel at site shall be as per IS: 4082. The safety precautions during handling and storage shall be as per IS: 7969.

2.1. Bricks:

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.

2.2. Aggregates:

Stack fine and coarse aggregates in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. Make stock piles of the aggregates on the ground that is hard, full drained and free from vegetation. Store different sizes of coarse aggregates in separate stock piles sufficiently away from each other to prevent intermixing. In case of aggregates directly placed on the ground, do not remove them from stock pile within 300 mm of the ground. Use the bottom 300 mm of stock pile only after thorough cleaning of the material.

Stack Fine aggregates in a place where loss due to the effect of wind is minimum.

2.3. Cement:

Store cement above ground level in perfectly dry and water tight sheds and stack to a height of not more than eight bags. Stake the cement bags off the floor on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor. The floor may comprise of lean cement concrete or two layers of dry bricks laid on well consolidated earth. Leave a space of 600 mm minimum all-round between the exterior walls and the stacks. Store each consignment separately to facilitate

easy identification, inspection. Use the cement in the sequence in which it is delivered at site. In case of use of bulk storage containers, clean the containers at least once in three months.

2.4. Lime:

Store lime in weather proof sheds. Store hydrated lime in the same manner as cement and the period of storage should not exceed one month.

2.5. Reinforcement/Untensioned Steel:

Steel reinforcement shall ordinarily be stored in such a way as to avoid deterioration and corrosion. Store the reinforcement bars about 300-450 mm above the surface of the ground upon platforms, skids or other supports and protect the steel from mechanical injury and from deterioration from exposure. Keep fusion bonded epoxy coated steel wrapped in opaque polythene sheets to avoid exposure to sun rays or rains.

2.6. Prestressing Materials:

Store all prestressing steel in a closed store having single door with double locking arrangements and no windows. Keep the air dry inside the store as far as possible with various means. Install the air humidity measuring instrument inside the store. Place all prestressing steel at least 300 mm above ground level wrapped with a protective covering of tar paper or polythene.

Store sheathing, anchorages and sleeves or couplers under cover from rain and damp ground and protect from the ambient atmosphere that is likely to be aggressive.

2.7. Water:

Use containers/tanks covered at top for the storage of water and clean them at regular intervals to prevent intrusion of foreign matter or growth of organic matter. Enclose the intake pipe suitably and ensure a minimum depth of 0.60 m of water below the intake at all times.

3. Quality Control Test prior to construction and quality control checks by AE/EE.:

Quality control tests to be conducted prior to construction on various materials and quality control checks by AE/EE wherever required are given in the relevant sections related to the use of particular materials for bridges and cross drainage structures.

C. Do's and Don'ts:

Do's	Don'ts
1. Use bricks of rectangular faces with sharp corners. 2. Immediately after delivery of cement consignment, carry out independent test on samples drawn from the consignment at the site laboratory or an approved independent laboratory for compressive strength and setting time of cement. 3. Use cement of the same grade and same source for a single work. 4. Use lime undamaged by rain moisture or air slacking. 5. Store different size of coarse aggregate in separate stockpiles and sufficiently away from each other. 6. Procure prestressing steel and accessories like jacks, anchorages, wedges, block plates etc. only from authorized manufacturers. 7. Subject prestressing steel to acceptance test prior to actual use in works. 8. Procure reinforcement steel only from original producers. 9. Use new steel for works.	1. Do not use stones with round shape. 2. Do not use hollow light weight concrete blocks. 3. Do not mix different types of cement together. 4. Do not substitute 33 grade cement with 43 grade or 53 grade. 5. Do not use in the works any cement consignment or part of a cement consignment which has deteriorated in any way during storage. 6. Do not use sand containing lumps, soft or flak particles, mica or other harmful particles. 7. Do not use aggregates having positive Alkali-silica Reaction. 8. Do not use chemical admixture which is not compatible to the type of cement and detrimental for the reinforcement or the concrete. 9. Do not use sea water for mixing or curing purposes. 10. Do not use scaled or re-rolled steel in works.

SECTION 2100

ENVIRONMENT AND SOCIAL SAFEGUARDS

2100. ENVIRONMENT AND SOCIAL SAFEGUARDS

A. Methodology

1. The Contractor shall take all precautions for safeguarding the environment during preconstruction and construction of the works, He shall abide by all laws, rules and regulations in force governing pollution and environment or wild life protection that are applicable in the areas where the works are situated.

2. The Contractor shall prepare an Environment Management Plan for the project duly taking into consideration the NRRDA Environment Codes of Practice(ECOP). Refer Section 2100 of the MORD Specifications.

3. The Contractor and his Sub-Contractor(s) shall comply with ECOP-14.0 for ensuring health and safety of workers and the public affected by the project. He shall bring awareness among the workers to undertake health and safety precautions.

4. The Contractor and his Sub-contractor(s) shall take all reasonable steps to abide by the social safeguards as per PMGSY guidelines relating to Environment and Social Management Framework for the project affected persons of nearby habitations/villages.

5. After completion of the works, the contractor should remove all his equipment, machinery, surplus building materials, labour camp, debris etc from the site.

CHAPTER 4
QUALITY MONITORING

1. General

1.1. As part of an overall Quality Management System, for rural roads 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, and that the PIUs are performing their basic function required under the first tier of quality management.

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 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 functioning effectively.

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 in the implementation of works 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(NQMs).

3. Field Inspections by State Quality Monitors

3.1 The State Quality Coordinator is required to ensure that each work is inspected by the SQM at least at three stages:

3.1.1 In case of roads, the three stages may be as under:

Stage I: When earthwork in cutting/embankment is in progress

Stage II: When pavement work in base course is in progress

Stage III: When work is nearing completion i.e. when surfacing work is in progress

3.1.2 In case of bridges of more than 15 m in length, the three stages may be as under:

Stage I: When work of foundation/ substructure is in progress

Stage II: When work of superstructure is in progress

Stage III: When work is just completed including approaches, protection work and wearing coat, but before opening to traffic

The formats for inspection reporting and grading of road works and bridge works are given in Appendix-5.

3.2 The State Quality Monitors are also required to inspect the field laboratory, comment on the lab equipment and deployment of laboratory technicians and functioning of the lab and verify whether the quality control registers are maintained by the contractors and supervised by the PIU and make a specific report on this. The SQC may direct any particular SQM to have a look at the district and central level laboratory for advice on improvements, if any.

4 Field Inspections by National Quality Monitors

4.1 The National Quality Monitors shall undertake field inspections as per the extant guidelines of the NRRDA and displayed on the PMGSY website. Presently, NQMs are assigned monthly schedules by NRRDA wherein they are required to inspect PMGSY roads in specified two districts of the State, during the visit. The NQM in consultation with concerned SQC/PIU is required to finalize suitable programme to spend not more than 5 days in each district inspecting normally between 2-3 works on each day and one old road work of PMGSY completed at least 1 year back to assess the maintenance in each district (2 works in progress or 1 work in progress and 1 completed work or 2 completed works but in both cases 1 work of earlier phases completed at least 1 year back to be inspected to assess the routine maintenance). The inspection of 2-4 road works is suggested with the view that normally, a PMGSY road would not be longer than 3 km.

The formats for inspection and reporting are given in Appendices 6, 7 and 8.

5. Checking of a completed section (before commencement of DLP)

5.1. For purposes of Quality Monitoring, only random checks are envisaged where a completed section

is to be checked before commencement of the DLP, 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 at least 9 m length and the transverse profile at two or three locations at each 100 m length.

6. Quality Monitoring during the first 5 years of Defects Liability Period and Maintenance

After the works are complete, the following system of quality monitoring at the second and third tiers would apply.

6.1 Quality Monitoring during First Year of Completion

6.1.1 Either the SQM or the NQM or both could be required to inspect the completed work at any time during the first year of the opening of the work to traffic. The inspections would be as per extant guidelines of the NRRDA. The SQM/NQM can resort to digging of pits for tests to be carried out if so felt 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 Drawings and Bill of Quantities forming part of the contract.

6.2 During the second year of completion and upto end of the DLP.

6.2.1 The inspection by the SQM/NQM would be visual. The tests, if any, to be conducted would be non-destructive and no digging of pits shall be resorted to. In case, the SQM/NQM feels that it is a suspect case of substandard construction or quality, he will make a report to the SQC with copy to the CQC and further necessary action in the matter would be left to the state. The State may thereafter, like to proceed further to search for the defect and ascertaining liability of contractor, if any as per provisions of the contract. The State shall inform the CQC of the action taken in the matter.

6.2.2 The State Quality Coordinator would ensure that SQM inspects the completed work twice a year, once each during the period April to September and October to March and makes his observations limited to performance of the contractor in respect of maintenance works as per provisions of the contract. If during such an inspection, the SQM notices any particular stretch or section that has been seriously damaged or failed, he would make a report accordingly with intimation to CQC/NRRDA and further action on the matter would be left to the state.

6.2.3 The NRRDA may arrange inspection by an NQM on a sample basis once a year to report on performance of the contractor and action taken by the PIU in regard to maintenance of works as per provisions of contract.

7. Items to be checked by Quality Monitors

The various items to be checked by the Quality Monitors with respect to the MORD Specifications for Rural Roads shall be as per formats prescribed by the NRRDA. The formats for items to be checked are given at Appendix 6 for Road Works and Appendix 7 for Bridge Works.

8. Reports by SQMs and NQMs

8.1 The NRRDA issues detailed guidelines for quality monitoring by SQMs and NQMs from time to time. The extant guidelines are required to be followed strictly for compliance by the PIUs and the Quality Monitors.

8.2 The PIU would provide basic information about the work as per Format Part I given in Appendix 6 for road works and Appendix 7 for bridge works. The SQM/NQM shall record his evaluated grading for the relevant items of work inspected in the appropriate space in Format 1 Part II given in Appendix 6 for road works and Appendix 7 for bridge works. The grading shall be Satisfactory(S) or Satisfactory Requiring Improvement (SRI) or Unsatisfactory (U) as prescribed in Appendix 6.The Report is then to be uploaded on the OMMAS.

8.3 The SQM should cover in his Report, the following aspects as well:

(i) Design of pavement and cross drainage works.

(ii) Provisions made in estimates.

(iii) Deployment of qualified personnel and establishment of Quality Control Laboratory and its functioning. Upload the photographs of the lab on the OMMAS duly geo-referenced.

(iv) Work Programme and progress of work.

(v) Recording of the tests in Quality Control Registers.

The guidelines suggested for SQMs by the NRRDA and SRRDAs from time to time shall be followed strictly for compliance by the SQMs.

8.4 The NQM should cover in his report, the following aspects as well:

(i) Quality of DPR

(ii) Performance on Contract Management by the PIU

(iii) Performance on Quality Management including the Field lab by the PIU

8.5 The SQMs and NQMs are also encouraged, as per these guidelines, to suggest rectification measures where the works are found to be unsatisfactory or satisfactory but requiring improvement.

8.6 The SQMs and NQMs shall ensure uploading of digital photography of the observations on the quality of materials and workmanship in OMMAS, through use of mobile application developed by NRRDA. The abstract of observations and a minimum of ten (max 20) digital photographs for each inspection shall be entered in OMMAS website as per extant guidelines of the NRRDA.

9. The States may like to adopt similar process of quality monitoring for their own rural road projects.

APPENDICES

APPENDIX - A

Cold Mixes for Construction and Maintenance of Rural Roads

I. Introduction of cold mixes

Increasing concern for energy security and carbon credit have generated an interest in use of cold mixes in place of hot mixed bituminous materials. A cold mix is defined as a mixture of bitumen emulsion and aggregate that are mixed together at ambient temperature using cold mixing process. Bitumen emulsion being liquid at ambient temperature, there is no need to heat bitumen emulsion and aggregate. Cold mix is useful for following applications.

- Sites where there is long haulage distance between plant and laying sites
- Climatic conditions are wet along with cold and moderate temperature
- Roads cater to moderate and low traffic
- Placement of hot mix plant is not permitted

The concept of cold mixing process is based upon breaking of bitumen emulsion in contact with aggregates during mixing or compaction followed by progressive development of strength with time. This Appendix deals with cold mixed Bituminous Macadam for bituminous base construction over granular surface or existing bituminous surface, cold mixed Mix Seal Surfacing, Semi Dense Bituminous Concrete for wearing coat and patching mixes for maintenance.

II. Bituminous Macadam (Cold Mix)

Bituminous Macadam (Cold Mixed) is laid in single layer of 50 mm thickness over granular base or bituminous base.

A. Methodology

1. Identify suitable cold mix binder which may be bitumen emulsion (minimum 75% coating) conforming to IS: 8887 (Annexure II) or proprietary cold mix binder which is compatible with available mineral aggregate at site. To check compatibility test is given in part VII of this Appendix.
2. Bituminous Macadam (Cold mix) shall be designed by Marshall method as given in Part VI of this Appendix.
3. It is essential to construct a 30 m to 50 m long test section using designed cold mix for compliance of mix properties and compaction requirements.
4. Prepare the base on which cold mix Bituminous Macadam course is to be laid and shape to the specified lines, grade and cross-section.
5. Apply tack coat of cationic bitumen emulsion over the base preparatory to laying of the cold mix Bituminous Macadam.

6. Cold mixed Bituminous Macadam shall be prepared in an approved cold mix plant or modified hot mix plant using conversion kit (Part VIII).

7. Cold mix shall be prepared and laid at ambient temperature (10°C or above).

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

9. 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.

10. Any high spot or depression noticed after the roller has passed over the whole area once should be corrected by removing or adding premixed material. Rolling shall recommence thereafter. Each pass shall have an overlap of at least one-third of the track made in the preceding pass. Rolling shall be continued till all roller marks have been eliminated.

11. For single lane road, no longitudinal joint is required. For double-lane road, longitudinal joints may be required depending on the paver width.

12. 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.

13. Cover the cold mix 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 seal coat before opening to traffic.

14. Cold mix BM is suitable for climatic conditions, where maximum atmospheric temperature is 45°C or below.

B. Quality Control Requirements

1. Materials

The cold mix Bituminous Macadam (BM) shall be composed of aggregate meeting the physical requirements indicated in Table A-1 and bitumen emulsion or cold mix binder complying with IS:8887 (Annexure II) or as specified in the Contract. The BM (Cold mix) shall be designed for the criteria given in Table A-2. The binder requirements shall be in conformity with the requirements indicated in Annex II of Section 500. The binder shall be a cold mix binder such as cationic bitumen emulsion of SS-2 grade or a proprietary binder compatible with aggregate. The manufacturer of cold mix binder shall supply certificate of compatibility with aggregate. The residue content in the binder shall be minimum 65%. The grading of aggregate shall be in as given in Table A-3.

Table A-1 Requirements of the Aggregates for Cold Mixes

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices*	Max 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 27%	IS:2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12 % Max 18 %	IS:2386 Part V
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Fine Clay Particles	Sand Equivalent Value	Minimum 50	IS: 2720 (part 37)
Surface Reactivates	Methylene Blue Test	Max 10	ISSA*

*International Slurry Seal Association

Table A-2: Grading of Aggregates for Compacted Thickness of 50mm Bituminous Macadam (Cold Mix)

Sieve size, mm	Percent passing by weight
26.5	100
19.0	90-100
13.2	56-88
9.5	20-55
4.75	16-36
2.39	4-19
0.30	2-10
0.075	1-4
Sand Equivalent Value (ASTM D2419)	50 Minimum
Percent Crushed Faces	75 %Minimum
Bitumen Emulsion % by Weight of Mix	5 %Minimum

Table A-3: Design Requirements for Bitumen Macadam (Cold Mix)

i.	Number of compaction blow on each side of Marshall specimen	50
ii.	Marshall Stability at 25ºC	350
iii.	Marshall flow (mm) at 25ºC	Max. 8
iv.	Per cent voids in mixture	10-14
v.	Content (residual bitumen) by weight of total mix (%),min	3.5
vi.	Retained indirect tensile strength at 25ºC after conditioning for 72 hours in air and 24 hours at 40ºC, in water, Percent	50

2. Horizontal Alignment

Same as specified in Subsection 504.

3. Surface Level

Same as specified in Subsection 504.

4. Surface Regularity

Same as specified in Subsection 504.

5. Quality Control Tests

5.1 Quality Control Tests Prior to Construction

Specified in Table A-4.

Table A-4: Tests to be done prior to construction

Type of test	Frequency
1. Quality of binder as per Annexure -II of IS:8887 a. Viscosity b. Storage stability c. Residue content d. Residue on 600µ sieve e. Compatibility with aggregate	One set of test per lot (Average of three tests)
2. Quality of aggregate a. Impact value b. Flakiness Index c. Sand Equivalent value d. Water absorption e. Methylene Blue	One test per km length

5.2 Tests during Construction

The quality control tests to be carried out during construction are given in Table A-5 .

Table A-5 Tests to be done during construction

Types of Tests	Frequency
1. Compatibility of binder with aggregate	One test per day
2. Grading of Aggregate	One test per day
3. Binder content test	Two tests per day
4. Thickness and density of compacted layer	Two tests per day

5.3 Quality Control Checks by AE/EE

Same as specified in section 504.

C. Do's and Don'ts

Same as specified in section 506.2

III. Semi Dense Bituminous Concrete (Cold Mix)

To be laid in 25-30 mm thickness over bituminous base course.

A. Methodology

1. Identify suitable cold mix binder which may be bitumen emulsion conforming to IS:8887 (Annexure II) or a proprietary cold mix binder which is compatible with available mineral aggregate at site. The compatibility test is described in Part VII of this Appendix.
2. SDBC (Cold Mix) shall be designed by Marshall Method as given in Part VI of this Appendix.
3. It is essential to construct a 30 m to 50 m long test section using designed mix for compliance of mix properties and compaction requirements.
4. The other requirements shall be same as given in Part II of this Appendix.

B. Quality Control Requirements

1. Materials

The cold mix SDBC shall be composed of mineral aggregate meeting the physical requirements indicated in Table A-1 and bitumen emulsion or cold mix binder complying with IS:8887 (Annexure II) or as specified in the Contract. The SDBC (Cold mixed) shall be designed for the criteria given in Table A-7. The binder shall be a cold mix binder such as bitumen emulsion of SS-2 grade or proprietary binder compatible with aggregate. The manufacturer of emulsion shall supply certificate of compatibility of cold mix binder with aggregate. The residue content in the emulsion shall be minimum 65%. The grading of aggregate shall be in as given in Table A-8.

Table A-7 Design Requirements of SDBC (Cold Mix)

1.	Number of compaction blows on each side of Marshall specimen	50
2.	Marshall Stability at 25ºC in kg (minimum), after curing the specimen at room temperature for 72 hours	500
3.	Marshall flow (mm)	8
4.	Per cent voids in mixture	6-10
5.	Binder content (residual bitumen) by weight of total mix (%), min	4.5
6.	Retained indirect tensile strength at 25ºC after conditioning for 72 hours in air and 24 hours at 40 ºC in water, Percemt	75

Table A-8: Gradation of Aggregate for SDBC (Cold Mix)

Sieve size (mm)	Percent passing by weight
13.1	100
9.5	90-100
4.75	35-51
2.36	24-39
1.18	15-30
0.300	9-19
0.075	2-8
Sand Equivalent Value (ASTM D2419)	50 Min
Percent Crushed Faces	75 Min
Bitumen Emulsion (SS-2) by Weight of Mix with 65% residue content	8-10%

2. Horizontal Alignment

Same as specified in Subsection 509.

3. Surface Level

Same as specified in Subsection 509.

4. Surface Regularity

Same as specified in Subsection 509.

5. Quality Control Tests

5.1 Tests Prior to Construction

Same as specified in Part II of this Appendix (Table A-4).

5.2 Tests during Construction

Same as specified in Part II of this Appendix (Table A-5).

5.3 Quality Control Checks by AE/EE

Same as specified in section 509.

C. Do's and Don'ts

Same as specified in section 506.2.

IV. Mix Seal Surfacing (Cold Mix)

Laid in thickness of 20- 25 mm over bituminous base or surface.

A. Methodology

1. Identify suitable cold mix binder which may be bitumen emulsion (MS or SS-2) conforming to IS:8887 (Annexure II) or proprietary cold mix binder which is compatible with available mineral aggregate at site.

2. It is essential to construct a 30 m to 50 m long test section using cold mixed MSS mix for compliance of mix properties and compaction requirement.

3. The other requirements shall be same as given in Part II of this Appendix.

B. Quality Control Requirements

1. Material

The cold mix MSS is a continuously graded cold mix which is composed of aggregate meeting the physical requirements indicated in Table A-1 and bitumen emulsion or cold mix binder complying with IS:8887 (Annexure II) or as specified in the Contract. The binder requirements shall be in conformity with the requirements indicated in Annexure II. The binder shall be a cold mix binder such as bitumen emulsion of MS or SS-2 grade or proprietary binder compatible with aggregate. The manufacturer of emulsion shall supply certificate of compatibility of cold mix binder with aggregate. The residue content in the emulsion shall be minimum 65%.The quantity of emulsion shall be 30-34 kg for 10m^2 area

The grading of aggregate shall be in as given in Table A-9.

Table A-9: Gradation of Aggregates for Mix Seal Surfacing (Cold Mix)

% Passing by weight		
Sieve	**Type A**	**Type B**
13.2 mm	-	100
11.2 mm	100	88-100
5.6 mm	52 – 88	31-52
2.8 mm	14-38	5-25
0.090 mm	0-5	0-5

2. Horizontal Alignment

Same as specified in section 507.

3. Surface Level

Same as specified in section 507.

4. Surface Regularity

Same as specified in section 507.

5. Quality Control Tests

5.1 Tests Prior to Construction

Same as specified in Part II of his Appendix (Table A-4).

5.2 Tests during Construction

Same as specified in Part II of his Appendix (Table A-5).

5.3 Quality Control Checks by AE/EE

Same as specified in section 507.

6. Do's and Don'ts

Same as specified in section 506.2.

V. Pot hole and Patching Mixes (Cold Mix)

A) Mix for Immediate Use (Emulsion Based)

Materials: Aggregate conforming to standard grading (Table A-10), MS or SS-2 grade bitumen emulsion conforming to IS: 8887, or a cold mix binder.

Table A-10: Gradation of Aggregate for Patching Mix

Sieve size, mm	Percent passing
9.5	100
4.75	40-100
2.36	10-40
1.18	0-10
0.075	0-2

Table A-11: Minimum Residual Content by Weight of Mix

Aggregate water absorption,%	Minimum residual bitumen content,%
Less than 1.0	4.5
1.1 to 1.5	5.0
1.6 to 2.0	5.5

Equipments: Measuring buckets, balance, concrete mixer/pug mill type mixer, cold mix plant or hot mix plant modified with conversion kit.

Procedure: Charge blended aggregate meeting standard grading(if needed) to pug mill or cold mix plant or concrete mixer followed by adding 1 to 3% water (if needed). Add MS/SS2 emulsion @ 7 to 8 percent weight of aggregate and mix for 1 minute. Discharge mix, when it is brown in color and then carry to site for use.

B) Cold Mix for Storage (Emulsion Based)

Materials: Aggregate conforming to standard grading, SS-2 grade emulsion conforming to IS: 8887.

Equipments: Same as above.

Procedure: Procedure for preparation of mix is same as given above. Store mixes in shade in clean and dry place in U-shaped concrete boxes (2m x 4m x 4m).Mix shall be covered with a tarpolene sheet to reduce exposure of mix to air, rain and sunlight.

C) Mix for Storage (Cutback Based)

The patching mix shall preferably be produced in a conventional batch type hot mix plant. However, if a portable or stationary asphalt drum plant is used, under no circumstances drying/heating of aggregates shall be done with a burner flame. Mixing with MC-800 shall be carried out simultaneously because MC-800 containing volatile kerosene will catch fire and pose a safety hazard. The contractor and the engineer shall ensure there is no open flame inside or outside the drum when MC-800 is added for mixing.

The mix should be such that it can be stocked, handled, placed and finished without stripping of the bitumen from the aggregate. To prevent stripping and avoid heat buildup in a stockpile(which may burn the entire stockpile due to chimney effect), the mixed material should not be stockpiled not higher than 1.5 meters for the first 48 hours. The stockpile then can be raised in height and made conical in shape. Unless specified otherwise, the readymade cold mix shall be placed and sealed in plastic lined, sturdy 50 kg bags on cooling.

The mineral aggregate shall be clean and surface dry before mixing. The temperature of aggregate and bituminous material should comply with those given in Table A-12.

Table A-12 Temperature ranges for producing stockpile Patching Mix

Bituminous Material	Aggregate Temperature, °C	Binder Temperature, °C
MC – 800	25-65	75-95

Since, the range of aggregate temperature is rather low and the maximum aggregate temperature is restricted to 65 °C, it may not be possible to dry the aggregate within this temperature range. Therefore, the aggregate can be processed in a dryer at high temperatures and allowed to cool before the bituminous binder is added. Pre-drying of the aggregate at high temperatures will also help in reducing the fines (material passing 0.075 mm sieve), which will go into the bag house. The resulting mix then would have fines less than 2 percent as required in the stringent gradation specifications.

High aggregate temperatures while mixing with the cutback bitumen will not only cause excessive loss of kerosene from the cutback but will also pose a safety hazard in the plant or pug mill. Proper and adequate venting of the pug mill is necessary. Under no circumstances, there shall be any open flame in the vicinity of MC-800 cutback because it contains volatile kerosene. Since, the mix contains volatile kerosene, it is not safe to store the loose mix or sealed bags in a closed building/warehouse. Store under an open shed or in a well ventilated warehouse. No open flame or smoking shall be allowed in the vicinity of the stored mix.

D) Laying Procedure

(i). Preparation of potholes

Pothole shall be cleaned with a stiff wire brush and all loose material including dust shall be removed with a soft brush. Pothole need not be dry. However, excess water shall be swept off the pothole.

(ii). Placing Mix in potholes

The mix is intended for patching potholes up to 75 mm deep. For deeper potholes, patching mix shall be placed and compacted in 75 mm thick multiple layers.

If the pothole is deep and extends to WMM or granular base, it is recommended to apply a suitable tack coat or prime coat as feasible before placing the patching mix. If granular aggregate (nominal size 25mm) is used to partially fill deep potholes, the aggregate should be compacted thoroughly and primed with MC-30 before placing the patching mix. At least 50 mm thick pothole patching mix shall be placed at the top.

(iii). Compacting the Mix

First the outside edge or periphery of the patch shall be compacted with a hand rammer/small compactor and then compaction shall proceed inwards. To prevent initial pick up of the loose mix by the hand rammer either continue to wet the hand rammer with water or place empty plastic lined bags on the loose mix.

For deep potholes, place the patching mix and compact in 75 mm thick layers. After compaction, the compacted patch shall be slightly proud of the existing road surface to allow further compaction by traffic.

If there are numerous closely spaced patches, it is preferred to use a small roller rather than a hand rammer. If a roller is used, the mix shall be placed and spread slightly proud of the surface so that after rolling, the compacted surface shall be flush with the adjoining surface.

(iv). Application of Sand

Before opening the compacted patch to traffic, sufficient amount of clean sand shall be sprinkled on the patch to prevent pick up by traffic.

E) Quality Control and Acceptance of patching mixtures

The composition of the produced mix (gradation and bitumen content) shall be tested by an independent, approved testing laboratory before acceptance by the Engineer. Before conducting the bitumen extraction test to determine residual bitumen content in the patching mix, the samples shall be cured completely to remove all kerosene. Curing shall be done as follows. Place the loose mix in an open metal container and heat slowly on a hot plate with frequent stirring until a constant weight is achieved.

The following two tests shall be performed by the contractor (in presence of a department representative) on the mixture, freshly prepared or taken from a stockpile or sealed bag at anytime during its storage life (usually 6 months).

i) Water Resistance Test (Part VII of Appendix)

ii) Workability Test (Part VII of Appendix)

The water resistance test would indicate whether the patching mix has a potential for stripping in the pothole in presence of water. If the mix fails this test, it means a proper type and/or amount of an anti-stripping agent has not been used in the bituminous binder.

If the mix fails workability it could be due to improper bitumen type, low bitumen content excessive fines or improper gradation. Even half a percent lower bitumen content can make the patching mix unworkable and useless.

Stocked patching material may be rejected, at any time during six months period if, in the opinion of the Engineer, the patching material has been stripped (more than 10 percent uncoated particles) or otherwise become unfit or unworkable for use.

VI. Design of Cold Mix (BM and SDBC)

The cold mix design procedure involves optimization of water as well as content of bitumen emulsion for the aggregates in the mix. The aggregates are made moist with water (if needed) to wet its surface and then coated with cationic bitumen emulsion. The different sizes of aggregates are blended in proportions to achieve the standard gradation of BM or SDBC. The following steps are necessary to design cold mix with cationic bitumen emulsion.

(i) **Testing of aggregate:** The aggregates supplied are subjected to sieve analysis and physical tests for determining the properties such as specific gravity, aggregate impact value, water absorption and sand equivalent value.

(ii) **Testing of cold mix binder:** The samples of slow setting bitumen emulsion to be used for construction shall be tested as per IS 8887 (Annexure II). The coating test of aggregates shall be carried out as given in Part VII of this Appendix.

(iii) **Determination of premixing water content:** For determination of optimum water content for premixing, the quantity of bitumen emulsion shall be determined using the following equation:

$P = 0.05A + 0.1B + 0.5C$ ..... Equation (1)

Where: P = Quantity of bitumen emulsion

A = percent of mineral aggregate retained on 2.8 mm,

B = percent of mineral aggregate passing 2.36 mm and retained on 90 micron sieve

C = percent of mineral aggregate passing 90 micron sieve

Different samples of aggregates and emulsion mixes are prepared keeping the quantity of bitumen emulsion constant (as determined by Equation 1) and varying the water content. The coated aggregates are then visually observed for coated area of the aggregate by the bitumen. The optimum water content is the water content at which maximum coating of aggregate occur. This water content is taken as premixed water content in designing the cold mix. The optimum water content for BM or SDBC is normally found to be 2 to 3 percent by weight of aggregate. However, this quantity may vary depending on the weather condition such as temperature, humidity and wind velocity) and properties of aggregates.

Example :

Samples are prepared to determine the optimum water content by keeping the emulsion content constant by mass of the aggregate (as numerically determined by Equation 1). Equation 1 was applied using the values with A = 66%, B = 30%, C = 4%. The value obtained for this mix is 8.3%. The pre-wetting water content was increased at intervals of 1.0% by mass of the aggregate starting from total fluid content of 2% and ending at 5%. Mechanical properties such as density obtained are plotted graphically and are shown in Figure 1. Using the above parameters, optimum water content based on maximum density is determined. Water content increases or decreases depend upon the properties of aggregates available.

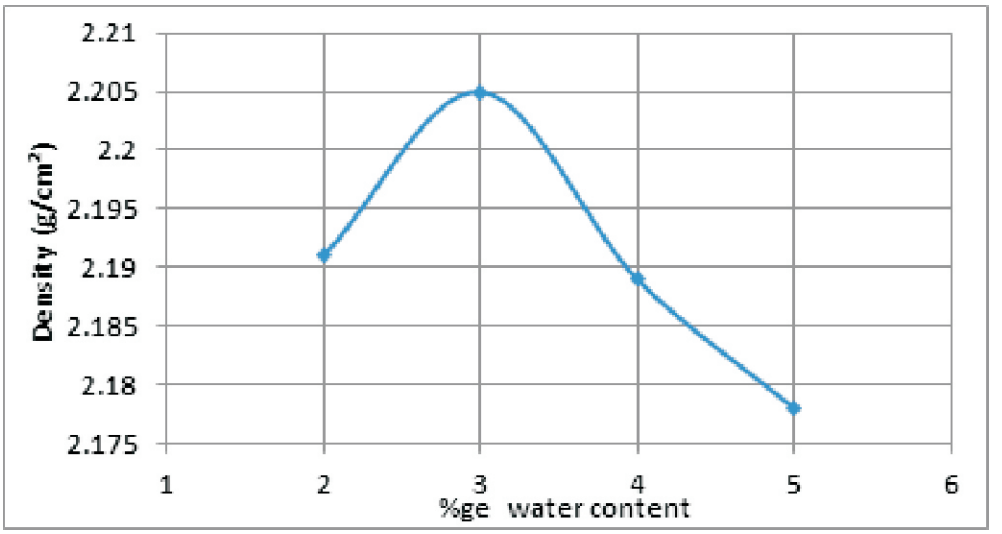


Figure 1: Percentage of water content versus density

The procedure for the design of cold mix utilizes standard Marshall equipment. Marshall test specimens in triplicate are prepared with different binder content (bitumen emulsion).Different sizes of aggregates are blended to achieve the specified aggregate gradation. About 1100 gm of graded aggregates are made wet uniformly with optimum water content. The different percentage of bitumen emulsion, say 5% by weight of aggregate, are then added to the aggregates and mixed for 1-2 minutes for achieving uniform binder coating. The mixture is dried for 1-2 hours using a fan. The cold mix is then kept in oven at 40 °C for 2 hours. The cold mix is then transferred into the Marshall mould with a filter paper on base plate and then compacted with 50 blows of Marshall hammer on both faces for BM and 75 blows for SDBC.

Similarly, the Marshall specimens are prepared at optimum water content and varying bitumen emulsion contents of 5, 6, 7, 8 and 9 percent by weight of aggregates. The Marshall specimens are then extracted from the mould after 24 hours and cured in air oven at 40 °C for 72 hours before subjecting to different tests such as bulk density, stability and flow values. Marshall Stability and flow values are determined in dry state at 25 °C. Different properties of the mixes are determined using procedure given in ms-14. Properties such as stability, flow, bulk density and voids are plotted against different binder content

to determine optimum emulsion content. The optimum emulsion content shall be determined based on average value for maximum density and stability values. Typical plots of stability and density versus different percentage of emulsion content are given in Figure 2 and 3. The retained ITS test shall be conducted at 40°C using method given in AASHTO T-283 (Annex-E of IRC:SP:79)

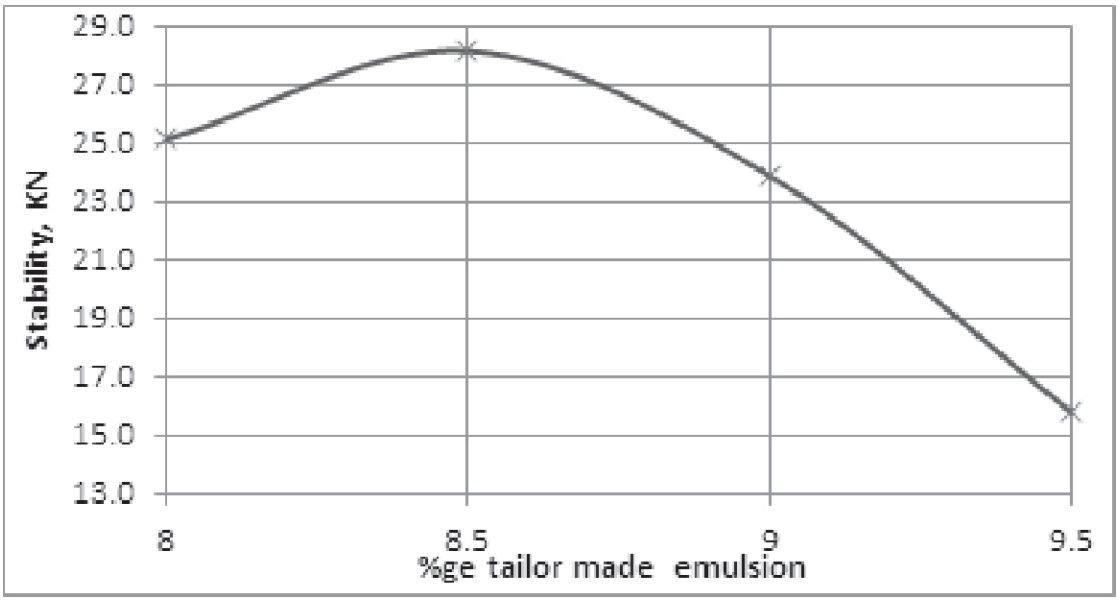


Figure 2: Stability versus different percentages of emulsion content

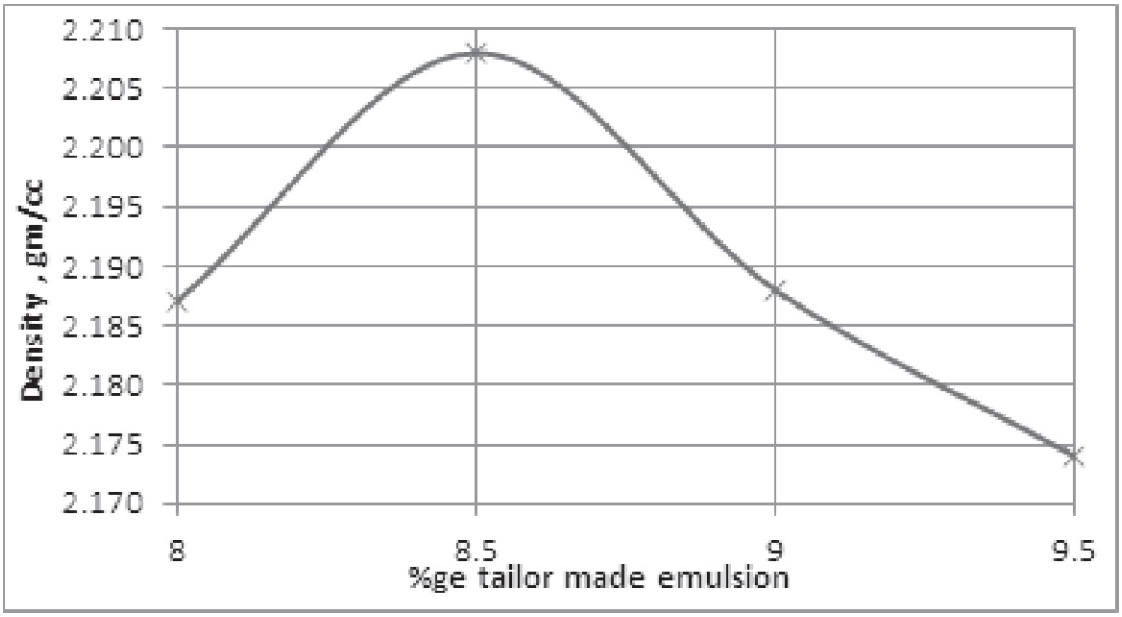


Figure 3: Density versus different percentages of emulsion content

VII. Tests on Cold Mixes

A) Emulsion aggregate compatibility Test

This test is conducted to study compatibility between aggregate and emulsion.

Apparatus: Circular aluminum pans of 8 inch dia and 6 inch dia , 2 spatulas, weighing balance with accuracy of 0.1g, 2 beakers of 400 ml capacity, white bloating paper, Bunsen burner and spatula.

Method: Sieve aggregate and collect the materials passing 19 mm sieve and retained on 13.2 mm sieve and passing 9.5 mm sieve and retained on 2.36 mm sieve. Wash both the aggregate and dry at 120 °C for 4 hrs in an oven then cool in air to ambient temperature. Take 600 gm of aggregate (passing 19mm and retained on 13.2 mm sieve) in pans of 8 inch dia and 6 inch dia (aggregate passing 9.5 mm sieve and retained on 2.36 mm sieve). Add 6.5% emulsion in coarser aggregate and 7% emulsion in finer aggregate and mix for 1min. Place aggregate emulsion mix in two different trays in sunlight for 4 hrs. Take 200 gm of both the mixes in 3 beakers of 400 ml (total 6 beakers). Observe coating of aggregates visually. 90% is acceptable for compatibility of emulsion with aggregate. Add 200 ml distilled water in all the 6 beakers. Then place first set of beakers at 40°C in water for 24hrs. Place second set of beakers which shall be subjected to boiling for 3mins. Decant distilled water from the beakers and place the mix on bloating paper. Observe coating. 75 percent coating is acceptable for compatibility of emulsion with aggregate.

B) Workability Test for Patching Mix

Approximately 2.5 kg of the patching mix shall be cooled to -7°C in a freezer. After cooling, the mixture shall be capable of being broken up readily with a spatula that has a blade of approximately 200 mm. This test shall be performed when the mix is produced and thereafter anytime during storage. If the mix is not workable at -7 °C, it shall be rejected and the composition of the mix shall be properly modified (for example, by increasing the bitumen content and/or gradation changes). This test is also applicable in areas with hot climate because it amplifies the workability characteristics of the mix by using a lower test temperature.

C) Test Method for Determination of Water Resistance of patching mix

Fifty grams of patching mix, shall be heated at 120 °C in a laboratory oven for 4 hours, and then cooled to 95 °C in laboratory by air, and then placed in 400 ml of boiling water in a 600 ml glass beaker and stirred with a glass rod at the rate of 1 revolution per second for 3 minutes. The water shall be decanted and the mix shall be spread on an absorbent paper for visual observation of the coating. The aggregate shall be at least 90 percent coated with a bituminous film.

D) Test Method for Determination of Emulsion Content in Cold Mix

The test is intended for determination of emulsion content in cold mix. The mineral aggregate recovered from the test can be used for checking their gradation. A representative cold mix sample (600 ± 1gm)by weight accurately shall be placed in an oven for 4 hours at 120 ± 1 °C. Cool the mix for about 15

minutes and weigh to nearest 0.1. gm. Place cooled mix (500 ± 0.5 gm) in the bowl of extraction apparatus and cover with trichloroethylene solvent. Repeat the procedure as described for hot mix. Determine percentage of residual binder in cold mix. Knowing the percentage of residual binder in bitumen emulsion, calculate percentage of emulsion added in cold mix.

VIII. Conversion Kit (Hot Mix Plant to Cold Mix Plant)

Cold mix can be easily prepared using modified hot mix plant. The sketch of conventional hot mix plant (modified) with conversion kit is shown Figure 4.

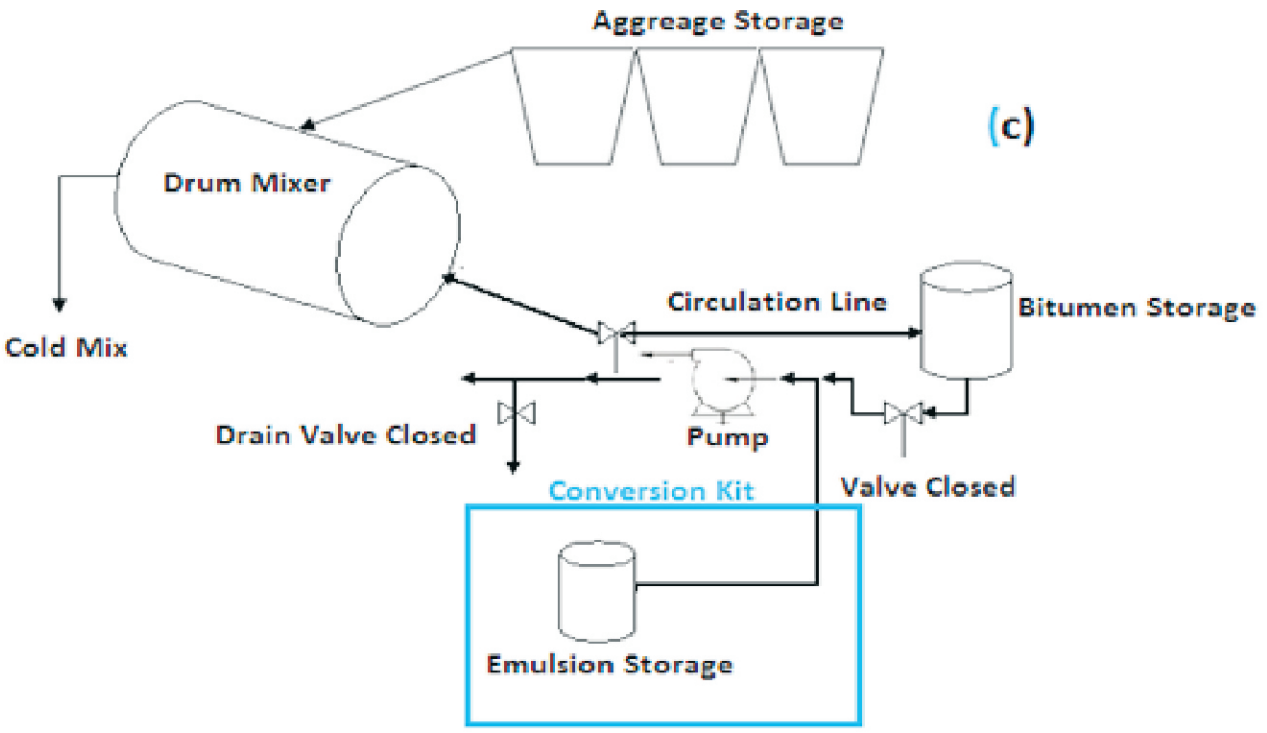


Figure 4: Diagram of Hot Mix Plant Modified to Cold Mix Plant using Conversion Kit

APPENDIX - B

Technology Initiatives Under PMGSY - Major Proven Technologies for Rural Roads

There are several useful technologies for rural road construction that need to be adopted on a wide scale. While for many of these technologies, IRC Guidelines or MORD Specifications are available, but for some technologies such Guidelines are not there. However many of these technologies have been successfully adopted in several countries abroad. NRRDA has issued Guidelines on Technology Initiatives including Innovative Materials in May 2013. The technologies which have been listed in NRRDA Guidelines, for which Specifications / Quality Assurance procedures available are given below:

(i) Soil Stabilisation using different methods such as:

- Lime stabilisation - Sub-section 403
- Cement stabilisation - Sub-section 404
- Mechanical stabilisation - Sub-section 402 and IRC SP:89

(ii) Improving properties of locally available materials and marginal materials, soft aggregates, brick aggregates, etc - Sub-section 408

(iii) Use of fly ash in cement concrete structures (culverts/ bridges) / Use of blended cement - Sub-section 2006 and 2007

(iv) Roller compacted concrete pavement - Sub-section 1502, IRC SP:68

(v) Interlocking concrete block pavement - Sub-section 1504, IRC SP:63

(vi) Cold mix technology using bitumen emulsion for bituminous wearing course (Premix carpet, surface dressing) - Section 500, IRC SP:100

(vii) Use of fly ash in road embankment - Sub-section 306, IRC SP:58

(viii) Use of waste plastic in bituminous works - Sub-section 512, IRC SP:98

(ix) Use of bio-engineering measures - Sub-section 1612, IRC:56

(x) Use of crusher run macadam - Sub-section 411

(xi) Gravel Roads - Sub-section 402 and 1906, IRC SP:77

(xii) Use of Blast Furnace Slag - Sub-section 410

(xiii) Use of Quarry Waste materials - Sub-section 410

The following technologies which have been listed by NRRDA and for which MORD Specifications are not available are given below:

(i) Patented Stabilisers

(ii) Use of Geotextiles including Jute and Coir Geotextiles

Quality assurance procedures for there technologies (i) and (ii) above are given below:

(i) Patented Stabilisers

A. Methodology

Several patented chemicals which have been accredited by Indian Roads Congress are available. The pavement layer in which stabiliser can be used (Subgrade / Sub-base / Base course), methodology to be adopted and dosage for using such chemicals should be as per procedure provided by the suppliers. For mixing such stabilisers with soil, tractor towed rotavators can be adopted in the same manner as given for lime and cement stabilisation (Sub-Section 403 and 404). Curing method and precautions to be taken if any, would again depend on information to be provided by suppliers.

B. Quality Control Requirements

1. Materials

(i) **Soil:** Any patented chemical may not be effective for all types of soils. The type of soil for which a particular patented stabiliser can be used, should be obtained from stabiliser suppliers.

(ii) **Patented Stabiliser:** Information pertaining to tests to be done on stabiliser and additional additives required if any, should be obtained from stabiliser suppliers.

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

2. Horizontal Alignment

The edges of the lime treated subgrade and 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 (-) 25mm; while for the lime-treated soil sub-base 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

Compacted density of stabilised subgrade shall be at least 98 per cent of the maximum dry density of the material as per IS 2720 (Part 7). Compacted density of stabilised sub-base or base shall be at least 100 per cent of the maximum dry density of the material as per IS 2720 (Part 7).

6. Quality Control Tests

When patented stabilisers are used for improving the subgrade or sub-base or base course, the strength to be achieved and type of strength test (CBR or Unconfined compressive strength) shall be stipulated by the supplier of the chemical.

6.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 1 below.

Table1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Type of Test	Frequency
Tests on Stabiliser	As per schedule of tests provided by stabiliser supplier
Proctor compaction test of soil admixed with stabiliser (IS 2720 Part 7) Test results to ascertain Dry Density - Moisture Content Relationship	One test from each source for one km length or part thereof.
Plasticity Index test (IS:2720 Part5) of the stabiliser treated soil	One test from each source for one km length or part thereof.
CBR (IS:2720 Part16) or Unconfined Compressive Strength (IS:4332 Part5) as 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 2.

Table 2: QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test	Frequency
Pulverisation of soil clods	At least 3 tests daily, well spread over the day's work
Placement Moisture Content (IS:4332 Part 2)	-do-
In-situ 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
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 3.

Table 3: QUALITY CONTROL CHECKS BY AE / EE

Stage	Test	Frequency	Designation of Inspecting Officer
1. Compacted stabilised 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 2	AE
		(b) Minimum one test per km length or part there of	EE
	(ii) Plasticity Index of the lime-treated mix from the layer	Minimum 3 tests for each km length or part thereof	AE

Stage	Test	Frequency	Designation of Inspecting Officer
	(iii)Unconfined Compressive Strength (IS:4332 Part 5) when specified, sample to be extracted from the compacted layer	(a) One test for each 500 m length or part there of. (b) One test for each km length or part thereof	AE EE
	(iv)Surface Regularity and Transverse Profile	Random Checking	AE

7. Performance Evaluation

The performance of the road constructed using patented stabilisers should be monitored for atleast 24 months or completion of two rainy seasons after construction, whichever is later. During this period 'Pavement Condition Survey' should be carried out annually immediately after rainy season. This should be carried out for both stabilised pavement section of the road as well as control section having conventional pavement. Pavement condition survey can be carried out as per procedure outlined in PMGSY Operations Manual.

C. Do's and Don'ts

Do's	Don'ts
1. Construct a 'Control Section' designed as per IRC SP:72 in the same road and do not use patented stabiliser in any of the layers of control section. 2. Do ensure that test section constructed using patented stabiliser is for a length of 500 m. 3. Ensure uniformity of mixing of stabiliser with soil by mechanical means using tractor-towed rotavator. 4. Look for soft patches, if any, and rectify them by removing or adding fresh material and compacting the same thoroughly. 5. After the curing period is over, subsequent pavement layers shall be laid as soon as possible to prevent any distress to the surface. 6. Ensure that patented stabilisers do not pollute sub-soil/ ground water in any way. Such tests can be got done from reputed National laboratories like NEERI, Nagpur or IITR, Lucknow.	1. Do not use graders for mixing since they are inefficient for mixing and a large number of passes may be required. 2. Do not allow any traffic other than mixing equipment to pass over the spread stabiliser till mixing has been completed 3. Do not allow traffic until the stabilised layer is cured as per instruction received from stabiliser supplier.

(ii) Use of Geotextiles including Jute and Coir Geotextiles

Any permeable synthetic textile used with soil/ rock or any other geotechnical engineering related material, as an integral part of infrastructure project is called a geotextile. The geotextile fabric can be woven or non-woven or knitted fabric and can be made from polymeric material or natural material like Jute or Coir.

The application areas for geotextile in road works are separation, filtration/drainage, reinforcement or a combination thereof. For drainage/ filtration function, geotextile shall be able to convey water across the plane of the fabric throughout its design life. For separation function, the geotextile shall prevent intermixing of two layers of dissimilar materials, throughout the design life of the structure. Synthetic geotextiles of appropriate strength can be used as basal reinforcement to improve performance of an embankment constructed over soft sub-soil. Natural geotextiles made from Jute and Coir, can be used for controlling surface erosion of top cover soil on cut or fill slopes/ embankment side slopes and to facilitate vegetation growth. Jute and Coir geotextiles can reinforce sub-soils of low shear strength at the initial stages. With the process of consolidation setting in, there will be gradual increase in shear strength of sub-soil and ultimately there may not be any need for JGT for this purpose.

A. Methodology

1. After clearing and grubbing operations, the embankment or subgrade layer above which geotextile is to be applied should be compacted to specified density.
2. The geotextile should be rolled over the prepared embankment / subgrade layer as smoothly as possible.
3. Adjacent rolls of geotextiles should be overlapped or sewn as specified. At curve portions of the alignment, geotextile should be folded or cut and overlapped in the direction of construction.
4. Any damage (holes, cuts, tears, etc) noticed in the geotextile layer should be covered by placing a new layer of geotextile over damaged area.
5. The geotextile should be anchored to the soil below by using nails/ stakes while using it in slopes or at steep gradients, to prevent movement of geotextile during further construction activities.
6. The next layer of pavement material should then be spread to its specified thickness over the geotextile, watered to bring its moisture content to OMC ± 2 per cent and then compacted to its specified density.

B. Quality Control Requirements

1. Materials

(i) Synthetic Geotextiles: Should conform to specifications for its particular application - separation / filtration / drainage application, geotextile to be as per IRC SP:59 and for erosion control application should conform to IRC 56.

Further, strength and hydraulic properties shall be in terms of its MARV (Minimum Average Roll Value) as specified in IRC SP:59. Further, the requirements of overlap, seam strength, etc shall be as specified in IRC SP:59.

(ii) Jute Geotextiles: IRC 56, IS 14986 and IRC HRB Special Report 21

(iii) Coir Geotextiles: IRC 56, IS 15869, IS 15872

For jute and coir geotextiles, strength and hydraulic properties shall be in terms of its MARV (Minimum Average Roll Value). Suppliers instructions should be followed for overlap requirements.

2. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4.

Table 4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Type of Test	Frequency
In-situ density tests of the embankment / subgrade before spreading geotextile	As per the requirements of Section 300
Properties of geotextiles	Manufacturer's Test Certificate

3. Tests During Construction

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

Table 5: QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test	Frequency
Laying of geotextile without wrinkles, providing specified overlap, covering defects in geotextile with new geotextile pieces, etc	Regular and continuous inspections during installation by AE and periodic inspections by EE

4. Performance Evaluation

The performance of the road constructed using geotextiles should be monitored for at least 24 months or completion of two rainy seasons after construction, whichever is later. During this period 'Pavement Condition Survey' should be carried out annually, preferably after rainy season. This should be carried out for both geotextile laid section of the road as well as control section constructed without geotextile. Pavement condition survey can be carried out as per procedure outlined in PMGSY Operations Manual.

C. Do's and Don'ts

Do's	Don'ts
1. Do remove wrinkles and folds in the geotextile by stretching and stacking as required. 2. While laying geotextile for erosion control, do ensure that, geotextile is in full contact with soil surface. 3. Before covering the geotextile layer with next pavement layer, inspect geotextile layer for any damages. 4. When using geotextile for erosion control of soil slopes, anchor the geotextile at the top and toe portions of the embankment, by placing it in trenches and backfilling the trenches.	1. Do not drag the geotextile rolls over the prepared subgrade / embankment. 2. Do not expose geotextile to elements (Sun, rains, etc) between lay down and covering it with pavement layer or soil, for more than 14 days.

APPENDIX - C

Cell filled concrete pavement

The technology consists of providing cell filled concrete pavement over a prepared sub base. The form work of plastic cells is stretched and iron spikes are driven at the corners of the cell so that the formwork remains taut. Nylon ropes through the cell walls prevent collapse of the cells during the placing of concrete or stones into the cells. The cells can be filled with conventional concrete or with roller compacted concrete (RCC).

A. Methodology

1. Approval of plant, material, equipment and construction method :

i. A trial length of at least 30 m will be constructed off the road in two days to demonstrate the proposed materials, plant, equipment and construction methodology before constructing the cell filled concrete pavement.

ii. Before taking up the trial length, the sources of all materials to be used in the concrete work and the mix design shall be approved by the Engineer at least 30 days before their use.

iii. If the first trial is unsatisfactory, the contractor shall have to demonstrate its capability to the Engineer to satisfactorily construct the pavement in subsequent trials.

iv. Based on the results of trial length and relevant tests and data, construction plants, methodology and curing methods shall be finalised before taking up the construction work at site.

v. The materials i.e. aggregates, concrete and HDPE sheets shall meet the requirements given in Para B. The HDPE sheets could be manufactured out of reclaimed HDPE. The thickness will vary from 220 to 250 micron. The sheets could be manufactured from recycled LDPE and in that case, the thickness will be from 300 to 350 micron. Coarse aggregates should have AIV less than 30 % and FI not more than 40%. The gradation shall be as given in Para-B.

vi. The mix design shall be based on the compressive strength of concrete as specified in the Contract. If it is not specified it shall not be less than 30MPa. The mix design will be done as per IRC:44 for conventional concrete and as per section 1502 in the case of roller compacted concrete.

vii. The cement content should not be more than 425 kg nor less than 350 kg per cum of concrete unless specified otherwise. If fly- ash is used to replace a part of cement in the concrete mix, the cement content should not be less than 270 kg/cum. The fly- ash content may be upto 30% by weight of cementitious material.

viii. All batching of materials shall be by weight and as per clauses 1501.11.3 and 1501.11.3.1 of MORD Specifications. Volume batching may be allowed for small jobs with the approval of the Engineer. Water cement ratio should not be more than 0.5. Chemical admixtures / plasticiser as per IS 9013 may be used to achieve the desired workability of 40 ± 10 mm.In case of RCC, the water content in the concrete will be 5-6% of the dry weight of the mix.

2. Prepare the Sub-grade to the specified grades and cross-sections. The CBR of the sub grade shall not be less than 5%. If it is less, it will be improved by stabilization to a CBR not less than 10%.

3. Lay granular or WBM grading 3 or WMM or lime treated sub-base of the specified type and thickness. The sub- base could also be of jhama brick metal, CRM fly-ash aggregates or locally available moorum treated with lime or cement. If aggregates are not available, the local soil may be stabilised to CBR of not less than 20%. The locally available material such as natural gravels/ soil aggregate or blended with suitable aggregates, fractions of stones, gravel, murrum, sand and combination of these depending upon the required grading may be used.

   If the traffic is more than 50 CVPD, 150 mm thick cementitious sub base with minimum 7 days strength of 1.5 MPa is to be provided. The stone / concrete block / brick on edge will be provided for edge protection. This should project 100 mm above the sub base for confinement and protection of the pavement.

4. Pavement concrete shall be produced near the site, using approved concrete mixers of at least 0.2 cum capacity in the case of conventional concrete and small pug mill in the case of RCC.

5. Concrete shall be placed between the edge restraints (stone or brick on edge or concrete kerbs) and shall be levelled with rakes and shovels, taking care not to tear-off any of the cells.

6. Around man-holes or other openings in pavement, the cells will be laid in the normal-way or as per pattern specified in the drawing.

7. As soon as practicable after compaction of concrete, smoothen the surface with a longitudinal float operated from the work bridge. The concrete shall be rolled with 80-100 kN vibrating / static road roller for compaction.

8. After completion of the finishing operations, the surface of the pavement shall be covered with wet hessian cloth, burlap or jute mats after initial set of concrete. They shall be maintained fully wetted and in position for at least 14 days. If fly-ash blended cement has been used, the curing period will be 16 days.

B. Quality Control Requirements

1. Materials

- Cement

- Aggregates : Coarse and fine
- Water
- Admixtures

These shall conform to the requirements specified in Para B of Sub- section 1501.

Bricks

These shall conform to Section 2000.

Sub Grade

It shall meet the requirements given in Sub- section 1501.

Sub base and base:

These shall conform to Sub-section 401 in the case of conventional concrete and to Sub- section 1502 if RCC is specified.

Coarse and fine aggregates shall be blended to obtain aggregate gradation given in Table1

Table 1 - Aggregate gradation for Concrete

Sieve Designation	Percentage by Weight passing the sieve
26.50 mm	100
19.0 mm	80-100
9.50 mm	55-80
4.75 mm	35-60
600 micron	10-35
75 micron	0-8

Plastic cells

The HDPE sheets could be manufactured out of reclaimed HDPE. The thickens will vary from 220 to 250 micron. The sheets could be manufactured from recycled LDPE and in that case, the thickness will be from 300 to 350 micron.

A pair of strips can be welded at 300 mm intervals. The third strip is welded to the first pair at 300 mm intervals so that the stitches lie at the center of the previous stitching. The third and the fourth ones are again welded like the first two.

1. Horizontal alignment

± 20 mm in Plain and rolling terrain.

± 30 mm in Hilly terrain.

2. Surface levels

Variations of ± 5 mm permitted

3. Surface regularity

Variations of ± 6 mm permitted in longitudinal and transverse directions

4. Thickness

It shall be as per drawings and a tolerance of ± 10 mm is permitted.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are given in Table 2.

TABLE 2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.NO.	Type of tests	Frequency
1)	Cement	As in Table 2000.4
2)	Fine aggregates	As in Table 2000.9
3)	Coarse aggregates	As in Table 2000.10
4)	Water	Once for each source, subsequently in case of doubt.
5)	Admixture	Manufacturer's Certificate before procurement
	- Chemical (workability) (IS: 6925 & IS: 9103)	-do-
	- Mineral (flyash) (IS:3812)	-do-
6)	Plants equipment and tools	As per contract
7)	Concrete mix Design for cement content w/c ratio and dosage of plasticizers for the specified design strength	To be approved by EE
8)	Granular Sub base	Table 401.2
9)	Trial Length	To be approved by EE before regular work.

6.2 Tests During Construction:

The quality control tests to be carried out during construction are given in Table 3.

TABLE 3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. no.	Tests / check	Frequency
1)	Sub grade and sub base	As in Tables 301.5 and 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 cum of concrete at paving site or one test for each dumper laid at plant site.
4)	Strength of concrete (IS:516)	Minimum 6 cubes and (3 each for 7 days and 28 days strength per day)
5)	Straightness of edge restraints	To be checked daily
6)	Batching and mixing of materials	Check for measurements and proper mixing
7)	Hot / cold weather concreting including compaction	Checks regularly
8)	Compaction equipment (needle, screed and plate vibrators)	For continuous working and standby arrangement
9)	Levels and alignment	
	I) Level Tolerance	To be checked for each day's work regularly
	II) Surface regularity (transverse and longitudinal including camber / cross slope)	
	III) Width of pavement and position of paving edges	To be checked for each day's work regularly at grid points
	IV) Pavement thickness	To be checked for each day's work

6.3 QUALITY CONTROL CHECKS BY AE/EE

The quality checks by AEE/EE are indicated in Table 4

TABLE 4: QUALITY CONTROL CHECKS BY AE/EE

1	Quality Checks by AE/EE - Width thickness of pavement - Surface levels - Surface regularity	 At random At random At random	 AE AE AE
2	Paving near culverts and bridges	At each site	AE/ EE
3	Performance of 30 m trial length	For each work	EE

C. Do's and Do not's

S.No.	Dos	Don'ts
1	Check the CBR and density of sub grade soil before laying the sub base.	1) Do not allow the sub grade to get softened.
2	Check the slump of concrete regularly.	2) Do not pave when it is raining.
3	Check the thickness of plastic sheets before the same are stitched and given rectangular shape.	3) Do not lay concrete if concrete temperature is less than 5°C and more than 30°C and ambient temperature more than 35°C.
4	Ensure sufficient supply of plastic sheet cells.	4) Do not allow any traffic till the curing period is over.

APPENDIX - 1

SIMPLE / HANDFEEL TESTS

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 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 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.

1.5 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.

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 principal 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 thickness 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, with capacity of 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:12-2009	Guidelines for Access, Location and Layout of Roadside Fuel Stations and Service Stations (Third 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:98-2011	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (Second Revision)
13.	IRC:99-1988	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads
14.	IRC:103-2012	Guidelines for Pedestrian Facilities (First Revision)
15.	IRC:106-1990	Guidelines for Capacity of Urban Roads in Plain Areas
16.	IRC:SP:23-1983	Vertical Curves for Highways

Sr.No.	Code/Document No.	Title of the Publication
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:35-2015	Code of Practice for Road Markings(with Paints) (Second 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:67-2012	Code of Practice for Road Signs (Third Revision)
6.	IRC:79-1981	Recommended Practice for Road Delineators
		1.(E). Road Safety & Traffic Management
1.	IRC:53-2012	Road Accident Forms A-1 and 4 (Second 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:44-1996	Highway Safety Code
5.	IRC:SP:55-2014	Guidelines on Traffic Management in work Zones (First Revision)
		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
3.	IRC:33-1969	Standard Procedure for Evaluation and Condition Surveys of Stabilised Soil Roads
4.	IRC:36-2010	Recommended Practice for Construction of Earth Embankments and Sub-Grade for Road Works (First Revision)
5.	IRC:56-2011	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)
6.	IRC:75-2015	Guidelines for the Design of High Embankments (First Revision)

Sr.No.	Code/Document No.	Title of the Publication
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 (Amalgamated with IRC: SP:89-2010)
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) (Amalgamated with IRC: SP:89-2010)
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:109-2015	Guidelines for Wet Mix Macadam (First Revision)
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:16-2008	Standard Specifications and Code of Practice for Prime and Tack Coat (Second Revision)
3.	IRC:19-2005	Standard Specifications and Code of Practice of Water Bound Macadam (Third Revision)
4.	IRC:27-2009	Specifications for Bituminous Macadam (First Revision)
5.	IRC:34-2011	Recommendations for Road Construction in Areas Affected by Water Logging, Flooding and/or Salts Infestation (First Revision)
6.	IRC:37-2012	Guidelines for the Design of Flexible Pavements (Second Revision)
7.	IRC:SP:72-2015	Guidelines for the Design of Flexible Pavements for low volume Rural Roads (First Revision)
8.	IRC:SP:77-2008	Manual for Design Construction & Maintenance of Gravel Roads

Sr.No.	Code/Document No.	Title of the Publication
09	IRC:55-1974	Recommended Practice for Sand-Bitumen Base Courses
10.	IRC:82-2015	Code of Practice for Maintenance of Bituminous Surface of Roads (First Revision)
11.	IRC:95-1987	Specification for Semi-Dense Bituminous Concrete (Amalgamated with IRC: SP:89-2010)
12.	IRC:110-2005	Standard Specifications and Code of Practice for Design and Construction of Surface Dressing
13.	IRC:SP:53-2010	Guidelines on Use of Modified Bitumen in Road Construction (Second Revision)
14.	IRC:SP:98-2013	Guidelines for the use of waste plastic in Bituminous Mixed (Dry Process) in wearing courses
15.	IRC:SP:100-2014	use of Cold Mix Technology in construction and maintenance of Roads using Bitumen
1.(I). Design, Construction and Maintenance of Cement Concrete Pavements		
1.	IRC:15-2011	Standard Specifications and Code of Practice for Construction of Concrete Roads (Fourth Revision)
2.	IRC:44-2008	Guidelines for Cement Concrete Mix Design for Pavements (Second Revision)
3.	IRC:57-2006	Recommended Practice for Sealing of Joints in Concrete Pavements (First Revision)
4.	IRC:58-2015	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (First Revision) (with CD)
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 (Amalgamated with IRC: SP:44-2008)
7.	IRC:77-1979	Tentative Guidelines for Repair of Concrete Pavements Using Synthetic Resins
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:49-2014	Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement
11.	IRC:SP:62-2014	Guidelines for the Design and Construction of Cement Concrete Pavement for Rural Roads (First Revision)
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
14.	IRC:SP-83-2008	Guidelines for maintenance, Repairs & Rehabilitation of cement concrete pavement
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

Sr.No.	Code/Document No.	Title of the Publication
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:57-2000	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:42-2014	Guidelines on Road Drainage (First Revision)
2.	IRC:SP:50-2013	Guidelines on Urban Drainage
		1.(M). Road Machinery
1.	IRC:43-2015	Recommended Practice for Tools, and Equipment required for construction on maintenance of Roads (First Revision)
2.	IRC:72-1978	Recommended Practice for Use and Upkeep of Equipment, Tools and Appliances for Bituminous Pavement Construction
3.	IRC:90-2010	Guidelines of Selection, Operation and Maintenance of Bituminous Hot Mix Plant (First Revision)
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:5-2015	Standard Specifications and Code of Practice for Road Bridges, Section I -General Features of Design (Eight Revision)
2.	IRC:6-2014	Standard Specifications and Code of Practice for Road Bridges, Section II Loads and Stresses (Revised Edition)
3.	IRC:21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III - Cement Concrete (Plain and Reinforced) (Third Revision) (Amalgamated with IRC:12-2011
4.	IRC:22-2015	Standard Specifications and Code of Practice for Road Bridges, Section VI - Composite Construction (Limit States Design) (Third Revision)

Sr.No.	Code/Document No.	Title of the Publication
5.	IRC:24-2010	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method) Third 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:78-2014	Standard Specifications and Code of Practice for Road Bridges, Section VII Foundations and Substructure (Revised Edition)
8.	IRC:83-2015 (Part-1)	Standard Specifications and Code of Practice for Road Bridges, Section IX Bearings, Part I : Roller & Rocker Bearings (Second Revision)
9.	IRC:83-2015 (Part II)	Standard Specifications and Code of Practice for Road Bridges, Section IX Bearings, (Elastomeric Bearings), Part II (First Revision)
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
11.	IRC:87-2011	Guidelines for Formwork, Falsework and Temporary Structures (First Revision)
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:54-2000	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:51-2015	Guidelines for Load Testing of Bridges (First Revision)

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, 2014 (First Revision)
2.	MORD	Standard Data Book for Analysis of Rates, 2014
3.	NRRDA	PMGSY Operations Manual, 2005
4.	NRRDA	PMGSY Guidelines for Quality Monitoring by National Quality Monitors, 2007 (Amended from time to time).
		II. Ministry of Road Transport & Highways (MORTH)
5.	MORTH	Pocketbook for Bridge Engineers, 2000 (First Revision)
6.	MORTH	Pocketbook for Highway Engineers, 2002 (Second Revision)
7.	MORTH	Manual for Maintenance of Roads, 1983
8.	MORTH	Report of the Committee on Norms for Maintenance of Roads in India, 2001
9.	MORTH	Guidelines for Maintenance Management of Primary, Secondary and Urban Roads, 2004
10.	MORTH	Specifications for Road and Bridge works, 2013 (Fifth Revision)
11.	MORTH	Standard Plans for Highway Bridges R.C.C. T-Beam & Slab Superstructure Span from 10 m to 24 m with 12 m width, 1991
12.	MORTH	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
13.	MORTH	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
14.	MORTH	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
15.	MORTH	Standard Plan for Highway Bridges Prestressed Concrete Beam & RCC Slab Type Superstructure Volume-II
16.	MORTH	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion

Sr.No.	Code/Document No.	Title of the Publication
17.	MORTH	Type Designs for Intersections on National Highways, 1992
18.	MORTH	Manual for Safety in Road Design

APPENDIX - 5

Format 1- Part I

Format for information to SQM for Inspection of PMGSY Work

PART I –Work Information *(To be filled- up by PIU)*

Work is Ongoing / Completed

GENERAL:

1.1. Date of Inspection : DD MM YY

1.2. Name of State Quality Monitor:

1.3. District: Block:

1.4. Name of Road: From to

1.5. Package No.:

1.6. Length: ….Km Flexible Pavement, ...Km. CC/other Pavement ……...m. = Total……..Km

1.7. Estimated Cost (As cleared by GOI): Rs. Lakh
Technical Sanction

1.8. Cost: Rs. Lakh

1.9. The Work is a Case of: New connectivity | Up gradation

1.10. Terrain: Plain | Rolling | Hilly

1.11. Date of Start of the Work:

1.12. Stipulated Date of Completion:

1.13. Actual Date of Completion (if work completed):

1.14 Quality Monitor visited Road: From Km. To Km.

2. PHYSICAL PROGRESS: *(In case of On going works only)* Construction Programme and Physical Progress:

Item	Completed percentage of Item	Dates for completion	Start Date	Completion Date	Delay in Months
Preparatory work		Due			
		Actual			
Earth Work		Due			
		Actual			
CD Works		Due			
		Actual			
Sub base i/c Shoulders		Due			
		Actual			
Base Course (Non Bitu.)		Due			
		Actual			
Base /Wearing Course (Bitu.)		Due			
		Actual			
CC Pavement		Due			
		Actual			
Signage etc		Due			
		Actual			

3. QUALITY CONTROL:

3.1. Location of Field Laboratory:

3.2. Quality Control Register Part-I is maintained by:

3.3. Quality Control Register Part-II is maintained by:

4. INSPECTIONS BY NQM, SQM or SENIOR OFFICERS AND ACTION TAKEN:

Inspection by NQMs, SQMs and senior (i.e. SE or CE) departmental officers and action taken statement:

Date of Visit	Inspected By	Observations	Action Taken by PIU with Date

Name and Signature of the Head of PIU, Date: .....

Format 1- Part II

Report of State Quality Monitor (SQM)

PART II - Observations of SQM for Ongoing/Completed Work

(To be filled-up by SQM, use additional sheets, if required.)

Stage of Work: | I | II | III |

1. SETTING OUT AND WORKING DRAWING: For all stages of work

#	Whether Bench marks @ 4 per km established (Y/N)	Exact Locations of the Bench Marks	Whether Center Line of Carriage Way accurately established and referenced with Marker Pegs and Chainage Boards (Y/N)	Whether properly Prepared Working Drawing for the work under progress is available (Y/N)

Grading: Grade:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement:

2. SITE CLEARANCE AND GRUBBING: For Stage I of Work

#	Whether Clearing and Grubbing is being done as per DPR and Material obtained is being disposed off property (Y/N)	Whether the material available from scarifying existing work or clearing operations can be salvaged and reused (Y/N)	Name the reusable material obtainable from clearance or scarification and indicate approximate quantity and its re-use by the PIU.

Grading: Grade:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement:

3. QUALITY ARRANGEMENTS AND ATTENTION TO QUALITY - For all stages of work

Observations about Field Laboratory:

#	Whether Field laboratory Established (Y/N)	List the equipments available	Whether adequate Equipment as per requirement of work are available and are being used. (Y/N)

Observations about Mandatory Tests - Detail out the quantities of various items of works and list the tests required. (Refer to abstract of QC Register Part-I)

#	Item of Work Executed	Quantity	Name of Test	No. of Tests required	No. of Tests Conducted by PIU/Contractor

#	Based on executed quantities whether all mandatory tests conducted	Whether QC Register Part I maintained as per provisions.	Whether QC Register Part II maintained and test results monitored as per provisions.
	Yes / Partly / No	Yes / Partly / No	Yes / Partly / No

Grading: Grade:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement:

4. **GEOMETRICS: The SQM should take at-least two measurements in 1 Km length and if it is found that the roadway and carriageway is inadequate SQM may take more observations:**

Observations - Road way width, Carriage way and Camber.

Ref. RD (m)	Roadway Width (m)	Carriage way Width (m)	Camber in %	Ref. RD (m)	Roadway Width (m)	Carriage way width (m)	Camber in %

Observations - Super-elevation and Extra Widening at curves.

Ref. RD	Super Elevation	Extra Widening provided (Y/N)	Ref. RD	Super Elevation	Extra Widening provided (Y/N)

Grade:	S	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement:

OBSERVATIONS REGARDING THE QUALITY OF ITEMS OF WORK:

5. **Earthwork:**

Observations Quality of Material for Embankment/ Sub-grade:

#	Location (RD)	On Visual Classification identify the Group Symbol and write	Quality of material is acceptable. (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

Observation - Workmanship for Embankment and Sub-grade Construction:

#	Location (RD) (Y/N)	MDD kN/m^3 (As per record)	Field Moisture Content %	Degree of Compaction		
				Field Density kN/m3	Dry Density kN/m^3	Compaction adequate (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

Observation - Side slopes and profile:

#	Location (RD)	Whether Side Slopes Satisfactory (Y/N)	Whether profile is Satisfactory (Y/N)

Observations - Earth work in Hilly/Rolling terrain or high Embankments:

#	Location (RD)	Cut Slopes & Profile, whether appears to be stable. (Y/N)	Adequate slope protection works executed. (Y/N)	Formation is properly dressed and traffic worthy. (Y/N)

Observations - Longitudinal Gradient in case of road in hilly/rolling terrain:

Ref. Between RD…& RD…	Longitudinal Gradient	S/U	Ref. Between RD…& RD…	Longitudinal Gradient	S/U

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

6. Sub-Base:

Observations - Quality of Material and Workmanship:

#	Location (RD)	Confirms to Grading. (Y/N)	Suitable from plasticity angle. (Y/N)	Whether compaction is adequate. (Y/N)	Observed Thickness of Layer (in mm)	Prescribed Thickness provided (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

7. Base Course:

Observations - Quality of Material and Workmanship of WBM:

#	Location (RD)	Thickness of each layer of WBM (mm)	Thickness is adequate. (Y/N)	Aggregate confirms to Grading (Y/N)	Filler material is non-plastic to desired extent. (Y/N)	Volume of filler material percent of course aggregate	Whether adequate compaction is done. (Y/N)

Observations - Surface evenness: Surface evenness in about 200 m critical representative length of completed WBM:

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

8. **Bituminous Course: Premix Carpet/Surface Dressing/ BM/ MPM etc including Seal Coat: Observations - Quality of Material and Workmanship of BT Layer (*in case of ongoing works):***

Observations about level of cleanliness of WBM surface prior to application of bituminous layer. (if work is ongoing observe the surface. If BT layer laid, assess by carefully removing the BT layer.):

Observations about Quality of Prime Coat and Tack Coat with respect to quality of material and workmanship - Visual Observation - if work is ongoing:

In case of PMC/BM/MPM/ Seal Coat

#	Location (RD)	Whether Course Aggregate confirms to grading (Y/N)	Whether the binder is of approved grade. (Y/N)	Write Mixing Temperature and whether it is in permissible limits. (Y/N)	Write Laying Temperature and whether it is in permissible limits. (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

Observations - Workmanship of BT layer PMC/BM/MPM ***(in case of completed works):***

S.No	Location(RD)	Thickness		Whether surface eveness is within acceptable limits(Y/N)	
		Thickness in mm	Whether thickness is adequate (Y/N)		

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

#	RD of observation	Thickness of layer in mm	Whether quality of the material is acceptable. (Y/N)	Whether quality of compaction workmanship is acceptable.(Y/N)	Whether Shoulders being constructed simultaneously with sub-base and base course (Y/N)

10. Cross Drainage Works: Observations - Quality of CDs:

#	RD at which CD is located	Type of CD	Whether quality of the material is acceptable. (Y/N)	Whether quality of workmanship is acceptable. (Y/N)

Grade:	S	SRI	U	If this item is graded SRI / U, write clear reasons and suggestions for improvement:

11. Side Drains and Catch water Drains: Observations:

#	Reference of RDs where side drain constructed	RD at which observation made.	Whether general quality of the side drains/ catch-water drains is acceptable. (Y/N)	Whether side drains are integrated to cross drains, (Y/N)

Grade:	S	SRI	U	If this item is graded SRI / U, write clear reasons and suggestions for improvement:

12. CC/ Semi-Rigid (SR) Pavements and Associated Pucca Side Drains:

#	Reference of RDs, CC/SR Pavements provided	RD at which observed on made	Thickness		General Quality of material acceptable (Y/N)	General Quality of is Workmanship Acceptable (Y/N)
			Thickness in mm	Accepted (Y/N)		

Comments about adequacy of face/main walls, wings and retaining walls:

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

13. Road Furniture and Markings

Observations - Quality Road Furniture and Markings: (on going/completed)

Main Informatory Board Fixed:	**Yes**	**No**
Citizen Information Board Fixed:	**Yes**	**No**

Grade:	**S**	**U**	**If this item is graded U, write clear reasons and suggestions for improvement:**

Observations - Quality Road Furniture and Markings (in case of completed works):

13.1.1. Logo Boards Fixed:	**Yes**	**No**
13.1.2. 200m. Stones fixed:	**Yes**	**No**
13.1.3. 1 Km. Stone fixed:	**Yes**	**No**
13.1.4. Guard Stones fixed on Curves:	**Yes**	**No**
13.1.5. Mandatory and Cautionary Signage	**Yes**	**No**

Grade:	**S**	**U**	**If this item is graded U, write clear reasons and suggestions for improvement:**

14. General Observations of SQM, (including the observations made during the interaction with PIU staff and Contractor / Consultant Engineers):

14.1. Observations about deficiency in project preparation (Give detailed observations about deficiencies in general and items which have been left but are required as per site conditions):

14.2. Whether the work has been completed/is in progress as per work programme or the delay has occurred. If delay has occurred, whether the liquidated damages have been withhold or recovered:

14.3. Whether the work has been completed within the sanctioned cost, if not, what is the action taken by the PIU (in case of complete works):

14.4. Observations about the action taken by the PIU on the observations of inspecting officers including SQMs and NQMs. (Clearly offer comments about the action taken on the observations of Departmental Officers, State Quality Monitors and National Quality Monitors).

14.5. Comments about difference in observations made by NQMs/SQMs in earlier inspections (the NQM shall study the earlier inspection reports of NQMs / SQMs, if any and offer his clear comments about the differences in observations, if any).

15. Other observations, if any:

16. Quality Grading of items and sub-items of work: The grading of every sub-item and item of work is given below.

#	Sub Item for Observation	Stage of Work	Awardable Grades	Awarded Grades
1	2	3	4	5
Item 1 – Setting Out and Working Drawing				
a	Bench Mark and Centre Line	All Stages	S/SRI/U	
b	Availability of Working Drawing	All Stages	S/SRI/U	
		Item Grade	S/SRI/U	
Item 2 – Site Clearance and Grubbing				
a	Site Clearance and Grubbing	Stage-I	S/SRI/U	
b	Re-use of Salvageable Material	Stage-I	S/SRI/U	
		Item Grade	S/SRI/U	
Item 3 - Quality Arrangements				
a	Quality Arrangements	All Stages	S/SRI/U	
b	Number of Mandatory Tests as per prescribed frequency	All Stages	S/SRI/U	
c	Maintenance of QC Registers	All Stages	S/SRI/U	
		Item Grade	S/SRI/U	
Item 4 – Geometrics				
a	Road way width	2 per Km in every inspection	S/U	
b	Carriageway width	2 per Km in every inspection	S/U	
c	Camber	2 per km	S/U	
d	Super-elevation & Extra Widening at Curves	1 curve in each km	S/U	
		Item Grade	S/SRI/U	
Item 5A - Earth Work and Sub-grade in Embankment/ Cutting				
a	Quality of Material for Embankment/ Sub-grade	In Stage-I, 1 per km/ In Stage- II or III, 1 per km	S/U	
b	Compaction	In Stage-I, 2 per km/ In Stage- II or III, 2 per km	S/U	
c	Side Slopes and Profile	2 per km in Stage III	S/U	

#	Sub Item for Observation	Stage of Work	Awardable Grades	Awarded Grades
1	2	3	4	5
Item 5B - Earth Work in Cutting in Hilly/ Rolling Terrain				
a	Stability and Workmanship of Cut Slopes	Stage I and II, at 2 critical locations with maximum height of cutting in each km	S/U	
b	Adequacy of Slope Protection	All Stages - In general	S/U	
c	Upon completion of formation cutting, dressing, traffic worthiness	At Stage III, at 2 critical locations with maximum height of cutting in each km	S/U	
d	Longitudinal Gradient	Stage II/III - 1 critical and fairly representative stretch of 200m in each Km	S/U	
		Item Grade	S/U	
Item 6 - Sub-Base				
	Quality of Material			
a	Grain Size	In Stage - II or III, 1 per km	S/U	
b	Plasticity		S/U	
c	Compaction	In Stage- II or III, 1 per km	S/U	
d	Total Thickness of Layer	2 per Km	S/U	
		Item Grade	S/U	
Item 7 - Base Course – Water Bound Macadam				
a	Grain Size of Course Aggregate		S/U	
b	Test for Liquid Limit and Plasticity Index in case fine aggregates are crushable type	In Stage-II or III, 1 per km	S/U	
c	Volumetric Analysis for assessment of compaction of WBM	In Stage- II or III, 1 per km	S/U	
d	Surface Evenness using straight edge	In completed WBM 2 tests per km	S/U	
e	Thickness of every layer of WBM.	2 per Km	S/U	

#	Sub Item for Observation	Stage of Work	Awardable Grades	Awarded Grades
1	2	3	4	5
		Item Grade	S/U	
Item 8 - Bituminous Layer – Premix Carpet (PMC)/ Surface Dressing (SD)				
a	Level of cleanliness of WBM surface prior to application of bituminous layer	1 per Km	S/U	
b	Quality of Prime Coat/ Tack Coat with respect to quality of material and workmanship	1 observation on the day of inspection	S/U	
c	Gradation Test for Course Aggregate (if the work in the item is ongoing)/visual observation in case of completed item of work	1 test on the day of inspection	S/U	
d	Grade of bitumen and temperature at the time of mixing and laying (if the work in the item is ongoing)	1 test on the day of inspection	S/U	
e	Bitumen Extraction Test if PMC is complete	1 test per Km	S/U	
f	Thickness of layer	2 per Km	S/U	
g	Surface Evenness in case of completed BT work	2 per Km	S/U	
		Item Grade	S/U	
Item 9 – Shoulders				
a	Quality of material for Shoulders	In Stage- II or III, 1 test per Km	S/SRI/U	
b	Degree of compaction	In Stage- II or III, 1 test per Km	S/SRI/U	
c	Thickness of layer	In Stage- II or III, 2 tests per km	S/SRI/U	
		Item Grade	S/SRI/U	
Item 10 - Cross Drainage Works – Causeways of all spans and Culverts upto 6 m. span.				
a	Quality of Material – Concrete, Stone/ brick masonry, Hume pipes including size etc.	All Stages	S/SRI/U	

#	Sub Item for Observation	Stage of Work	Awardable Grades	Awarded Grades
1	2	3	4	5
b	Quality of Workmanship such as positioning of pipes, wing walls, cushion over H Pipes etc.	All Stages	S/SRI/U	
		Item Grade	S/SRI/U	
Item 11 - Side Drain and Catch Water Drain				
a	General quality of Side Drains/ Catch Water Drains and their integration with CDs.	All Stages	S/SRI/U	
		Item Grade	S/SRI/U	
Item 12 - CC/ Semi Rigid Pavements and Associated Pukka Drains				
a	Quality of Material – Concrete, Stone/ Concrete Block Pavement etc.	In Stage- II or III, 1 per 100 m. Length of Pavement	S/U	
b	Strength of CC in Concrete Pavement/ Concrete Block Pavement	In Stage- II or III,1 per 100 m. Length of Pavement	S/U	
c	Quality of Workmanship – Wearing surface texture, Adequacy of setting of concrete, Joints, Edges etc.	In Stage- II or III	S/U	
d	Thickness of Layer	In Stage- II or III, 1 per 100 m. Length of Pavement	S/U	
		Item Grade	S/U	
Item 13 - Road Furniture and Markings				
a	Citizen Information Board, Main Informatory Board, Quality and whether fixed during construction.	Stage-I	S/U	
b	Logo boards, 200 m stones and Km stones, quality and whether fixed after completion	Stage-III	S/U	
c	Whether the information in boards is given in local language.	Stage-I and III	S/U	

17. Overall Grading of Work: The overall grading calculated on the basis of item and sub-item wise grading is given below:

Item No.	Sub Item for Observation	Awarded Grade
Item No 1	Setting Out and Working Drawing	
Item No 2	Site Clearance and Grubbing	
Item No 3	Quality Arrangements	
Item No 4	Geometrics	
Item No 5 A	**Earth Work and Sub-grade in Embankment/Cutting**	
Item No 5 B	**Earth Work in Cutting in Hilly/ Rolling Terrain**	
Item No 6	**Sub-Base**	
Item No 7	**Base Course Water Bound Macadam**	
Item No 8	**Bituminous Layer Premix Carpet (PMC)/ Surface Dressing (SD)**	
Item No 9	Shoulders	
Item No 10	Cross Drainage Works - Causeways of all spans and Culverts upto 6 m. span.	
Item No 11	Side Drain and Catch Water Drain	
Item No 12	CC/ Semi Rigid Pavements and Associated Pukka Drains	
Item No 13	Road Furniture and Markings	
	Overall Grading	

Signature: .....

Name: .....

Date: ..…….....

APPENDIX - 6

Format 1- Part I

Format for information to NQM for Inspection of Ongoing/Completed Work
PART I Work Information (To be filled-up by PIU)

Work is | **Ongoing** | **Completed** |

GENERAL:

1.1. Date of Inspection:

1.2. Name of National Quality Monitor: _____

1.3. State: District: Block:

1.4. Name of Road: From

1.5. Package No.: to

1.6. Length: ....Km Flexible Pavement, ...Km. CC/other Pavement = Total .....Km.

1.7. Estimated Cost (As cleared by GOI):

Rs. Lakh

1.8. Technical Sanction Cost: Rs. Lakh

1.9. The Work is a Case of: | New connectivity | Up gradation |

1.10. Terrain | Plain | Rolling | Hilly |

1.11. Date of Start of the Work:

1.12. Stipulated Date of Completion:

1.13 Actual Dtae of Completion (if work completed)

1.14 Quality Monitor visited road From Km. To Km.

2. PHYSICAL PROGRESS: ***(In case of Ongoing works only)*** Construction Programme and Physical Progress:

Item	Completed percentage of Item	Dates for completion	Start Date	Completion Date	Delay in Months
Preparatory work		Due			
		Actual			
Earth Work		Due			
		Actual			
CD Works		Due			
		Actual			
Sub base i/c Shoulders		Due			
		Actual			
Base Course (Non Bitu.)		Due			
		Actual			
Base /Wearing Course (Bitu.)		Due			
		Actual			
CC Pavement		Due			
		Actual			
Signage etc		Due			
		Actual			

3. QUALITY CONTROL:

3.1. Location of Field Laboratory:

3.2. Quality Control Register Part-I is maintained by:

3.3. Quality Control Register Part-II is maintained by:

4. INSPECTIONS BY NQM, SQM or SENIOR OFFICERS AND ACTION TAKEN:

Inspection by NQMs, SQMs and senior (i.e. SE or CE) departmental officers and action taken statement:

Date of Visit	Inspected By	Observations	Action Taken by PIU with Date

Name and Signature of the Head of PIU, Date:……

Format 1- Part II

Report of National Quality Monitor (NQM)

PART II Observations of NQM for Ongoing/Completed Work

(To be filled-up by NQM, use additional sheets, if required.)

1. QUALITY ARRANGEMENTS-OBSERVATIONS (In Case of ongoing works only):

Observations:

#	Whether laboratory (Y/N)	Field Established (Y/N)	Whether necessary Equipments available (Y/N)	Whether Equipments have been used (Y/N)

Grading: Grade:	S	RI	U	If this item is graded RI/U, write clear reasons and suggestions for improvement:

2. ATTENTION TO QUALITY: (In Case of ongoing works only):

Observations - Item 2a: Maintenance of QC Registers:

#	Based on executed quantities whether all mandatory tests conducted	Whether QC Register Part-I maintained as per provisions.	Whether QC Register Part-II maintained and test results monitored as per provisions.
	Yes / Partly / No	Yes / Partly / No	Yes / Partly / No

Observations - Item 2b: Verification of Test Results (P - conforms, F - does not conform):

#	Name of Test	Results of the test conducted by NQM at a defined location. (P/F)	Test result as per QC Register at the same location. (Mention the Page No. of QC Register also) (P/F)	Whether the test results recorded in QC register found correct? (Y/N)

Grade:	S	RI	U	If this item is graded RI/U, write clear reasons and suggestions for improvement:

3. **GEOMETRICS:** The NQM should take at-least two measurements in 1 Km length and if it is found that the roadway and carriageway is inadequate NQM may take more observations:

Observations Item 3 a, b and c: Road way width, Carriage way and Camber

Ref. RD (m)	Roadway Width (m)	Carriage way Width (m)	Camber in %	Ref. RD (m)	Roadway Width (m)	Carriage way width (m)	Camber in %

Observations - Item 3 d: Superelevation and Extra Widening at curves.

Ref. RD	Super Elevation	Extra Widening provided (Y/N)	Ref. RD	Super Elevation	Extra Widening provided (Y/N)

Observations - Item 3 e: Longitudinal Gradient in case of road in hilly/rolling terrain

Ref. Between RD…& RD…			Longitudinal Gradient	S/U	Ref. Between RD…& RD…	Longitudinal Gradient	S/U
GRADE:	S	U	If this item is graded U,write clear reasons and suggestions for improvement				

OBSERVATIONS REGARDING THE QUALITY OF ITEMS OF WORK:

4. Earthwork:

Observations - Item 4 a Quality of Material for Embankment/ Sub-grade:

#	Location (RD)	On Visual Classification identify the Group Symbol and write	Quality of material is acceptable. (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

Observation - Item No. 4 b: Workmanship for Embankment and Sub-grade Construction:

#	Location (RD)	MDD kN/m^3 (As per record)	Field Moisture Content	Degree of Compaction		
				Field Density kN/m^3	Dry Density kN/m^3	Compaction adequate. (Y/N)

Grade:	S	U	If this item is graded RI/U, write clear reasons and suggestions for improvement:

Observation - Item No. 4 c, Side slopes and profile:

#	Location (RD)	Whether Side Slopes Satisfactory (Y/N)	Whether profile is Satisfactory (Y/N)

Observations - Item No. 4 d and e, Earth work in Hilly/Rolling terrain or high Embankments:

#	Location (RD)	Cut Slopes & Profile, whether appears to be stable. (Y/N)	Adequate protection	Slope Works	Formation is dressed and worthy (Y/N)	properly traffic
Grade:s		If this item is graded U, write clear reasons and suggestions for improvement				

5. Sub-Base:

Observations- Item No. 5 a, b, c and d, Quality of Material and Workmanship:

#	Location (RD)	Confirms to Grading. (Y/N)	Suitable from plasticity angle. (Y/N)	Whether compaction is adequate. (Y/N)	Observed Thickness of Layer (in mm)	Prescribed Thickness provided (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

6. Base Course:

Observations- Item No. 6 a, b, c and d, Quality of Material and Workmanship of WBM:

#	Location (RD)	Thickness of each layer of WBM (mm)	Thickness is adequate. (Y/N)	Aggregate confirms to Grading (Y/N)	Filler material is non-plastic to desired extent. (Y/N)	Volume of filler material percent of course aggregate	Whether adequate compaction is done. (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

7. Bituminous Course: Premix Carpet/Surface Dressing/ BM/ MPM etc including Seal Coat:

Observations- Item No. 7 a, b, and c, Quality of Material and Workmanship of BT Layer (*in case of ongoing works*):

#	Location (RD)	Whether Course Aggregate confirms to grading. (Y/N)	Whether the binder is of approved grade. (Y/N)	Write Mixing Temperature and whether it is in permissible limits. (Y/N)	Write Laying Temperature and whether it is in permissible limits. (Y/N)

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

Observations - Item No. 7 d and e, Workmanship of BT layer (*in case of completed works):*

#	Location (RD)	Thickness		Whether surface evenness is within acceptable limits. (Y/N)
		Thickness in mm	Whether thickness is adequate. (Y/N)	

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

8. Observations- Item No. 8 a and b, Quality of Shoulders (*in case of completed works):*

#	RD of observation	Whether general quality of material acceptable. (Y/N)	Whether general the quality is workmanship acceptable. (Y/N)	Whether Camber in of Shoulders is adequate is (Y/N)

9. Cross Drainage Works: Observations Item No. 9 a and b, Quality of CDs:

#	RD at which CD is located	Type of CD	Whether general quality of the material is acceptable. (Y/N)	Whether general quality of workmanship is acceptable. (Y/N)

Grade:	S	RI	U	If this item is graded RI/U, write clear reasons and suggestions for improvement:

10. Side Drains and Catch water Drains: Observations:

#	Reference of RDs where side drain constructed.	RD at which observation made.	Whether general quality of the side drains/ catch - water drains is acceptable. (Y/N)	Whether side drains are integrated to cross drains. (Y/N)

Grade:	S	RI	U	If this item is graded RI/U, write clear reasons and suggestions for improvement:

11. CC/ Semi-Rigid (SR) Pavements and Associated Pucca Side Drains: Item No. 11 a, b, c and d:

#	Reference of RDs, CC/SR Pavements provided.	RD at which observation made.	Thickness		General quality of material is acceptable. (Y/N)	General quality of workmanship acceptable (Y/N)
			Thickness in mm	Acceptable (Y/N)		

Grade:	S	U	If this item is graded U, write clear reasons and suggestions for improvement:

12. Road Furniture and Markings

Observations - Item No. 12 a: Quality Road Furniture and Markings (in case of ongoing/completed works):

Main Informatory Board Fixed: Yes/No

Citizen Information Board Fixed: Yes/No

Grade: S / U If this item is graded U, write clear reasons for improvement:

Observations - Item No. 12 b: Quality Road Furniture and Markings (in case of completed works):

i.	Logo Boards Fixed:	Yes	No
ii.	200m. Stones fixed:	Yes	No
iii.	1 Km. Stone fixed:	Yes	No
iv.	Guard Stones fixed on Curves:	Yes	No
v.	Mandatory and Cautionary Signage	Yes	No
Grade:	S / U		

If this item is graded U, write clear reasons and suggestions for improvement

13. General Observations of NQM, (including the observations made during the interaction with PIU staff and Contractor/ Consultant Engineers):

a. Observations about deficiency in project preparation (Give detailed observations about deficiencies in general and items which have been left but are required as per site conditions):

b. Whether the work has been completed/is in progress as per work programme or the delay has occurred. If delay has occurred, whether the liquidated damages have been withhold or recovered:

c. Whether the work has been completed within the sanctioned cost, if not, what is the action taken by the PIU (in case of complete works):

d. Observations about the action taken by the PIU on the observations of inspecting officers including SQMs and NQMs. (Clearly offer comments about the action taken on the observations of Departmental Officers, State Quality Monitors and National Quality Monitors).

e. Comments about difference in observations made by NQMs/SQMs in earlier inspections (the NQM shall study the earlier inspection reports of NQMs / SQMs, if any and offer his clear comments about the differences in observations, if any).

14. Other observations, if any:

15. Quality Grading of items and sub-items of work: The grading of every sub-item and item of work is given below.

#	Sub Item for Observation	In case of work	Awardable Grades	Awarded Grades
1	2	3	4	5
Item 1 - Quality Arrangements				
	Quality Arrangements	On-going	S/RI/U	
		Item Grading	S/RI/U	
Item 2 - Attention to Quality				
a	Maintenance of QC Registers	On-going	S/RI/U	
b	Verification of test results	On-going/Complete	S/U	

#	Sub Item for Observation	In case of work	Awardable Grades	Awarded Grades
1	2	3	4	5
		Item Grading	S/RI/U	
Item 3 – Geometrics				
a	Road way width	Ongoing or complete	S/U	
b	Carriageway width		S/U	
c	Camber		S/U	
d	Superelevation & Extra Widening at Curves		S/U	
e	Longitudinal Gradient in case of road in hilly/ rolling terrain.	Ongoing/ complete	S/U	
		Item Grading	S/U	
Item 4 - Earth Work and Sub-grade in Embankment/ Cutting				
a	Quality of Material for Embankment/Sub-grade	Ongoing or complete	S/U	
b	Compaction		S/U	
c	Side Slopes and Profile	Complete	S/U	
d	Stability and Workmanship of Cut Slopes (in case of hilly/rolling terrain)	Ongoing or complete	S/U	
e	Adequacy of Slope Protection (in case of high embankments/hilly/rolling terrain)		S/U	
		Item Grading	S/U	
Item 5 - Sub-Base				
a	Grain Size	Ongoing or complete	S/U	
b	Plasticity		S/U	
c	Compaction	Ongoing or complete	S/U	
		Item Grading	S/U	
Item 6 - Base Course – Water Bound Macadam				
a	Grain Size of Course Aggregate	Ongoing or complete	S/U	
b	Plasticity of Crushable Aggregate used as fillers		S/U	

#	Sub Item for Observation	In case of work	Awardable Grades	Awarded Grades
1	2	3	4	5
c	Adequacy of Compaction through volumetric analysis.	Ongoing or complete	S/U	
d	Thickness of every layer of WBM.		S/U	
		Item Grading	S/U	
Item 7 - Bituminous Layer – Premix Carpet (PMC)/ Surface Dressing (SD)				
a	Gradation of Aggregate	Ongoing	S/U	
b	Mixing Temperature of Mix.	Ongoing	S/U	
c	Laying Temperature of Mix.	Ongoing	S/U	
d	Thickness of layer	Ongoing or complete	S/U	
e	Surface Evenness	Ongoing or complete	S/U	
		Item Grading	S/U	
Item 8 – Shoulders				
a	Quality of material for shoulders	Complete	S/RI/U	
b	Degree of compaction	Complete	S/RI/U	
c	Camber.	Complete	S/RI/U	
		Item Grading	S/RI/U	
Item 9 - Cross Drainage Works				
a	Quality of Material–Concrete, Stone/ brick masonry, Hume pipes including size etc.	Ongoing or complete	S/RI/U	
b	Quality of Workmanship such as positioning of pipes, wing walls, cushion over H Pipes etc.		S/RI/U	
		Item Grading	S/RI/U	
Item 10 - Side Drain and Catch Water Drain				
	General quality of Side Drains/ Catch Water Drains and their integration with CDs.	Ongoing or complete	S/RI/U	

#	Sub Item for Observation	In case of work	Awardable Grades	Awarded Grades
1	2	3	4	5
		Item Grading	S/RI/U	
Item 11 - CC/ Semi Rigid Pavements and Associated Pukka Drains				
a	Quality of Material – Concrete, Stone/ Concrete Block Pavement etc.	Ongoing or complete	S/U	
b	Strength of CC in Concrete Pavement/Concrete Block Pavement		S/U	
c	Quality of Workmanship–Wearing surface texture, Adequacy of setting of concrete, Joints, Edges etc.		S/U	
d	Thickness of Layer		S/U	
		Item Grading	S/U	
Item 12 - Road Furniture and Markings				
a	Citizen Information Board, Main Informatory Board, Quality and whether fixed during construction.	Ongoing	S/U	
b	Logo boards, 200 m stones and Km stones, quality and whether fixed after completion.	Complete	S/U	
c	Whether the information in boards is given in local language.	Complete/ Ongoing	S/U	

16. **Overall Grading of Work:** The overall grading calculated on the basis of item and sub-item wise grading is given below:

#	Item	Awarded Grade
1	Quality Control Arrangements	
2	Attention to Quality	
3	Geometrics	
4	**Earthwork and Sub-grade in Embankment/Cutting**	
5	**Granular Sub-base**	
6	**Base Course Non-Bituminous and shoulders**	
7	**Bituminous Surfacing**	
8	Shoulders	
9	CD Works	
10	Side Drains and Catch Water Drains	
11	CC/Semi-Rigid Pavement and Associated Pukka Drains	
12	Road Furniture and Markings	
	Overall Grading	

Signature: .....

Name: .....

Date: ..…….....

APPENDIX - 7

Format 1- Part I

NATIONAL RURAL ROADS DEVELOPMENT AGENCY

FORMAT FOR INSPECTION OF BRIDGE WORK UNDER PMGSY

Part 1 - Work Information (to be filled by PIU)

GENERAL:

1.1 Date of Inspection :

1.2 Name of NQM :

1.3 State: _____ District : _____Block_____

1.4 Name of the Road : From

1.5 Package No. _____ Through Road No. _____

1.6 Location of Bridge : RD

1.7 Estimated Cost as cleared by GoI Rs. : _____

1.8 Date of Start

1.9 Date of Completion as per Agreement

1.10 Actual date of Completion(if work is completed)

2. PROGRESS

(In case of ongoing works only) Construction programme & Physical progress

Item	% of Progress	Date of Starting as per programme	Date of completion as per programme	Actual Completion Date	Delay in months
Lay out					
Foundation					
Sub-Structure					
Supper structure					
Protection Work					
Approaches					

3. PARTICULARS OF THE BRIDGE :

3.1	Type of the bridge	:	Open	Raft	well	Pile
3.2	Type of foundation	:				
3.3	No. of Spans / Spans length	:	.....Spans of.....m. c/c			
3.4	Width of Bridge	:	5.50 m.	7.50 m.		
3.5	R.T.L	:				
3.6	HFL /OFL	:				
3.7	Bed level (Lowest)	:				

3.8 Catchment area ____, Cross Section of Drain at HFL ____, Design discharge__

3.9 Type of river protection works if any : _____

3.10 Type of Substructure : _____

3.11 Type of Bearing : _____

3.12 Type of Superstructure : _____

3.13 Type of Returns : _____

3.14 Whether approaches are in cutting or filling : _____

3.15 Whether Bench Mark and alignment are established near the bridge site (give location and RL) : _____

3.16 Type of Railing (Steel/RCC/Others) : _____

3.17 Type of Wearing coat : _____

4. QUALITY CONTROL :

4.1 Location of Field Laboratory : _____

4.2 Q.C. Test Records maintained by (Name) : _____

4.3 Abstract of Q.C. Records maintained by (Name) : _____

4.4 Quality of Concrete executed : _____

4.5 No. of cube tests done : _____

5. Inspection by NQM/SQM and action taken

Sr. No	Date of Visit	Inspected by (Name)	Deficiencies observed	Action taken by PIU with date
1				
2				
3				
4				

Date

Place :

Name & Signature of PIU

_____

Format 1- Part II

PACKAGE NO _____

PART – II (to be filled by National Quality Monitor)

1. QUALITY ARRANGEMENTS AND ATTENTION TO QUALITY - For on-going work

Observations about Field Laboratory : _____

Whether Field Laboratory Established (Y/N)	List the equipments available in field laboratory Including first Aid-Box	Whether adequate equipments as per requirement of work are available and are being used (Y/N)

Observations about Mandatory Tests – The quantities of various items of works and list the tests required.

(Refer to abstract of QC Register Part-I)

Sr. No.	Item of work executed	Quantity	Name of Test	No of tests required	No. of tests conducted by PIU / Contractor

Based on executed quantities, whether all mandatory tests conducted			Whether QC Register Part-I maintained as per provision			Whether QC Register Part-II maintained and test results monitored as per provisions		
Yes	Partly	No	Yes	Partly	No	Yes	Partly	No

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

2. FOUNDATION (Stage I)

a) Ongoing (Work in progress)

Location		Availability of field drawing	Grade of concrete	Whether mix design enclosed or not	Passed by competent authority	Quality of Cement	Quality Of coarse aggregate	Quality Of fine aggregate	Quality of Steel	Form work arrangement	Whether reinforcement checked by competent authority	Workability Of Concrete	Compaction arrangement	Thickness compared to design	Curing arrangements	Grade awarded
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

b) **Completed work**

Location	Grade of concrete	Compressive strength of Concrete cube as per QC Register	Surface acceptability	Workman ship	Quality assessment by personal judgment	Grade awarded
1	2	3	4	5	6	7

Grade:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement:

3. SUBSTRUCTURE (Stage II)

a) Ongoing (Work in progress)

Location	Item of work	Mix design / Grade of Concrete	Quality of material				Workmanship				Arrangement of weep holes	Rubble filling behind abutment and return	Grade awarded
			Cement	Course Aggregate	Fine Aggregate	reinforcement	Shuttering	Workability of C.C.	Compaction	Laying of reinforcement			
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

b) **Completed work**

Location	Item of work	Grade of concrete	Compressive strength of Concrete cube	Surface acceptability	Size & Shape as per design	Weep holes Adequacy (For abutment and return)	Riding returns	Grade awarded
1	2	3	4	5	6	7	8	9

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

4. SUPERSTRUCTURE (Stage III)

a) Ongoing (Work in progress)

Location	Item of work	Mix design/ Grade of Concrete	Quality of material				Workmanship				Camber	Grade awarded
			Cement	C.A.	F.A.	Reinforcement Verification of properties of lot with standard norms	Shuttering	Workability of C.C.	Compaction	Reinforcement checking with drawing		
1	2	3	4	5	6	7	8	9	10	11	12	13

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

b) **Completed work**

Location	Item of work	Mix design / Grade of Concrete	Compressive strength of concrete cube	Surface acceptability	Size & Shape as per design	Camber	Bearing	Krebs	Wearing coat	Railing	Exp. Joints	Approach slab	Stopper	Protection work	Grade awarded
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

5. Contraction joint according to IS Code

(i) Type ____

(ii) Spacing Y/ N

(iii) Cross Section Y /N

6. Results of load test according to IS Y / N

If yes, comment required & copy of test result shall be enclosed.

7. APPROACHES (Stage II & III)

7.1 Embankment

Location	Suitability of soil	Compaction	Side slopes	Shoulders	Grade
1	2	3	4	5	6

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

7.2 Sub Base (G.S.B.)

Location	Suitability of Material	Thickness as compared to design	Compaction	Grade
1	2	3	4	5

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

7.3 Base Course (Non Bituminous (WBM) and Bituminous (MPM)

Location	Suitability of Material	Thickness as compared to design	Compaction	Grade
1	2	3	4	5

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

7.4 Wearing Course

Location	Suitability of Material	Thickness as compared to design	Surface regularity	Camber	Grade
1	2	3	4	5	6

Grading:	S	SRI	U	If this item is graded SRI/U, write clear reasons and suggestions for improvement :

8 ROAD FURNITURE AND MARKINGS :

Observations: : Quality of Road Furniture and Markings : (All stages)

Main Information Board Fixed :	Yes	No
Citizen Information Board Fixed :	Yes	No

Grade:	S	U	If this item is graded as U, write clear reasons and suggestions for improvement :

Observations: : Quality of Road Furniture and Markings : (Stage III)

8.1	Logo Boards fixed	:	Yes	No
8.2	Guard stones fixed on approaches	:	Yes	No
8.3	Mandatory and caution signage	:	Yes	No

Grade :	S	U	If this item is graded as U, write clear reasons and suggestions for improvement :

9 Whether the work has been completed / is in progress as per work programme or the delay has occurred. If delay has occurred, whether the liquidated damages have been withheld or recovered

10 Whether the work has been completed within the sanctioned cost, if not, what is the action taken by the PIU (in case of completed works);

11 Observations about the action taken by the PIU on the observations of inspecting officers including SQMs and NQMs. (Clearly offer comments about the action taken on the observations of Departmental. Officers, State Quality Monitors and National Quality Monitors.)

12 Comments about difference in observations made by NQMs / SQMs in earlier inspections (the NQM shall study the earlier inspection reports of NQMs / SQMs, if any and offer his clear comments about the differences in observations, if any.)

13 Other Observations, if any:

(1).

(2).

(3).

(4).

14. Overall Grading of works: The overall grading calculated on the basis of item and sub-item wise grading is given below. The overall grading shall be 'U' if any of the grading of item no 2,3 or 4 is 'U'. Overall grading shall be 'SRI' if item no. 2,3,4 are graded as 'S' and any of the item no. 1,5,6 are graded as 'U' or 'SRI'. If all the items are graded as 'S', the overall grading will be 'S'.

Item No.	Sub Item for observation	Awarded Grade
Item No. 1	Quality arrangements	S/SRI/U
Item No. 2	Foundation	S/SRI/U
Item No. 3	Sub structure	S/SRI/U
Item No. 4	Super structure	S/SRI/U
Item No. 5	Approaches	S/SRI/U
Item No. 6	Road furniture & marking	S/SRI/U
	Overall grading	S/SRI/U

Signature of NQM

Date …….. **Name ……..……**

APPENDIX - 8

Format for Inspection of Maintenance Aspects of completed PMGSY Work

1. Date of Inspection:

2. Name of National Quality Monitor:

3. State: District: Block:

4. Name of Road: From To

5. Package No:

6. Year of clearance:

7. Length in Flexible pavement- CC/other pavement- Km. Total- Km.

8. Estimated Cost (As cleared by GOI):

9. Cost upon Completion:

10. The Work is a Case of: New connectivity | Up gradation

11. Actual Date of Completion:

Observations:

1.	**Name of Item/ Activity:** Maintenance of road in respect to Restoration of rain cuts as per clause 1902 of the Specifications and Cutting of branches of trees shrubs and trimming of grass and weeds etc as per clause 1915 of the Specifications.	
a.	**Observations:** What is the condition of Roads in the respect of this item.	
b.	**Grading for the above item**	S/U

2.	**Name of Item/ Activity:** Restoration of rain cuts and dressing of berms as per clause 1902 of the Specifications and making up of shoulders as per Clause 1903 of the Specifications.				
a.	**Observations:** What is the condition of Road in respect to this item:				
b.	**Grading for the above item**	S/U			
3.	**Condition of Pavement including filling pot holes and patch repairs etc as per clause 1904, 1905 and 1906 of the Specifications.**				
a.	**Observations:** What is the condition of Road in respect to this item. Detailed observations should be made as to whether the pavement has potholes, cracking, ravelling etc. which is causing disturbance / discomfort in driving? if yes, whether these defects has been repaired properly under routing maintenance ?				
b.	**Observations:** What is the pavement condition index (PCI) as per annexure 14.7 Para 14.9 of Operations Manual	5	4	3	<3
c.	**Grading for the above item**	S/U			
4.	**Name of item/ Activity :** Maintenance of drains as per clause 1908 of the Specification, Maintenance of culverts and causeways as per clause 1909 and 1910 of the Specifications				
a.	**Observations:** What is the condition of Road in respect to this item :				
b.	**Grading for the above item**	S/U			
5.	**Name of Item/ Activity :** Maintenance of Road signs as per clause 1911 of the Specification are white washing guard stones Re-fixing displaced Guard stones, white washing parapets of C.D. works				
a.	**Observation:** What is the condition of Road in respect to this item :				

b.	**Grading for the above item**	S/U
6.	**Name of Item/ Activity:** Maintenance of guard rails and parapet rails as per clause 1912 of the Specifications, Maintenance of 200 m and Kilo Meter stones as per clause 1913 of the Specifications.	
a.	**Observation:** What is the condition of Road in respect to this item :	
b.	**Grading for the above item**	S/U
7.	**Over all grading**	**S/SRI/U**

Signature

Date ……

Name of NQM

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