Department of Civil Engineering

Course File

Highway Construction and Management (CE622PE)

III B.Tech II Semester

2023-24

Dr.M.S.Siva Kumar
Professor

Anurag Engineering College
(An Autonomous Institution)
Ananthagiri, Kodad, Telangana 508 206, India.

Department of Civil Engineering

HIGHWAY CONSTRUCTION AND MANAGEMENT

Check List

Department of Civil Engineering

Int. Marks: 25 Ext. Marks: 75 Total Marks: 100

ANURAG ENGINEERING COLLEGE
(An Autonomous Institution)
III Year B.Tech. II Semester

L	T	P	C
3	0	0	3

(CE622PE) HIGHWAY CONSTRUCTION AND MANAGEMENT

UNIT-I

TYPES OF HIGHWAY CONSTRUCTION AND LAYERS: Water Bound Macadam (WBM), Wet Mix Macadam (WMM), Dry Lean Concrete (DLC), Soil Stabilized Roads and Interface treatments. Construction techniques and Construction equipment's. Quality control tests during construction of sub grade, sub-base and base courses. IRC specifications.

UNIT-II

BITUMINOUS CONSTRUCTION CONSTRUCTIONS: Types of bituminous layer constructions: SDBC, BC, BM, DBM, Slurry seal and micro surfacing. Selection of wearing course under different climatic and traffic conditions, IRC specifications, construction procedures, and tests on various bituminous mixes, Construction equipment's, Quality Control during and post construction of bituminous pavements and IRC specifications.

UNIT-III

TYPES OF PAVEMENT CONSTRUCTION PROCEDURE: Construction of Cement Concrete pavement Constructions (IRC:15). Introduction to continuously reinforced, Prestressed and Steel Fiber Reinforced (SFRC) Pavements, Methods of construction of joints in concrete pavements, IRC and MORTH specifications, Pavement and overlay construction. Construction techniques and Construction equipment's, Quality control tests during and post construction of concrete pavements.

UNIT-IV

HILL LANDSIDES: Causes and control measures: Hill road construction practices, Construction of bituminous and cement concrete roads at high attitudes, Hill road drainage. Construction techniques and Construction equipment's, Quality control tests during and post construction of Hill Roads.

UNIT-V

PAVEMENT EVALUATION: Structural and functional evaluation of pavements, Introduction to IRI, Bump Integrator, Benkelman Beam and Falling weight deflect meter, Overlay design by Benkelman beam tests, Distress types in bituminous and concrete pavements, causes of distresses, Maintenance Problems and their remedial measures.

TEXT BOOKS:

1. Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
2. Fundamentals of ITS planning –MashnurA.Chowdary

REFERENCE BOOKS:

1. H.M.SO. (London), "Bituminous Materials in Road Construction", 1966.
2. Hewes, Laurance, Isley "American Highway Practice", New York, John Wiley and Sons, Inc.Vol. II, 4th Edition, 1949.
3. IRC:15, IRC:81, Relevant and latest IRC Codes. 109
4. Morth, Specifications for Road and Bridge Works, 5h Rev, Published by IRC, 2013.
5. Srinivasa Kumar R, "Pavement Evaluation, Maintenance and Management", Universities Press, 2014.

Department of Civil Engineering

Timetable

III B.Tech. II Semester – HCM

Day/Hour	9.30-10.20	10.20-11.10	11.20-12.10	12.10-01.00	01.40-2.25	2.25-3.10	3.15-04.00
Monday	HCM						
Tuesday					HCM		
Wednesday			HCM				
Thursday	HCM						
Friday				HCM			
Saturday							

Department of Civil Engineering

Vision of the Institute

To be a premier Institute in the country and region for the study of Engineering, Technology and Management by maintaining high academic standards which promotes the analytical thinking and independent judgment among the prime stakeholders, enabling them to function responsibly in the globalized society.

Mission of the Institute

To be a world-class Institute, achieving excellence in teaching, research and consultancy in cutting-edge Technologies and be in the service of society in promoting continued education in Engineering, Technology and Management.

Quality Policy

To ensure high standards in imparting professional education by providing world-class infrastructure, top-quality-faculty and decent work culture to sculpt the students into Socially Responsible Professionals through creative team-work, innovation and research.

Vision of the Department

To impart knowledge, skill and excellence in civil engineering with a global perspective to enable the students as competent, qualitative & ethically strong engineers with an intuition to improve quality of life for the benefit of the society.

Mission of the Department

- To train the students in the civil engineering domain.
- To develop knowledge and skill to solve regional and global problems.
- To transform into qualitative and ethically strong professional engineers through research and
- Development.

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Program Educational Objectives (B.Tech – CE)

Graduates will be able to

PEO1: To provide knowledge in mathematics, science, and engineering principles for a successful Career In sectors of civil engineering and allied industry and/or higher education.

PEO2: To develop an ability to identify, formulate, solve problems along with adequate analysis, Design, Synthesizing and interpretation skills in civil engineering systems.

PEO3: To exhibit professionalism, ethics, communication skills and team work in their profession and engaged in lifelong learning of contemporary civil engineering trends.

Program Outcomes (B.Tech – CE)

At the end of the Program, a graduate will have the ability to

PO 1: An ability to apply knowledge of mathematics, science, and engineering

PO 2: An ability to design and conduct experiments, as well as to analyze and interpret data

PO 3: An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability

PO 4: An ability to function on multidisciplinary teams

PO 5: An ability to identify, formulates, and solves engineering problems

PO 6: An understanding of professional and ethical responsibility

PO 7: An ability to communicate effectively

PO 8: The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

PO 9: A recognition of the need for, and an ability to engage in lifelong learning

PO 10: Knowledge of contemporary issues.

PO 11: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

PO 12: An ability to carry out research in different areas of Civil Engineering including latest technology like GIS/Remote Sensing resulting in design, development, analyze and journal publications and technology development.

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COURSE OBJECTIVES

On completion of this Subject/Course the student shall be able to:

S.No	Objectives
1	To get knowledge of construction methodology materials and planning.
2	To know complete knowledge of types of pavement & their applications.
3	To know about innovative methods of construction by using the latest technology.
4	To understand the Hill landslides & causes and control measures.
5	To understand the pavement evaluation & its techniques.

COURSE OUTCOMES

The expected outcomes of the Course/Subject are:

S.No	Outcomes
1	Have the knowledge of construction methodology materials and planning
2	Have the complete knowledge of types of pavement & their applications.
3	Get the innovative methods of construction by using the latest technology.
4	Able to understand the Hill landslides & causes and control measures.
5	To understand the pavement evaluation & its techniques.

Signature of faculty

Note: Please refer to Bloom's Taxonomy, to know the illustrative verbs that can be used to state the outcomes.

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GUIDELINES TO STUDY THE COURSE / SUBJECT

Course Design and Delivery System (CDD):

- The Course syllabus is written into number of learning objectives and outcomes.
- Every student will be given an assessment plan, criteria for assessment, scheme of evaluation and grading method.
- The Learning Process will be carried out through assessments of Knowledge, Skills and Attitude by various methods and the students will be given guidance to refer to the text books, reference books, journals, etc.

The faculty be able to –

- Understand the principles of Learning
- Understand the psychology of students
- Develop instructional objectives for a given topic
- Prepare course, unit and lesson plans
- Understand different methods of teaching and learning
- Use appropriate teaching and learning aids
- Plan and deliver lectures effectively
- Provide feedback to students using various methods of Assessments and tools of Evaluation
- Act as a guide, advisor, counselor, facilitator, motivator and not just as a teacher alone

Signature of HOD　　　　　　　　　　　　Signature of faculty

Date:　　　　　　　　　　　　　　　　　Date:

Department of Civil Engineering

COURSE SCHEDULE

The Schedule for the whole Course / Subject is:

S. No.	Description	Duration (Date)		Total No. of Periods
		From	To	
1.	**UNIT-I** **TYPES OF HIGHWAY CONSTRUCTION AND LAYERS**: Water Bound Macadam (WBM), Wet Mix Macadam (WMM), Dry Lean Concrete (DLC), Soil Stabilized Roads and Interface treatments. Construction techniques and Construction equipment's. Quality control tests during construction of sub grade, sub-base and base courses. IRC specifications.	22.01.2024	06.02.2024	12
2.	**UNIT-II** **BITUMINOUS CONSTRUCTION CONSTRUCTIONS:** Types of bituminous layer constructions: SDBC, BC, BM, DBM, Slurry seal and micro surfacing. Selection of wearing course under different climatic and traffic conditions, IRC specifications, construction procedures, and tests on various bituminous mixes, Construction equipment's, Quality Control during and post construction of bituminous pavements and IRC specifications.	07.02.2024	26.02.2024	13
3.	**UNIT-III** **TYPES OF PAVEMENT CONSTRUCTION PROCEDURE:** Construction of Cement Concrete pavement Constructions (IRC:15). Introduction to continuously reinforced, Prestressed and Steel Fiber Reinforced (SFRC) Pavements, Methods of construction of joints in concrete pavements, IRC and MORTH specifications, Pavement and overlay construction. Construction techniques and Construction equipment's, Quality control tests during and post construction of concrete pavements.	29.02.2024	26.03.2024	13
4.	**UNIT-IV** **HILL LANDSIDES:** Causes and control measures: Hill road construction practices, Construction of bituminous and cement concrete roads at high attitudes, Hill road drainage. Construction techniques and Construction equipment's, Quality control tests during and post construction of Hill Roads.	28.03.2024	27.04.2024	12

5.	**UNIT-V** **PAVEMENT EVALUATION:** Structural and functional evaluation of pavements, Introduction to IRI, Bump Integrator, Benkelman Beam and Falling weight deflect meter, Overlay design by Benkelman beam tests, Distress types in bituminous and concrete pavements, causes of distresses, Maintenance Problems and their remedial measures.	29.04.2024	12.06.2024	14

Total No. of Instructional periods available for the course: 64 Hours

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SCHEDULE OF INSTRUCTIONS - COURSE PLAN

Unit No.	Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1.	1	22.01.2024	1	Introduction	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	2	23.01.2024	1	Water Bound Macadam (WBM)	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	3	24.01.2024	1	Wet Mix Macadam (WMM)	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	4	25.01.2024	1	Dry Lean Concrete (DLC)	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	5	27.01.2024	1	Soil Stabilized Roads and Interface treatments	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	6	29.01.2024	1	Construction technique	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	7	30.01.2024	1	Construction equipment’s	1 1	Intelligent Transport systems- Amit kumarjain,

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						Sarkarpradipkumar ,2003.
	8	31.01.2024	1	Quality control tests during construction of sub grade courses	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	9	01.02.2024	1	Quality control tests during construction of sub-base courses	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	10	02.02.2024	1	Quality control tests during construction of base courses	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	11	05.02.2024	1	IRC specifications	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	12	06.02.2024	1	IRC specifications	1 1	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
2.	1	07.02.2024	1	Types of bituminous layer constructions: SDBC, BC	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	2	08.02.2024	1	Types of bituminous layer constructions: BM, DBM	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	3	09.02.2024	1	Types of bituminous layer constructions: Slurry seal	2 2	Intelligent Transport systems- Amit

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						kumarjain, Sarkarpradipkumar ,2003.
	4	12.02.2024	1	Types of bituminous layer constructions: micro surfacing	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	5	13.02.2024	1	Selection of wearing course under different climatic and traffic conditions	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	6	14.02.2024	1	Selection of wearing course under different climatic and traffic conditions	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	7	15.02.2024	1	IRC specifications	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	8	16.02.2024	1	Construction procedures	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	9	19.02.2024	1	Tests on various bituminous mixes	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	10	20.02.2024	1	Construction equipment’s	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	11	21.02.2024	1	Quality Control during	2	Intelligent Transport

				construction of bituminous pavements and IRC specifications	2	systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	12	24.02.2024	1	Quality Control post construction of bituminous pavements and IRC specifications	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	13	26.02.2024	1	IRC specifications	2 2	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
3.	1	29.02.2024	1	Construction of Cement Concrete pavement Constructions (IRC:15)	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	2	01.03.2024	1	Construction of Cement Concrete pavement Constructions (IRC:15)	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	3	04.03.2024	1	Introduction to continuously reinforced	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	4	05.03.2024	1	Introduction to continuously reinforced	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	5	12.03.2024	1	Prestressed and Steel Fiber Reinforced (SFRC) Pavements	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.

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	6	14.03.2024	1	Prestressed and Steel Fiber Reinforced (SFRC) Pavements	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	7	16.03.2024	1	Methods of construction of joints in concrete pavements	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	8	21.03.2024	1	IRC and MORTH specifications	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	9	21.03.2024	1	Pavement and overlay construction	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	10	22.03.2024	1	Construction techniques	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	11	23.03.2024	1	Construction equipment's	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	12	26.03.2024	1	Quality control tests during construction of concrete pavements	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	13	27.03.2024	1	Quality control tests post construction of concrete pavements	3 3	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar

						,2003.
4	1	28.03.2024	1	Causes of hill landslides	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	2	03.04.2024	1	control measures of hill landslides	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	3	04.04.2024	1	Hill road construction practices	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	4	06.04.2024	1	Construction of bituminous roads at high attitudes	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	5	08.04.2024	1	Construction of cement concrete roads at high attitudes	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	6	12.04.2024	1	Hill road drainage	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	7	18.04.2024	1	Construction techniques	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	8	19.04.2024	1	Construction equipment's	4 4	Intelligent Transport systems- Amit kumarjain,

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						Sarkarpradipkumar ,2003.
	9	20.04.2024	1	Hill road construction practices	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	10	22.04.2024	1	Hill road drainage	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	11	24.04.2024	1	Quality control tests during and post construction of Hill Roads	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	12	27.04.2024	1	Quality control tests during and post construction of Hill Roads	4 4	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
5	1	29.04.2024	1	Pavement Evaluation	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	2	30.04.2024	1	Structural evaluation of pavements	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	3	01.05.2024	1	Functional evaluation of pavements	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	4	04.05.2024	1	Introduction to IRI	5 5	Intelligent Transport systems- Amit

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						kumarjain, Sarkarpradipkumar ,2003.
	5	06.05.2024	1	Introduction to Bump Integrator	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	6	07.05.2024	1	Introduction to Benkelman Beam	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	7	08.05.2024	1	Introduction to Falling weight deflectometer	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	8	09.05.2024	1	Overlay design by Benkelman beam tests	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	9	10.05.2024	1	Distress types in bituminous pavements	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	10	04.06.2024	1	Distress types in concrete pavements	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	11	06.06.2024	1	Causes of distresses	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	12	07.06.2024	1	Maintenance Problems	5	Intelligent Transport

					5	systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	13	10.06.2024	1	Maintenance Problems and their remedial measures	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.
	14	12.06.2024	1	Revision	5 5	Intelligent Transport systems- Amit kumarjain, Sarkarpradipkumar ,2003.

Signature of HOD

Date:

Signature of faculty

Date:

Note:

1. Ensure that all topics specified in the course are mentioned.
2. Additional topics covered, if any, may also be specified in bold.
3. Mention the corresponding course objective and outcome numbers against each topic.

Department of Civil Engineering

LESSON PLAN (U-I)

Lesson No: 01, 02 Duration of Lesson: 1hr40 min

Lesson Title: Introduction & Water Bound Macadam (WBM)

Instructional / Lesson Objectives:

- To make students understand basics of Highway construction
- To familiarize students on layers of WBM Road.
- To provide knowledge on the WBM Road.
- To provide information on construction of WBM roads.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 min for taking attendance 70 min for the lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – I & tutorial-I sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-I)

Lesson No: 03, 04 Duration of Lesson: 1hr40 min

Lesson Title: Wet Mix Macadam (WMM), Dry Lean Concrete (DLC)

Instructional / Lesson Objectives:

- To make students understand basics of Wet Mix Macadam (WMM)
- To familiarize students on formation of layers
- To provide knowledge on the types of mixes.
- To provide information on Dry Lean Concrete (DLC).

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 min for taking attendance
70 min for the lecture delivery
20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – I & tutorial-I sheets

Signature of faculty

LESSON PLAN (U-I)

Lesson No: 05, 06, and 07 Duration of Lesson: 2hrs 30 min

Lesson Title: Soil Stabilized Roads and Interface treatments. Construction techniques and Construction equipment’s

Instructional / Lesson Objectives:

- To make students understand Soil Stabilized Roads
- To familiarize students on Interface treatments.
- To provide knowledge on the Construction equipment’s
- To provide information on Construction techniques.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 min for taking attendance
105 min for the lecture delivery
30 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – I & tutorial-I sheets

Signature of faculty

Anurag ENGINEERING COLLEGE (An Autonomous Institution)

Department of Civil Engineering

LESSON PLAN (U-I)

Lesson No: 08, 09, and 10 Duration of Lesson: 2hrs 30 min

Lesson Title: Quality control tests during construction of sub grade, sub-base and base courses

Instructional / Lesson Objectives:

- To make students understand basics of sub grade, sub-base and base courses
- To familiarize students on Quality control tests during construction of sub grade course.
- To provide knowledge on the Quality control tests during construction of sub-base course.
- To provide information on Quality control tests during construction of base course.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 min for taking attendance
105 min for the lecture delivery
30min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – I & tutorial-I sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-I)

Lesson No: 11, 12 Duration of Lesson: 1hr 40 min

Lesson Title: IRC specifications

Instructional / Lesson Objectives:

- To make students understand IRC specifications
- To familiarize students on IRC specifications.
- To provide knowledge on the IRC specifications.
- To provide information on IRC specifications.

Teaching AIDS : PPTs, Digital Board

Time Management of Class :

10 min for taking attendance 70 min for the lecture delivery 20 min for doubts session

Assignment / Questions:

(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – I & tutorial-I sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-II)

Lesson No: 01, 02 Duration of Lesson: 1hr40 min

Lesson Title: Types of bituminous layer constructions: SDBC, BC, BM, DBM

Instructional / Lesson Objectives:

- To make students understand Types of bituminous layer constructions.
- To familiarize students on the Types of bituminous layer constructions: SDBC, BC.
- To understand students the Types of bituminous layers.
- To provide information on Types of bituminous layer constructions: BM, DBM.

Teaching AIDS : PPTs, Digital Board

Time Management of Class :

10 mins for taking attendance
70 min for lecture delivery
20 min for doubts session

Assignment / Questions:

(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-II)

Lesson No: 03, 04 Duration of Lesson: 1hr40 min

Lesson Title: Types of bituminous layer constructions: Slurry seal and micro surfacing

Instructional / Lesson Objectives:

- To make students understand Types of bituminous layers.
- To familiarize students on the concept of bituminous layer constructions.
- To understand students the Types of bituminous layer constructions: Slurry seal.
- To provide information on Types of bituminous layer constructions: micro surfacing

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Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance
70 min for lecture delivery
20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-II)

Lesson No: 05, 06 Duration of Lesson: 1hr40 min

Lesson Title: Selection of wearing course under different climatic and traffic conditions

Instructional / Lesson Objectives:

- To make students understand Selection of wearing course.
- To familiarize students on the Selection of wearing course under different traffic conditions.
- To understand students the concept of construction of bituminous pavements.
- To provide information on Selection of wearing course under different climatic conditions.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-II)

Lesson No: 07, 08, and 09 Duration of Lesson: 2hrs30 min

Lesson Title: IRC specifications, construction procedures, tests on various bituminous mixes

Instructional / Lesson Objectives:

- To make students understand IRC specifications.
- To familiarize students on the construction of bituminous pavements.
- To understand students the, tests on various bituminous mixes.
- To provide information on construction procedures.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance 115 min for lecture delivery 30 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

LESSON PLAN (U-II)

Lesson No: 10, 11 Duration of Lesson: 1hr40 min

Lesson Title: Construction equipment's, Quality Control during construction of bituminous pavements

Instructional / Lesson Objectives:

- To make students understand Construction equipment's.
- To familiarize students on the concept construction of bituminous pavements.
- To understand students the Quality Control during construction of bituminous pavements
- To provide information on Quality Control.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-II)

Lesson No: 12, 13 Duration of Lesson: 1hr40 min

Lesson Title: Construction equipment's, Quality Control during and post construction of bituminous pavements and IRC specifications

Instructional / Lesson Objectives:

- To make students understand construction of bituminous pavements.
- To familiarize students on the Construction equipment's.
- To understand students the Quality Control during and post construction of bituminous pavements.
- To provide information on IRC specifications.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – II & tutorial-II sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-III)

Lesson No: 01, 02, and 03 Duration of Lesson: 2hrs30 min

Lesson Title: Construction of Cement Concrete pavement Constructions (IRC: 15). Introduction to continuously reinforced

Instructional / Lesson Objectives:

- To make students learn about Construction of Cement Concrete pavement Constructions.
- To provide information to students about Cement Concrete pavement.
- To make students understand the concept of Introduction to continuously reinforced
- To provide information about Construction of Cement Concrete pavement Constructions (IRC: 15).

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance
15 min for revision of previous class
90 min for lecture delivery
30 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – III & tutorial-III sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-III)

Lesson No: 04, 05, and 06 Duration of Lesson: 2hrs30 min

Lesson Title: Introduction to continuously reinforced, Prestressed and Steel Fiber Reinforced (SFRC) Pavements.

Instructional / Lesson Objectives:

- To make students learn about pavement construction procedure.
- To provide information to students about Prestressed and Steel Fiber Reinforced (SFRC) Pavements.
- To make students understand the concept of Introduction to continuously reinforced.
- To provide information about Prestressed and Steel Fiber Reinforced (SFRC) Pavements.

Teaching AIDS : PPTs, Digital Board

Time Management of Class :

15 mins for taking attendance 15 min for revision of previous class 90 min for lecture delivery 30 min for doubts session

Assignment / Questions:

(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – III & tutorial-III sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-III)

Lesson No: 07, 08, and 09 Duration of Lesson: 2hrs30 min

Lesson Title: Methods of construction of joints in concrete pavements, IRC and MORTH specifications, Pavement and overlay construction.

Instructional / Lesson Objectives:

- To make students learn about pavement construction procedures.
- To provide information to students about Pavement and overlay construction.
- To make students understand the concept of Methods of construction of joints.
- To provide information about IRC and MORTH specifications.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance
15 min for revision of previous class
90 min for lecture delivery
30 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – III & tutorial-III sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-III)

Lesson No: 10, 11 Duration of Lesson: 1hr40 min

Lesson Title: Construction techniques and Construction equipment's,

Instructional / Lesson Objectives:

- To make students learn about pavement construction procedures.
- To provide information to students about IRC and MORTH specifications.
- To make students understand the Construction techniques.
- To provide information about various Construction equipment's.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – III & tutorial-III sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-III)

Lesson No: 12, 13 Duration of Lesson: 1hr40 min

Lesson Title: Quality control tests during and post construction of concrete pavements

Instructional / Lesson Objectives:

- To make students learn about pavement construction procedures.
- To provide information to students about Quality control tests during construction of concrete pavements.
- To make students understand the Quality control tests for post construction of concrete pavements.
- To provide information about IRC and MORTH specifications.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – III & tutorial-III sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-IV)

Lesson No: 01, 02, and 03 Duration of Lesson: 2hrs30 min

Lesson Title: HILL LANDSIDES: Causes and control measures: Hill road construction practices

Instructional / Lesson Objectives:

- To make students learn about hill landsides.
- To provide information to students about Causes of hill landslides.
- To make students understand the concept of Hill road construction practices
- To provide information about control measures of hill landslides

Teaching AIDS : PPTs, Digital Board

Time Management of Class :

15 mins for taking attendance 15 min for revision of previous class 90 min for lecture delivery 30 min for doubts session

Assignment / Questions:

(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – IV & tutorial-IV sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-IV)

Lesson No: 04, 05 Duration of Lesson: 1hr40min

Lesson Title: Construction of bituminous and cement concrete roads at high attitudes.

Instructional / Lesson Objectives:

- To make students learn about hill landsides.
- To provide information to students about Construction of cement concrete roads at high attitudes.
- To make students understand the concept of Construction of bituminous roads at high attitudes.
- To provide information about Construction of bituminous and cement concrete roads.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance
70 min for lecture delivery
20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – IV & tutorial-IV sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-IV)

Lesson No: 06, 07, and 08 Duration of Lesson: 2hrs30 min

Lesson Title: Hill road drainage. Construction techniques and Construction equipment's.

Instructional / Lesson Objectives:

- To make students learn about hill landsides.
- To provide information to students about Construction techniques.
- To make students understand the concept of Hill road drainage.
- To provide information about Construction equipment's.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance
15min for revision of previous class
90 min for lecture delivery
30 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – IV & tutorial-IV sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-IV)

Lesson No: 09, 10 Duration of Lesson: 1hr40 min

Lesson Title: Hill road construction practices, Hill road drainage.
Instructional / Lesson Objectives:

- To make students learn about hill landsides.
- To provide information to students about Hill road construction practices.
- To make students understand the concept of Hill road drainage.
- To provide information about Construction techniques.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance
70 min for lecture delivery
20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – IV & tutorial-IV sheets

Signature of faculty

LESSON PLAN (U-IV)

Lesson No: 11, 12 Duration of Lesson: 2hrs30 min

Lesson Title: Quality control tests during and post construction of Hill Roads.

Instructional / Lesson Objectives:

- To make students learn about hill landsides.
- To provide information to students about Quality control tests during construction of Hill Roads.
- To make students understand the concept of Quality control tests.
- To provide information about Quality control tests for post construction of Hill Roads.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance
15 min for revision of previous class
105 min for lecture delivery
15 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – IV & tutorial-IV sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-V)

Lesson No: 01, 02, and 03 Duration of Lesson: 2hrs30 min

Lesson Title: Pavement Evaluation: Structural and functional evaluation of pavements

Instructional / Lesson Objectives:

- To make students understand the Structural and functional evaluation of pavements.
- To provide information to students about Structural evaluation of pavements.
- To make students understand the concept of Pavement Evaluation.
- To provide information about functional evaluation of pavements.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance 15 min for revision of previous class 105 min for lecture delivery 15 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – V & tutorial-V sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-V)

Lesson No: 04, 05, and 06 Duration of Lesson: 2hrs30 min

Lesson Title: Introduction to IRI, Bump Integrator, Benkelman Beam.

Instructional / Lesson Objectives:

- To make students understand the Pavement Evaluation.
- To provide information to students about Bump Integrator.
- To make students understand the Introduction to IRI, Bump Integrator, Benkelman Beam.
- To provide information about Benkelman Beam.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance 15 min for revision of previous class 105 min for lecture delivery 15 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment – V & tutorial-V sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-V)

Lesson No: 07, 08 Duration of Lesson: 1hr40 min

Lesson Title: Introduction to IRI, Bump Integrator, Benkelman Beam and falling weight deflect meter, Overlay design by Benkelman beam tests.

Instructional / Lesson Objectives:

- To make students understand the Pavement Evaluation.
- To provide information to students about IRI, Bump Integrator, Benkelman Beam.
- To make students understand the concept of Overlay design by Benkelman beam test.
- To provide information about falling weight deflect meter.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

10 mins for taking attendance 70 min for lecture delivery 20 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment –V & tutorial-V sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-V)

Lesson No: 09, 10, and 11 Duration of Lesson: 2hrs30 min

Lesson Title: Distress types in bituminous and concrete pavements, causes of distresses

Instructional / Lesson Objectives:

- To familiarize students on causes of distresses.
- To make students learn about Pavement Evaluation
- To provide information about Distress types in bituminous pavements.
- To provide information about Distress types in concrete pavements.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance 15 min for revision of previous class 105 min for lecture delivery 15 min for doubts session

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment –V & tutorial- V sheets

Signature of faculty

Department of Civil Engineering

LESSON PLAN (U-V)

Lesson No: 12, 13, and 14 Duration of Lesson: 2hrs30 min

Lesson Title: Maintenance Problems and their remedial measures and revision

Instructional / Lesson Objectives:

- To familiarize students on Maintenance Problems of project elevation.
- To make students learn about remedial measures of project elevation
- To provide information about highway construction.
- To provide information about construction management.

Teaching AIDS : PPTs, Digital Board
Time Management of Class :

15 mins for taking attendance
15 min for revision of previous class
120 min for lecture delivery

Assignment / Questions:
(Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..)

Refer assignment –V & tutorial- V sheets

Signature of faculty

Department of Civil Engineering

ASSIGNMENT – 1

This Assignment corresponds to Unit No. 1

Question No.	Question	Objective No.	Outcome No.
1	Explain briefly about construction techniques of dry lean concrete	1	1
2	Write briefly about quality control test conducted on sub-base and sub-grade courses	1	1
3	Describe construction procedure of WMM	1	1

Signature of HOD

Date:

Signature of faculty

Date:

Anurag ENGINEERING COLLEGE (An Autonomous Institution)

Department of Civil Engineering

ASSIGNMENT – 2

This Assignment corresponds to Unit No. 2

Question No.	Question	Objective No.	Outcome No.
1	Describe about semi dense bituminous concrete road construction methods	2	2
2	Write about slurry seal and micro surfacing and micro surfacing preparation of testing methods	2	2
3	Quality control during and post construction of bituminous pavements and IRC specifications	2	2

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

ASSIGNMENT – 3

This Assignment corresponds to Unit No. 3

Question No.	Question	Objective No.	Outcome No.
1	Describe with diagram the method of construction procedure of cement concrete pavement and different types of joints as per IRC15	3	3
2	Explain briefly about construction details of pre-stressed and steel fiber reinforced pavements	3	3
3	Inspect the quality control tests during and post construction of concrete pavement	3	3

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

ASSIGNMENT – 4

This Assignment corresponds to Unit No. 4

Question No.	Question	Objective No.	Outcome No.
1	What is landslide? What are the causes of landslides? What are factors to prevent land sliding	4	4
2	Discuss the importance of highway drainage with special emphasis on hill roads?	4	4

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

ASSIGNMENT – 5

This Assignment corresponds to Unit No. 5

Question No.	Question	Objective No.	Outcome No.
1	Analysis in detail Benkelman beam deflect meter for structural evaluation of pavements?	5	5

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

TUTORIAL – 1

This tutorial corresponds to Unit No. 1 (Objective Nos.: 1, Outcome Nos.: 1)

Q1. Which of the following materials is primarily used in Water Bound Macadam (WBM)?

A) Cement and aggregates B) Bitumen and aggregates C) Water and aggregates D) Aggregates and screenings

Q2Wet Mix Macadam (WMM) is preferred over WBM primarily because:

A) It requires less compaction effort B) It provides better water resistance C) It is cheaper to construct D) It allows for faster traffic opening

Q3. Dry Lean Concrete (DLC) is typically used as:

A) A wearing course B) A base course C) A surface course D) A stabilization layer

Q4. Which of the following is a common quality control test during the construction of subgrade?

A) Marshall Stability Test B) California Bearing Ratio (CBR) Test C) Benkelman Beam Deflection Test D) Slump Test

Signature of HOD | Signature of faculty

Date: | Date:

Department of Civil Engineering

TUTORIAL – 2

This tutorial corresponds to Unit No. 2 (Objective Nos.: 2, Outcome Nos.: 2)

Q1. Which type of bituminous layer construction is typically used as a base course in flexible pavements?
A) Semi-Dense Bituminous Concrete (SDBC)
B) Bituminous Concrete (BC)
C) Bituminous Macadam (BM)
D) Dense Bituminous Macadam (DBM)

Q2. Slurry seal and micro surfacing are primarily used for:
A) Preventing reflective cracking
B) Providing structural support
C) Improving skid resistance
D) Enhancing load-bearing capacity

Q3. Which test is commonly performed to determine the stability and flow properties of bituminous mixes?
A) Marshall Stability Test
B) California Bearing Ratio (CBR) Test
C) Benkelman Beam Deflection Test
D) Slump Test

Q4. Quality control during construction of bituminous pavements involves monitoring:
A) Compaction density and temperature
B) Aggregate gradation and shape
C) Asphalt content and viscosity
D) All of the above

Signature of HOD   Signature of faculty

Date: Date:

Department of Civil Engineering

TUTORIAL SHEET – 3

This tutorial corresponds to Unit No. 3 (Objective Nos.: 3, Outcome Nos.: 3)

Q1. . Which method is typically used for construction joints in cement concrete pavements to control cracking?

A) Doweled joints

B) Expansion joints

C) Contraction joints

D) Butt joints

Q2. Steel Fiber Reinforced Concrete (SFRC) pavements are beneficial for:

A) Increasing pavement thickness

B) Improving fatigue resistance

C) Enhancing surface texture

D) Reducing construction time

Q3. Quality control tests during construction of concrete pavements typically include monitoring:

A) Asphalt content and viscosity

B) Aggregate gradation and shape

C) Concrete mix design proportions

D) Compaction density and temperature

Signature of HOD | Signature of faculty

Date: | Date:

Department of Civil Engineering

TUTORIAL – 4

This tutorial corresponds to Unit No. 4 (Objective Nos.: 4, Outcome Nos.: 4)

Q1. Which of the following is a primary cause of landslides on hillsides?
A) Excessive vegetation
B) Proper drainage systems
C) Controlled blasting
D) Heavy rainfall and erosion

Q2. In hill road construction, which type of pavement is typically preferred due to its ability to adapt to the undulating terrain and prevent surface water accumulation?
A) Cement concrete pavement

B) Flexible pavement

C) Semi-Dense Bituminous Concrete (SDBC)
D) Dense Bituminous Macadam (DBM)

Q3. Hill road drainage systems are designed primarily to:

A) Enhance aesthetic appeal
B) Reduce construction costs
C) Control landslides and erosion
D) Provide habitat for wildlife

Q4. Quality control tests during and post construction of hill roads often include monitoring:
A) Concrete curing time
B) Asphalt compaction density
C) Soil compaction moisture content
D) Vegetation growth rate

Signature of HOD | Signature of faculty

Date: | Date:

Department of Civil Engineering

TUTORIAL SHEET – 5

This tutorial corresponds to Unit No. 5 (Objective Nos.: 5, Outcome Nos.: 5)

Q1. Which pavement evaluation method is primarily used to assess the structural capacity of a pavement by measuring the deflection under a known load?
A) International Roughness Index (IRI)

B) Bump Integrator
C) Benkelman Beam
D) Falling Weight Deflect meter (FWD)

Q2. Distress types in bituminous pavements include all of the following EXCEPT:
A) Rutting
B) Bleeding
C) Spalling
D) D-cracking

Q3. The Falling Weight Deflect meter (FWD) is used to evaluate:
A) Skid resistance of the pavement

B) Surface roughness of the pavement
C) Structural capacity of the pavement
D) Pavement distress types

Q4. Overlay design using Benkelman beam tests primarily focuses on assessing:
A) Pavement smoothness
B) Pavement distress types
C) Pavement deflection
D) Pavement surface texture

Signature of HOD | Signature of faculty

Date: | Date:

Department of Civil Engineering

EVALUATION STRATEGY

Target (s)

a. Target Percentage of Pass : 95%

Assessment Method (s) (Maximum Marks for evaluation are defined in the Academic Regulations)

a. Daily Attendance
b. Assignments
c. Online Quiz (or) Seminars
d. Continuous Internal Assessment
e. Semester / End Examination

List out any new topic(s) or any innovation you would like to introduce in teaching the subjects in this semester

Case Study of any one existing application

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

COURSE COMPLETION STATUS

Actual Date of Completion & Remarks if any

Units	Remarks	Objective No. Achieved	Outcome No. Achieved
Unit 1	Completed on 06.02.2024	1	1
Unit 2	Completed on 26.02.2024	2	2
Unit 3	Completed on 27.03.2024	3	3
Unit 4	Completed on 27.04.2024	4	4
Unit 5	Completed on 12.06.2024	5	5

Signature of HOD

Date:

Signature of faculty

Date:

Department of Civil Engineering

Mappings

1. **Course Objectives-Course Outcomes Relationship Matrix**
(Indicate the relationships by mark “X”)

Course-Outcomes / Course-Objectives	1	2	3	4	5
1	H		M		
2		M			
3			H		
4				M	
5					H

2. **Course Outcomes-Program Outcomes (POs) & PSOs Relationship Matrix**
(Indicate the relationships by mark “X”)

P-Outcomes / C-Outcomes	a	b	c	d	e	f	g	h	i	j	k	l	PSO 1	PSO 2
1	H			H					M				H	
2		H	H		H	M		M		H	H			H
3	M	L			M			H	H		M			M
4	L		M	M		L							M	
5		M								M				

Department of Civil Engineering

Rubric for Evaluation

Performance Criteria	Unsatisfactory	Developing	Satisfactory	Exemplary
	1	**2**	**3**	**4**
Research & Gather Information	Does not collect any information that relates to the topic	Collects very little information some relates to the topic	Collects some basic Information most relates to the topic	Collects a great deal of Information all relates to the topic
Fulfil team role's duty	Does not perform any duties of assigned team role.	Performs very little duties.	Performs nearly all duties.	Performs all duties of assigned team role.
Share Equally	Always relies on others to do the work.	Rarely does the assigned work - often needs reminding.	Usually does the assigned work - rarely needs reminding.	Always does the assigned work without having to be reminded
Listen to other team mates	Is always talking— never allows anyone else to speak.	Usually doing most of the talking-- rarely allows others to speak	Listens, but sometimes talks too much.	Listens and speaks a fair amount.

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III B.TECH VI SEMESTER I MID EXAMINATIONS - MARCH 2024

Branch : B.Tech. (CE)
Date : 21.03.2024 FN

Subject : HIGHWAY CONSTRUCTION & MANAGEMENT

Max. Marks : 20M
Time : 90 Minutes

PART - A

ANSWER ALL THE QUESTIONS. **5 X 1M = 5M**

Q.No	Question	CO	BTL
1.	Define WBM Roads?	C01	L2
2.	what is wet mix macadam?	CO1	L1
3.	list the different types of bituminou binders	CO2	L1
4.	what is Micro surfacing?	CO2	L2
5.	What is regid pavement ?	CO3	L1

PART - B

ANSWER ALL THE QUESTIONS. **3 X 5M = 15M**

Q.No	Question	CO	BTL
6.	Explain the quality control tests carried out during the construction of the subgrade in road construction.	CO1	L4
	OR		
7.	Write the construction procedure of Water Bound Macadam (WBM) roads/	CO1	L3
8.	Explain the construction procedure of Dense Bituminous Macadam (DBM) in road construction?.	CO2	L3
	OR		
9.	Explain the tests conducted on various bituminous mixes during the construction of pavements?	CO2	L3
10.	Discuss in detail about different types of joints in cement concrete roads as per IRC:15	CO3	L3
	OR		
11.	Explain the role of MORTH and IRC in highway develoment	C03	L3

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III B.TECH VI SEMESTER II MID EXAMINATIONS - JUNE 2024

Branch : B.Tech. (CE) **Max. Marks : 20M**
Date : 20-Jun-2024 **Session : Morning** **Time : 90 Min**
Subject : HIGHWAY CONSTRUCTION & MANAGEMENT,CE622PE

PART - A

ANSWER ALL THE QUESTIONS **5 X 1M = 5M**

Q.No	Question	CO	BTL
1.	What are types of joints in cement concrete pavements?	CO3	L1
2.	Explain about stoping sight distance?	CO4	L2
3.	List the drainage system provided in hill roads?	CO4	L2
4.	Deine the term funtional evaluation?	CO5	L2
5.	Relate the causes of disress in pavements?	CO5	L2

PART - B

ANSWER ALL THE QUESTIONS **3 X 5M = 15M**

Q.No	Question	CO	BTL
6.	Clasify about construction of Steel Fiber Reinforced(SFRC) pavementsand its limitaions	CO3	L3
	OR		
7.	Discuss the necessity for providing reinforcement in cenent concrete pavement.	CO3	L4
8.	Explain the Quality Control Tests During and Post Construction of Hill Roads	CO4	L3
	OR		
9.	Illustrate the Hill Road Construction Practices	CO4	L3
10.	Clasify the typical causes of distresses on pavement?	CO5	L4
	OR		
11.	Discuss the procedure for overlay design using Benkelman Beam tests	CO5	L3

First Internal Examination Marks

Programme: **B Tech** Year: **III** Course: **Theory** **A.Y: 2023-24**

Course: Highway construction and management Section: A Faculty Name: Dr. M.S.Siva Kumar

S. No	Roll No	Objective Marks (5)	Subjective Marks (15)	Total Marks (20)
1	21C11A0101	16	5	21
2	21C11A0103	12	5	17
3	21C11A0104	AB	AB	0
4	21C11A0105	19	5	24
5	21C11A0106	12	5	17
6	21C11A0107	17	5	22
7	21C11A0108	19	5	24
8	21C11A0110	AB	AB	0
9	21C11A0111	13	5	18
10	21C11A0112	15	5	15
11	21C11A0114	18	5	23
12	21C11A0115	18	5	23
13	21C11A0116	12	5	17
14	21C11A0117	14	AB	14
15	21C11A0118	18	5	23
16	22C15A0101	16	5	21
17	22C15A0102	20	5	25
18	22C15A0103	18	5	23
19	22C15A0104	18	5	23
20	22C15A0105	15	5	20
21	22C15A0106	16	5	21
22	22C15A0107	18	5	23
23	22C15A0108	13	5	18
24	22C15A0109	12	5	17
25	22C15A0110	16	5	21

No. of Absentees: **02**

Total Strength: **25**

Signature of Faculty

: **Signature of HoD**

Second Internal Examination Marks

Programme**: B Tech** Year: **III** Course: **Theory** **A.Y: 2023-24**

Course: Highway construction and management Section: A Faculty Name: Dr. M.S.Siva Kumar

S. No	Roll No	Objective Marks (5)	Subjective Marks (15)	Total Marks (20)
1	21C11A0101	19	5	24
2	21C11A0103	14	5	19
3	21C11A0104	AB	AB	0
4	21C11A0105	19	5	24
5	21C11A0106	17	5	22
6	21C11A0107	16	5	21
7	21C11A0108	20	5	25
8	21C11A0110	AB	AB	0
9	21C11A0111	11	5	16
10	21C11A0112	18	AB	18
11	21C11A0114	20	5	25
12	21C11A0115	20	5	25
13	21C11A0116	15	5	20
14	21C11A0117	16	5	21
15	21C11A0118	20	5	25
16	22C15A0101	17	5	22
17	22C15A0102	20	5	25
18	22C15A0103	20	5	25
19	22C15A0104	20	5	25
20	22C15A0105	18	5	23
21	22C15A0106	19	5	24
22	22C15A0107	18	5	23
23	22C15A0108	19	5	24
24	22C15A0109	16	5	21
25	22C15A0110	18	5	23

No. of Absentees: **02**

Total Strength: **25**

Signature of Faculty

: **Signature of HoD**

NAME :- D. Srilatha.

SUB:- Highway Constsuction & Managment.

Hall Ticket No:- 21C11A0118

III. B. Tech. II. Semester

I - Mid.

1) Explain briefly about construction techniques of dry lean Concrete

Dry lean Concrete (hereinafter reffered to as "DLC") is first layer of rigid Pavement mechanically rolled and compacted over sub-base (GSB). for all major state Highway and National Highway Projects, a thickness of at least 150mm is advised. when DLC is used as a sub base for roads other than the ones mentioned above, a thickness of 100mm is advised.

Machinery

1. Excavator or JCB
2. Loader
3. Tippers / Dumpers
4. Concrete Batching Plant
5. Paver with sensor or Motor Grader
6. vibratory Rollers
7. water tanker
8. survey Kit etc.,

Material:-

All the material required in the Constsuction will be from the approved sources by the Engineer and according to the relevant clauses.

Cement - 601.2.2

Coarse Aggregate - 602.2, 4.2

fine Aggregate - 602.2, 4.3

water - 601.2, 4

Mix of dry lean Concrete will be approximately Proportioned to achieve the strength requirement mentioned in the specifications.

Transportation:-

The Concrete is transported in tippers from the batching plant and to the place of laying.

* the tippers are covered with tarpaulins in order to Protect them from the weather during transit. It will ensure that there will be a sufficient number of tippers for an uninterrupted supply of material to the Paving equipment.

Paving:-

The grader is set in Position and the Concrete is dumped in the hopper in the Case of a normal sensor grader and grading is done with a loose thickness of about 200mm for achieving the Compacted thickness of 150mm.

The loose thickness is ascertained by the trail laying of DLC. the grading will be done in two lanes. After Compaction an average length of 300mm, the second lane is done on the same day matching with the first lane.

A Combination of two graders for a 7m width may also be tried for grading full width at a time with a little time gap between the two grading lanes.

Compaction:-

the Compaction is carried out immediately after the material is laid and leveled, rolling will be continued at full width till there is no further visible movement under the roller and the Surface is closed.

the minimum dry density obtained will be 98% of that achieved during the trail length construction vide clause 601.7.

the required Compactive effort in terms of a number of passes is ascertained by employing one single drum smooth wheeled vibratory roller and one double drum smooth wheeled vibratory roller on the trail stretch of DLC.

Curing:-

Curing the DLC will be done by covering the Surface with gunny bags or Hessain cloth, which will be kept continuosly moist for 7 days by sprinkling water using water tankers.

Quality Control:-

After the Construction of the trail length the in-situ density of freshly material will be determined by the sand replacement method with a 80mm dia density cylinder. The density will be taken at three locations along the diagonal which bisects the trail length.

A DLC mixture's average compressive strength shouldn't be less than 10 MPa over 7 days. The Primary acceptance criteria for dry lean concrete mixtures is the cube's compressive strength after 7 days.

Repairs:-

Rectification if any will be taken up before overlaying, the low spots loose material Potholes etc., will be made good by using fresh lean concrete material duly compacting the same as per specifications.

Uses:

It is used as a Sub-Base for Rigid Pavement.

It has high resistance to deformation.

2) Write briefly about quality Control test conducted on Sub-base and sub-grade courses. 3

Sub-base:-

Sub-base is composed of the layers of material between the Subgrade and the Concrete Pavement. A Subbase may not always be required.

The Sub-base may be enconocrete, cement treated Subbase, Soil-cement, asphalt-treated subbase crushed stone or other suitable material.

Quality Control of Sub-base Course

* Conducting Atterber's limit gradation CBR, FI, LAA, and Proctor density of the base material for its suitability.
* Checking of camber and grade as per design and specification.
* Checking of field moisture and dry density (>98%)

Quality control test on Sub-grade.

Type of Test	frequency.
1. Soil Classification as per BIS 1489. i) Sieve Analysis (wet sieve analysis except for cohesionless soils) ii) LL, PL and PI as per IS2720	one test from each source for one km length or part off

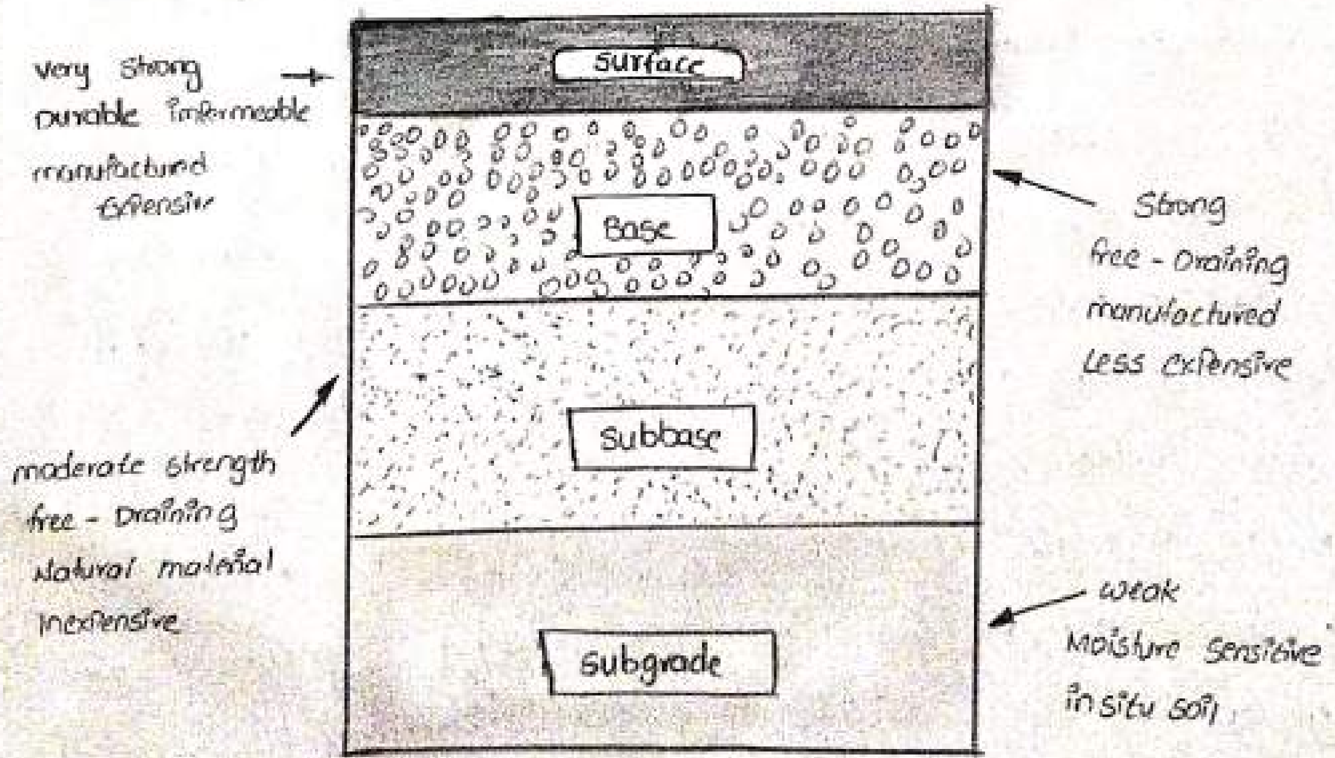
2) Standard Proctor Compaction test	-do-
3) free swell index Test	-do-
4) Deleterious content i) organic matter content by loss on ignition method. ii) Total soluble Sulphate Content	-do-
5) CBR test (soaked or unsoaked) as specified.	one test per km: this will comprise testing of 3 specimens and CBR value has to be reported as the average of three test results.

Quality control on sub-base.

Type of construction	Test	frequency (min).
Sub-base, of Stabilized soil.	i) Quality of lime / cement	one test for Each Consignment subject to a minimum of one test Per 5 tonnes.
	ii) Lime / cement content	Regularly, through, Procedural checks

	iii) Degree of Pulverization	Periodically as considered necessary.
	iv) CBR or unconfined compressive strength test on a set of 3 specimens	As required.
	v) Moisture content prior to compaction	one set of two tests per 500 sq.m
	vi) Density of compacted layer	one set of two tests per 500 sq.m
	vii) Deleterious constitues	As required.

* The sub-grade must be able to support loads transmitted from the pavement structure.



* A Subgrade that can support a high amount of loading without excessive deformation is considered good.

3) Describe construction Procedure of WMM.

WMM:-

wet mix macadam is a type of road construction material that is used for base and sub-base layers. It is composed of crushed aggregates, including gravel and stone dust, mixed with water and a binding agent such as bitumen Emulsion or cement.

the coarse aggregate must be crushed stone from a known quarry that meets all the requirements. the wet mix macadam material should meet the technical standards and wet mix macadam specifications related to shape, size and strength Parameters.

* If the coarse aggregate water absorption value test is more than 2%. the soundness test should be conducted on the materials to be used for the wet mix macadam construction. the basic requirements to be met by wet mix material include.

- the Aggregate impact value should not Exceed 30%.
- the combined value of flakiness and elongation index should not Exceed 35%.

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- The water absorption value should not be more than 2% in the case of aggregate.
- Plasticity index of materials finer than 425 microns should not exceed 6.

Wet mix macadam Construction operations:

Preparation of wet mix macadam Mix:

- On a wet mix macadam mixing plant, an appropriate quantity of ingredients should be mixed with the right amount of OMC
- water should be added in a controlled way, and proper mixing arrangments should be ensured.
- By following IS 2720 the aggregate fraction on the 22.40 mm sieve should be replaced with the material that ranges in size 4.75mm to 22.4 mm
- when adding water, Evaporation loss must be taken into account
- During compaction, the amount of water in the wet mix should not change by more than the allowable limit
- The materials should be mixed thoroughly.

Transportation, spreading, compaction and finishing of wet mix macadam

Transportation:

the materials must be thoroughly mixed in the wet mix

Plant

- The materials should then be loaded straight from the wet mix plant onto the dumpers and driven to the wet mix macadam location.
- On the finished GSB layer, lime powder or pegs should be used to mark the lines of wet mix macadam.
- For lateral confinement, the shoulder material must be placed before the wet mix laying operation.

Spreading of wet mix macadam:-

- The first layer be spread with a motor grader, and the subsequent layer shall be spread with a sensor paver
- The motor grader must be able to spread the wet mix macadam material out evenly on all surfaces. Its blade must have some hydraulic control that can be used to make initial adjustments so that the slope and grade meet the requirements.

Compaction of wet mix macadam

- When the laying is done, wet mix macadam will be compacted right away with a vibratory compactor.
- The number of passes during compaction shall be arrived at by trails till 98% of Maximum Dry density

as determined by IS: 2720 is achieved.

* The roller must move both forward and backwards during one Pass, and the speed of the roller should not be greater than 5km/hr

* The first rolling is done with a vibratory roller is two static Passes

* After rolling 4, vibration Passes are accomplished.

* The compacting will start at the bottom edge and move up, width by width to the top edge.

* At 1/3 of its width until the whole area has been rolled.

* Finishing and opening to Traffic:-

• wet mix macadam layer should be left, to dry for 24 hours after the final compaction.

• The wet mix macadam surface should have a sufficient cross slope to drain off water.

• the finished level of the top surface of the wet mix macadam must be within the tolerance limits of +10 mm to -10mm

• the finished wet mix macadam top surface should not be thrown open to the traffic until it has dried and not before placing the wearing course

Advantages of wet mix macadam

- A wet mix macadam road is much more durable as compared to a WBM road
- wet mix macadam roads dry out faster than WBM roads and can be quickly opened to traffic. on the other hand, the WBM road cannot be opened to traffic for a month.
- wet mix macadam is measured is square meters, and WBM is measured in cubic meters

Disadvantages of wet mix macadam

- The aggregate that makes up the water - bound macadam are held together by sand and clay, and no other cementing material is used.
- when a fast-moving vehicle passes over a wet mix macadam road, the slurry of sand and clay is sucked out by the pneumatic tires, the stone pieces are moved around, and the road surface breaks down.
- when iron wheels are repeatedly used over the wet mix macadam roads, the roads metal has a tendency to get crushed.

Name: P.Meghana   Examination: II-semester II-Mid
Unit -IV Assignment
Hall ticket No: 21C11A0108
Subject: Highway Construction & Management

[1] What is Land slide? What are the causes of landslides? what are factors to prevent land sliding:

Landslides: Landslides are a natural phenomenon, but it involves many human activities which lead to the mass movement of landmass. In recent times we find the causes of landslides increasing day by day and the primary cause is deforestation. To survive, one needs to keep a check on these human activities

Causes of landslides: Landslides are caused by various factors, which are mentioned below

* It can be caused because of heavy rain
* It can be caused by Earthquakes as well
For ex: in the himalayas, the terror occured, because Earthquake unstabilized the mountains, which led to landslides
* Volcanic eruptions in specific regions can also cause landslides
* Landslides often occur in mountain regions while making road and construction; a large number of rocks has to be removed, which can cause landslides over there
* In the regions of North east India, landslides occur because of shifting agriculture
* Due to the increasing population, a large no. of house are being created which leads to the creation of large amount of debris which can cause landslides

Factors to prevent landsliding:

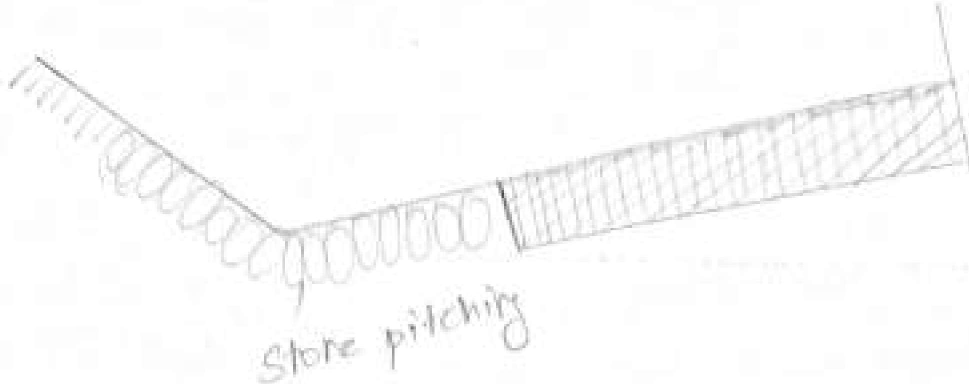
* Afforestation program should take place
* Terrace farming should be adopted in hilly areas
* Early warning systems and monitoring should be there

[2] Discuss the importance of highway drainage with special emphasis on hill roads?

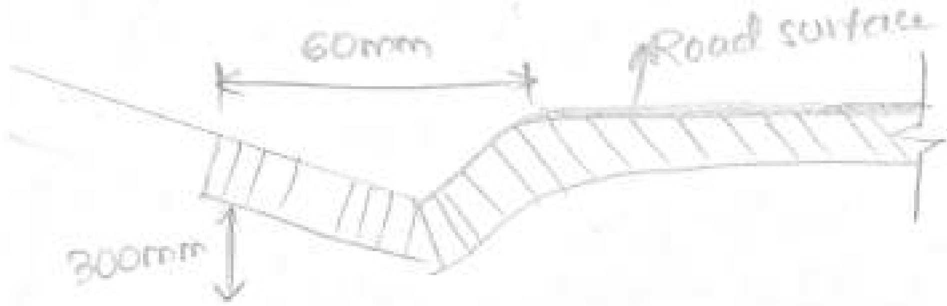
the rainfalls very heavily on the hills and as the slopes of hills are quite steep, the water reaches the road side very quickly creates drainage problems. the water thus collected should be disposed off in a proper way through the well-planned and designed drainage system

[1] Sub-surface drainage: the seepage flow of water on hills creates problems during and after monsoons. The level of seepage water may be at, above or below the road level depending upon several factors such as depth of hard stratum & its inclination, the quantity of underground flow of water, etc

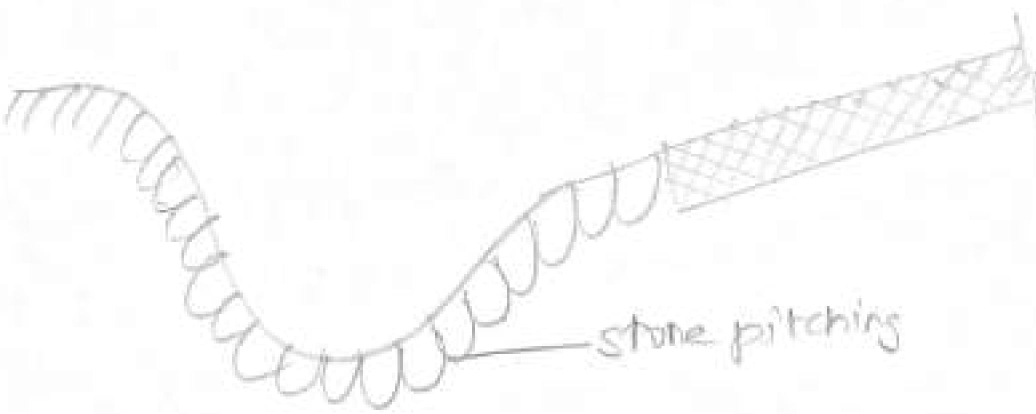
[2] surface drainage: For carrying the surface water, the side drains are provided only on the hill side of the road. there is limitation in the formation width of road and hence these drains are constructed of such a shape that the vehicles could utilize the space of side drains incase of an emergency for crossing or parking.



Angle side drain for hill roads drainage works



Kerbs and channel side drain



Saucer side drain

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(CE622PE) HIGHWAY CONSTRUCTION AND MANAGEMENT

UNIT-I

TYPES OF HIGHWAY CONSTRUCTION AND LAYERS: Water Bound Macadam (WBM), Wet Mix Macadam (WMM), Dry Lean Concrete (DLC), Soil Stabilized Roads and Interface treatments. Construction techniques and Construction equipment’s. Quality control tests during construction of sub grade, sub-base and base courses. IRC specifications.

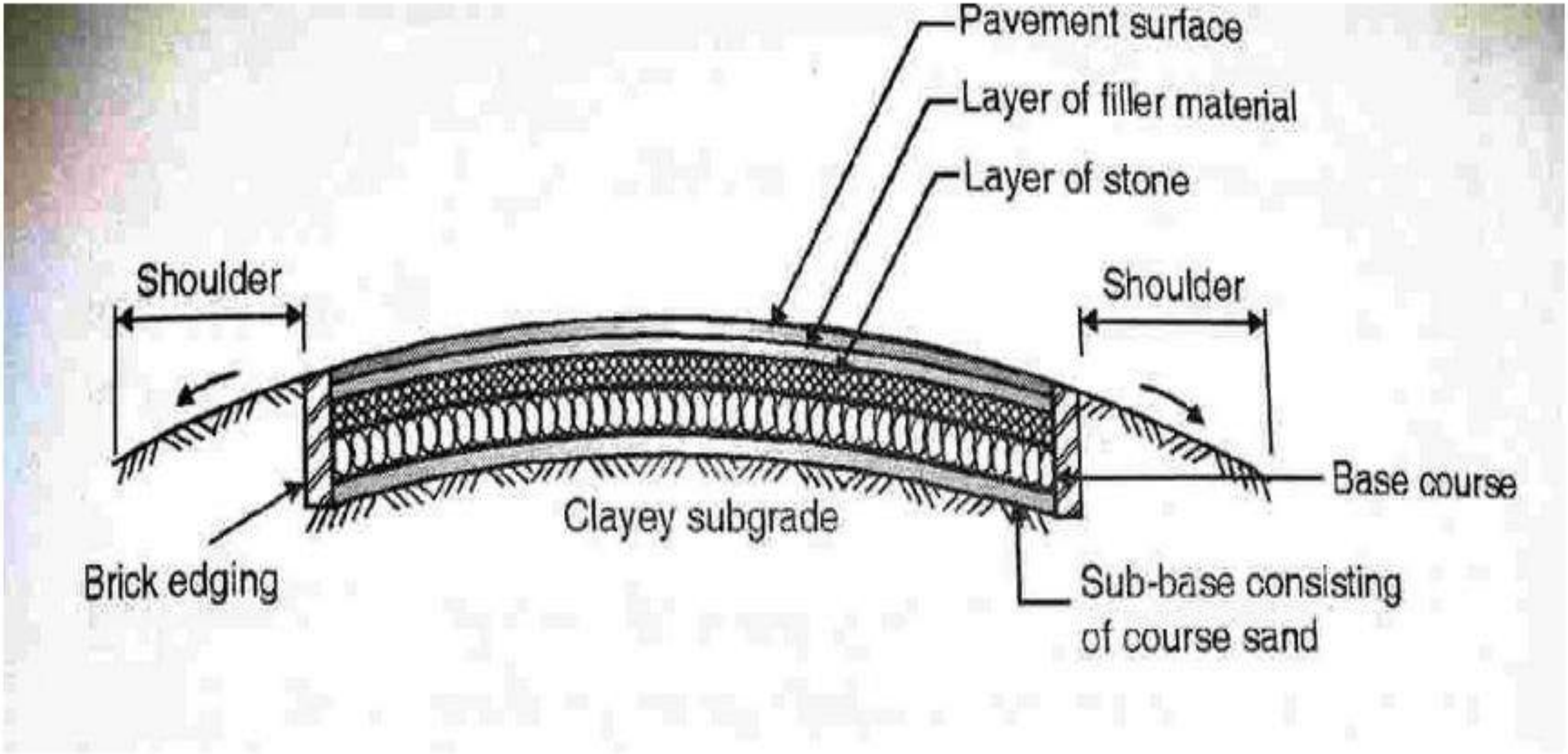
PAVEMENT

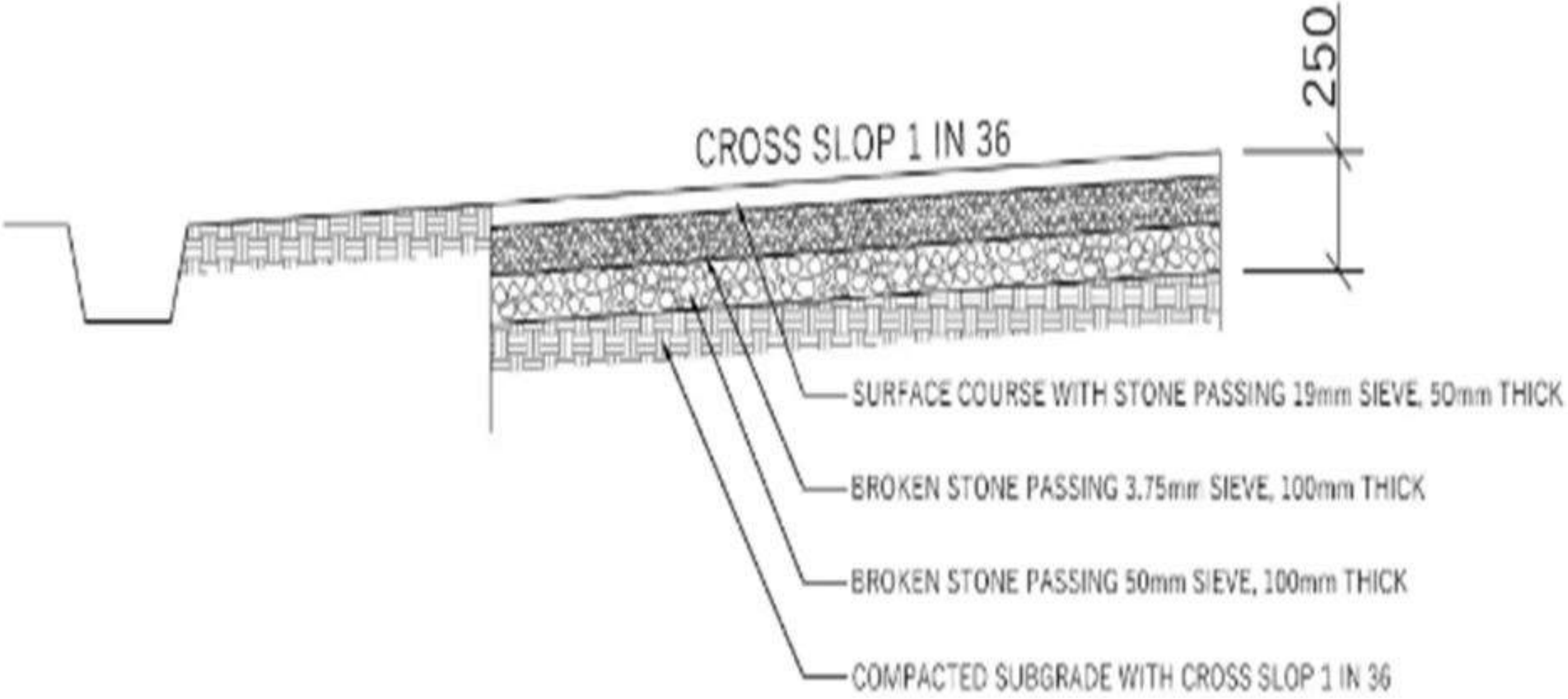
- Pavement is the durable surface material laid down on an area intended to sustain vehicular load or foot traffic, such as a road or walkway.
- It is of two types :
- Flexible pavement or bituminous pavement or black top pavement
- Rigid pavement or cement concrete pavement or white surface pavement

FLEXIBLE PAVEMENT

- The pavement which possess low flexural strength (bending strength) and can transfer the wheel loads on the soil sub grade below by deformation action is called flexible pavement.
- For example, Bituminous roads, Stabilized soil roads, WBM roads, Earth/ Gravel roads.

Construction Procedure of WBM Road.





WBM Road Cross Section

FUNCTIONS OF SUBGRADE, SUB-BASE, BASE AND WEARING COURSE

Subgrade:

- To receive the stress generation from the above layers
- To receive the materials of the above layers and act as a bedding layer.

Sub-base course:

- Act as a support for base and wearing course
- To improve drainage condition
- To remove heave
- To protect above layers from bad qualities from underlying soils

Base course:

- To horizontal shear stresses and vertical pressure produced by moving and standing wheel load
- To provide density and resistance to weathering
- Distribution of higher wheel load pressure

Wearing course:

- To provide resistance against wear and tear due to traffic movements
- To provide smooth and dense riding surface to resist the pressure exerted by vehicle and to resist surface water infiltration.

What Is WBM Road?

The water bound macadam, commonly abbreviated as WBM, is a type of road, named after John Macadam. It consists of raw materials like clean and crushed aggregates, screening and binding materials.

The aggregates are mechanically interlocked by rolling and the screenings and binding materials, are used to fill the voids in the aggregates. All the materials are mixed with water.

The mixture of such materials is laid on a well prepared subgrade, sub-base, or on existing road pavement. Water bound macadam can be used as a sub-base, base course, or surface course. The thickness of each layer in WBM road ranges between 7.5 cm to 10 cm.

According to IRC – 19-1997, a camber of 1 in 48 is provided at the formation level of the subgrade as well as the finished surface if the rainfall in that area is not heavy, and if the rainfall is heavy, a camber of is suggested. 1 in 36

1. Preparation of the Foundation for Receiving the Water-Bound Macadam Course

Materials Used In WBM Road

The materials used for the preparation of water bound macadam are as follows:

1. Coarse aggregates,
2. Screenings,
3. Binding materials, and
4. Water.

1. Coarse aggregates

The coarse aggregates used for water bound macadam are as follows:

Crushed aggregates
Over burnt bricks
Crushed slag
Kankar
Broken stones
Laterite

The table given below shows the maximum permissible values of tests for aggregates, required for various layers of pavement.

Sr. No.	Test	Sub base	Base course	Surfacing course
1	Los Angeles abrasion test	60	50	40
2	Aggregate impact value test	50	40	30
3	Flakiness index test		15	15

Indian Road Congress (IRC) recommended values for size and grading requirements of coarse aggregates used in water bound macadam are as given in the table below:

Grading number	Aggregate size range in mm	Sieve size in mm	% passing by weight
1	90 to 40	100	100
		80	65 – 85
		63	25 – 60
		40	0 -15
		20	0 – 5
2	63 to 40	80	100
		63	90 – 100
		50	30 – 70
		40	0 – 15
		20	0 – 5
3	50 to 20	63	100
		50	95 – 100
		40	35 – 70
		20	0 – 10
		10	0 – 5

2. Screenings

The screenings are basically used for filling up the voids in the layer of coarse aggregates. Screenings include aggregates of smaller sizes. The screenings are generally the same material as coarse aggregates used in water bound macadam. The table below states the grading requirements of screenings for water bound macadam.

Grading	Size of screenings	Sieve size	% By weight passing
A	12.5 mm	12.5 mm	100
		10 mm	90 – 100
		4.75 mm	10 – 30
		150 micron	0 – 8
B	10 mm	10 mm	100
		4.75 mm	85 – 100
		150 micron	10 – 30

3. Binding Materials

To avoid raveling of aggregates, fine grained materials such as kankar nodules or lime stone dust are used as binding materials for the construction of water bound macadam.

When WBM is used as a surface course, the binding materials used in it should have a plasticity index between 4 to 9.

When and where crushable materials such as moorum or soft gravel are used as screenings, binding materials are not required.

WBM Road Construction Procedure

1. Preparing the foundation for receiving the WBM course

The foundation supporting the layer of WBM is either the subgrade or sub-base course. It is prepared to the required grade and camber. It is cleaned of all the dust particles and loose materials present on it. The foundation, supporting the WBM, should be dried.

When the existing road is topped black, furrows are cut at an interval of 1m at an angle of 45 degrees to the centre line of carriageway.

2. Lateral confinement of aggregates

The aggregates in WBM are confined because if they are placed on the subgrade, there are possibilities that the aggregates may come out due to the load of traffic. It is done by construction of shoulders of thickness similar to the thickness of the compacted layer of WBM (7.5 cm).

3. Spreading coarse aggregates

The aggregates should be evenly and uniformly spread on the prepared base in the required amount. They may be spread manually or mechanically. The thickness of the layers (compacted) of WBM constructed should not be more than 75 mm.

4. Rolling

Once the aggregates are spread evenly, the rollers are deployed to carry out the process of compaction. The rollers used shall be of 6 to 10 tonnes capacity. The compaction of aggregates should start from the edge of the surface. The aggregates are compacted partially then the compaction is paused to permit the application of screening

5. Application of screenings

After partial compaction of aggregates, screenings are applied so that the voids in the aggregates are filled completely. They are applied gradually over the surface in three or more applications. Again after applying screenings, dry rolling is resumed so that they are completely filled in the voids.

6. Sprinkling and grouting

The surface is sprinkled with water after applying the screenings. The surface is then swept and rolled so that the voids are completely filled. If any voids are left empty, additional screenings may be applied.

7. Application of binding materials

After applying the screenings, binding materials are applied in thin layers. Two or more thin layers of binders are applied. After the application of each layer of binding materials, water is sprinkled followed by compaction of layers by rollers of 6 to 10 tonnes capacity.

8. Setting and drying

After all the above mentioned processes, the layer of WBM is allowed to set overnight. Next day the road is inspected and if any voids are empty, they are filled and compacted.

Advantages Of WBM Road

The advantages of WBM roads are as follows:

Initially, the construction of WBM road is cheaper.

Locally available materials are used.

No specially trained labours required.

If it is maintained properly, it can take up to 900 tonnes of traffic per day.

Disadvantages Of WBM Road

The disadvantages of WBM roads are as follows:

Higher maintenance cost.

It is permeable. So it causes softening of subsoil and may get damaged during the rainy season.

The life span of WBM roads is less.

It is not able to bear heavy traffic loads

Defects in WBM

1.Alligator Cracking.
2.Consolidation of pavement layers.
3.Shear failure.
4.Longitudinal cracking.
5.Frost Heaving.
6.Lack of binding to lowers course.
7.Reflection crushing.
8.Formation of waves and corrugation.

Construction Methodology of Wet Mix Macadam(WMM)

This work shall consist of laying spreading and compacting clean, crushed, graded aggregate and granular material, pre-mixed with water, to a dense mass on prepared and approved granular sub-base in accordance with clause 406 of MORT&H specification.

Wet Mix Macadam is also known as “John Macadam”.

MACHINERY

1.Wet mix plant

2.Dumpers

3.Paver finisher or Motor grader

4.The smooth wheeled vibratory roller of 80 to 100 KN

5.Survey kit

MATERIAL

As per clause 406.2 of MORT&H, the material Wet Mix Macadam to be used for the construction of Wet Mix Macadam (WMM) shall satisfy the following requirements.

1.Aggregate impact value shall not be more than 30%.

2.Combined flakiness and elongation indices shall not be more than 35%.

3.The water absorption value of aggregate shall not be more than 2%.

4.Materials finer than 425mocrons shall have a plasticity index (PI) not exceeding 6.

5.The mix graduation shall be satisfied as per MORT&H table no. 400-13.

5.In other words, it is a mixture of 40mm, 20mm, 12mm aggregates and dust with the assistance of water.

METHODOLOGY

1.The base of the approved GSB layer shall be leaned off all foreign matter and marking shall be done to its length and breadth.

2.The wet mix produced from the plant shall be transported to the site by means of end dumpers.

3.As the mix is laid by means of a paver finisher or motor grader, the string line shall be given as per MORT&H intervals to its gradient.

4.The mix shall be unloaded gently into the paver hopper and paving shall be started uniformly, In the exceptional case where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with prior approval of the engineer,

5.The motor grader shall be capable of spreading the material uniformly all over the surface. For petitions where mechanical means can’t be used, manual means as approved by the engineer shall be used only in restricted areas.

6.The levels shall be checked just after paving or grading and after compaction with respect to designed levels. If there is 7.variation in the levels, the same shall be adjusted in further paving.

While constructing the WMM layer, the proper arrangement shall be made for the lateral confinement of the wet mix.

8.If there is any segregation after spreading or paving, the same shall be rectified by spreading fines before rolling.

9.In either case, the rolling shall be carried out from lower edge to upper edge with 80 to 100KN smooth wheeled vibratory roller at a speed not more than 5km/hr.

10.Rolling shall be continued until there are no tyre impressions or drum impressions on the surface and

QUALITY CONTROL

Quality control for the above work shall be as per table 900-3 of MORT&H specification.

1.The gradation and moisture content of the mix shall be controlled at the plant as per the approved design mix.

2.The compacted surface shall be checked for field density at the frequency of 1 test per 1000sqm. The degree of compaction should not be less than 98%

3.The surface shall be checked for levels per MORT&H intervals longitudinally and transversely and the same shall be within +/- 10mm.

4.Surface irregularities shall be checked as per MORT&H clause 900.

ENVIRONMENTAL CONTROL

1.While producing or crushing of aggregates in the crusher plant care should be taken in respect of controlling and minimizing flow of dust, noise and use of blasting materials such as dynamites, etc., safety aspects to workers are also vital and should be taken of.

2.Care will be taken to prevent spilling of material from the trucks during transportation.

If there is any change in the quality of aggregates or in the gradation of the individual aggregates a fresh mix to be worked out. Proper proportioning of materials and production of uniform mix shall be ensured. Proper quality control I required to achieve the design mix and adequate compaction in the field.

WET MIX MACADAM

It is a road base material consisting of crushed rock/slag usually premixed with controlled amount of water sufficient for adequate compaction.

PROCEDURE OF LAYING DRY LEAN CONCRETE

DRY LEAN CONCRETE is cement concrete with low slump as well as low cement which is being laid as a first layer for rigid pavement over sub-base (GSB) , rolled & compacted by mechanical means.We will discuss with all sections one by one as per following order:

1.GENERAL

This work should be carried out accordance with the wants of Contract Specifications and in conformity with the lines, grades , drawings or as directed by the Engineer. The work will include furnishing of all plant and equipment, materials , labour and performing all operations, in reference to the work as approved by the Engineer. The design parameters of dry lean concrete , if any will be as stipulated in the contract drawings.

2. REFERENCE

i) Clause 600 of MORT&H – 5th Edition
ii) IRC:SP: 49-2014
iii) IS: 16714-2018
iv) Relevant Approved Drawings

3. EQUIPMENT WITH ESSENTIAL FEATURES

i) Batching Plant
ii) Paver with Electronic Sensor
iii) Dump Trucks
iv) Water Tanker
v) 8-10 Tonne Roller
vi) Hand Tools: Shovels, Broom, Wire brush, Straight edge
vii) Testing Equipment’s: 20 cm dia Density cone, Vibrating Hammer, Cube Moulds, Thermometer.

4. MANPOWER REQUIREMENTS

i) Site Engineer

ii) Surveyor (With Team)

iii) Operators, Supervisors and Laying Team

5. MATERIALS

5.1 Source of Materials

Source the approval of material should be obtained from the Engineer at least 45 days before the scheduled commencement of the work. If later it is proposed to obtain the materials from a different source, Engineer will be notified for his approval at least 45 days before such materials are to be used.

5.2 Cement

Following sorts of cement could also be used with prior approval of the Engineer. Ordinary Portland Cement 53 Grade IS:8112 Cement to be used may rather be obtained in bulk form. It will be stored in accordance with stipulations contained in Clause 1014.

5.3 Ground Granulated Blast Furnace Slag

GGBS should be used from approved source & complying the requirements of IRC SP: 49-2014

5.4 Aggregates

Aggregates for lean concrete will be crushed material complying with IS: 383. The aggregates will not be alkali reactive. The limits of deleterious materials will not exceed the requirements set out in IS: 383.

a)Coarse aggregate

Coarse aggregates will consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stones or crushed gravel . The maximum size of the coarse aggregate will be 26.5 mm. The water absorption of coarse aggregate shall not exceed 3%.

b)Fine aggregate

The fine aggregate will consist of clean, natural sand or crushed stone sand or a combination of the two and will conform to IS: 383. Fine aggregate will be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The water absorption of coarse aggregate shall not exceed 3%.
The material after blending will conform to the grading as indicated in Table -1 of IRC SP 49-2014

Table: Aggregate Gradation for Dry Lean Concrete

Sieve Designation	Percentage Passing the sieve by weight
26.50 mm	100
19.00 mm	75-95
9.50 mm	50-70
4.75 mm	30-55
2.36 mm	17-42
600 micron	8-22
300 micron	7-17
150 micron	2-22
75 micron	0-10

5.5WATER

Water used for mixing and curing of concrete will be clean and free from injurious amounts of oil, salt, acid, substance or other substances armful to the finished concrete. It will meet the requirements stipulated in IS: 456.

5.6 Proportioning of Materials for the Mix

The mix will be proportioned with a maximum aggregate cement ratio of 14:1. The water content will be adjusted to the optimum as per Clause 4.2 of IRC SP 49 for facilitating compaction by rolling. The strength and density requirements of concrete will be determined in accordance with Clause 7.1 of IRC SP 49-2014 by making trial mixes.

5.7 Cement Content

The minimum cementitious content in the lean concrete will not be less than 140 kg/cum. of concrete. If using GGBS minimum cement content shall not be less than 100 kg/m3.If this minimum cement content is not sufficient to produce concrete of the specified strength, it will be increased as necessary to obtained the strength.

5.8 Concrete strength

The average compressive strength of each consecutive group of 5 cubes made in accordance with IR: SP:49-2014 will not be less than 7 MPa at 7 days. In addition, the minimum compressive strength of any individual cube will not be less than 5.5 MPa at 7 days. The design mix complying with these requirements shall be worked out before start of work.

5.9 Sub-grade

The sub-grade will conform to the grades and cross sections shown on the drawings and will be uniformly compacted to the design strength in accordance with these specifications and specification stipulated in the contract. The lean concrete sub-base shall not be laid on a poor sub-grade , if any must be properly back-filled and compacted as per specification. As far as possible, the construction traffic will be avoided on the prepared sub-grade. A day before placing of the sub-base, the sub-grade surface will be given a light sprinkling of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilize loose surface and then check for compliance.

5.10 Construction

The pace and program of the lean concrete sub-base construction will be matching suitably with the program of construction of the cement concrete pavement over it. The sub base will be overlaid with cement concrete pavement only after 7 days after sub-base construction.

5.11 Batching and mixing

The batching plant will be capable of proportioning the materials by weight, each type of material being weighed separately. The cement from the bulk stock will be weighed separately from the aggregates. The capacity of batching and mixing plant should be at least 25 % higher than the proposed capacity for the laying arrangements & batching and mixing plant should have necessary automatic controls to ensure accurate proportioning and mixing. Other types of mixers will be got approved subject to demonstration of their satisfactory performance during the trial length.

6.0 Trial Stretch

A trial stretch shall be made to the required width and minimum of 60 metre length . The trial length shall contain construction of at least one transverse construction joint involving hardened concrete and sub-base to be laid subsequently, so as to demonstrate the soundness of the procedure. In one day not more than 30 m of trial stretch shall be laid. The in-situ density of the freshly laid concrete shall be determined by sand replacement method by making 3 density holes at equal distances that diagonally bisects the trial length, these shall not be made in the strip of 500 mm from the edges. The average of these shall be considered as 100%, and with this the field density of the regular work shall be compared. The hardened concrete may be cut for 3m width in the trial length and reversed to check the bottom surface for any segregation or honey-combing, if found necessary adjustments shall be made in the mix design.

6.1 Transportation and placing

The plant mix concrete shall be transported by sufficient number of trucks to ensure continuous, uniform supply of concrete to feed the laying Equipment. The mix shall be protected from the weather, by covering the tippers/dumpers with tarpaulin during the transit. The lean concrete shall be laid to the required widths, grades,camber and thickness with self-propelled, electronic sensor or mechanical paver.

6.2 Compaction

The compaction shall commence as soon as the concrete laid and levelled to the full width till there is no further movement under the roller and the surface is closed. In addition to the number of passes required for compaction, there shall be a pass without vibration as preliminary pass and another at the end as final pass. The minimum dry density obtained shall be 97% of that achieved in trial length, and at a distance of 500 mm from edge it shall be 95% of that achieved in the trial length. The finished surface should be inspected immediately, and all loose, segregated or defective areas if any ,shall be corrected by using fresh lean concrete.

7.0 Quality Control Testing and Acceptance

Curing

As soon as the lean concrete surface is completed, curing shall commence.

a) Curing shall be done by covering the surface by hessian cloth in two layers which shall be kept continuously moist for 7 days by sprinkling water.

b) If water-curing is not possible, the curing shall be done by spraying with liquid curing compound. The curing compound shall be white pigmented type with water retention index of minimum 90 percent, when tested in accordance with the test method given in Annexure-A of IRC SP 49 -2014 To check the efficiency of the curing compound, the supplier shall be required to provide the test certificate from a recognized laboratory. Curing compound shall be sprayed immediately after when rolling is complete & the surface shall also be covered with wet hessian for three days.

2)Tolerance

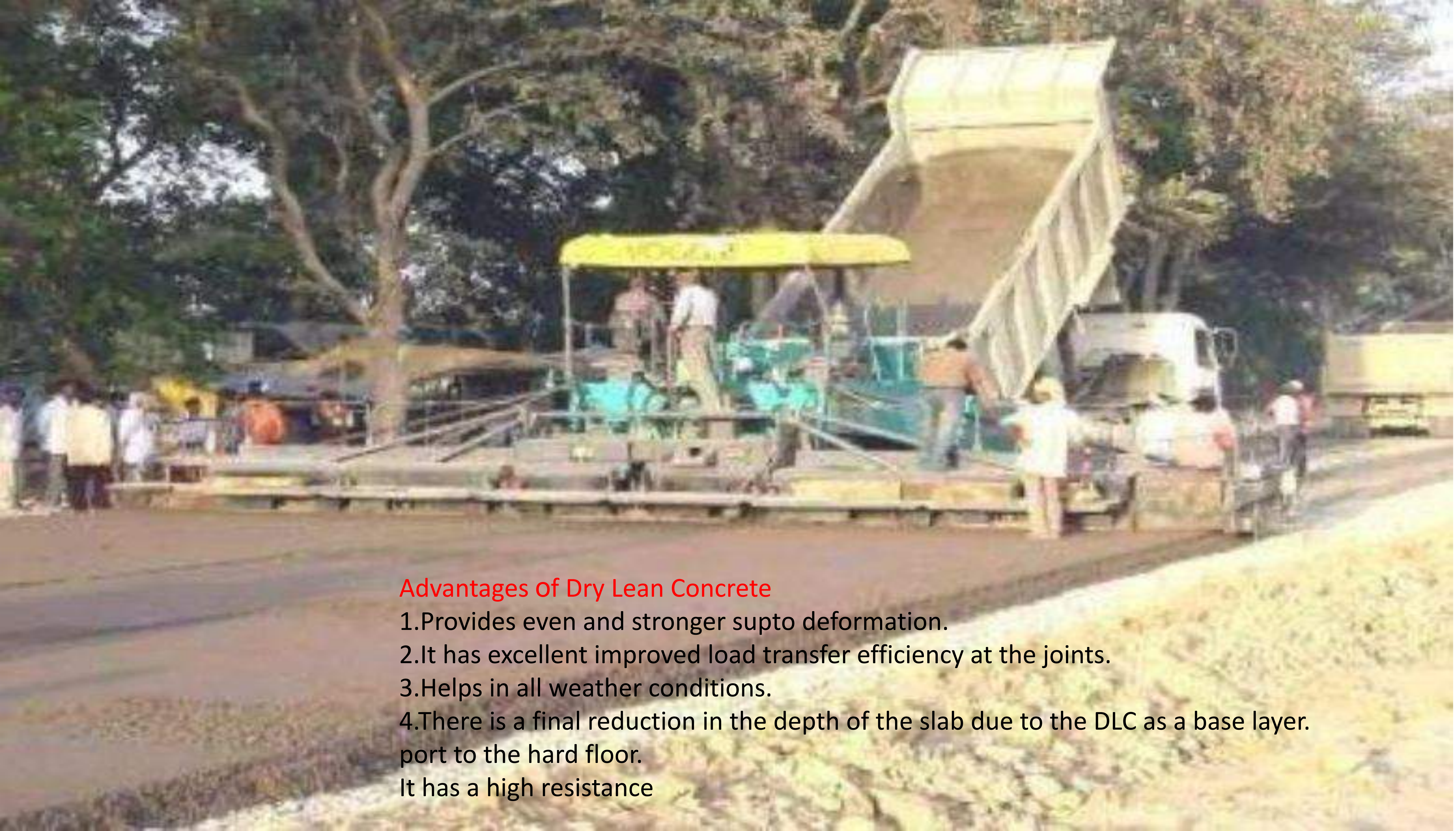
The tolerances for thickness shall be ± 10 mm.

3)Density

The dry density of the laid material shall be determined from density holes at locations equally spaced along a diagonal that bisects each 2000 sq.m or part thereof, of material laid each day. It shall not be less than 97% of design density .The control of strength shall be exercised by taking samples of dry lean concrete for making cubes at the rate of 3 samples for each 1000 sq.m or part thereof laid each day. The cube samples shall be compacted, cured and tested in accordance with IS: 51 6.

8.Safety Requirements/Measures

DLC laying team will wear personal protective equipment while producing, transporting and laying the mix. All safety measures will be taken as per approved plan.



Advantages of Dry Lean Concrete

1.Provides even and stronger supto deformation.

2.It has excellent improved load transfer efficiency at the joints.

3.Helps in all weather conditions.

4.There is a final reduction in the depth of the slab due to the DLC as a base layer.

port to the hard floor.

It has a high resistance

SOIL STABILIZATION

- The term soil stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and/or the addition of suitable admixtures.
- **Necessity of soil stabilization :**
- To increase the bearing capacity (stability) of soil.
- To reduce the cost of construction.
- To modify chemical properties of soil.
- To increase the shear strength of soil.
- To increase the flexibility of soil.

PURPOSE OF SOIL STABILIZATION

1. To improve the strength of sub-bases, bases and sometimes surface courses, in case of low cost roads
2. To bring about economy in the cost of road.
3. To make use of inferior quality of locally available soils/material. (every time it is not possible to find required or specified strength in locally available material at that time we can go for soil stabilization methods)*
4. To improve certain undesirable properties of soils, such as excessive swelling or shrinkage, high plasticity, difficulty in compacting etc.
5. To facilitate compaction and increase load-bearing capacity
6. To reduce compressibility and thereby settlements.
7. To improve permeability characteristics.

Different techniques of soil stabilization

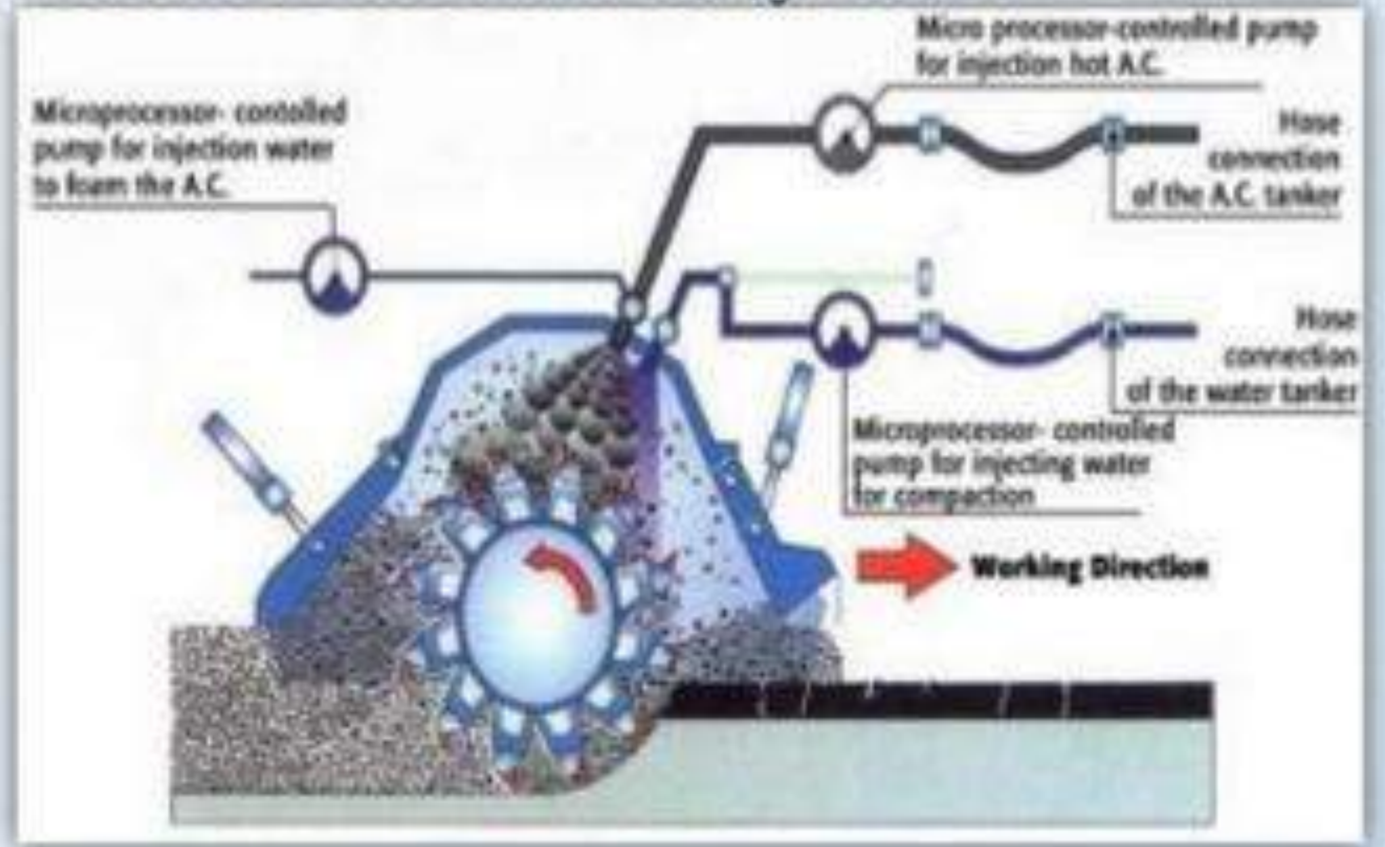
types of soil stabilization techniques

Mechanical stabilization	chemical stabilization or stabilization by additives such as
- soil-aggregate mixture	-lime
-soil- clay mixture	-cement
-sand-gravel mixture	-sodium silicate
- stabilization of soil with soft aggregates	-Calcium chloride
	-bituminous material
	-resinous material

Mechanical Stabilization

- Two or more types of soils are mixed to attain a desired property to suit a particular construction and soils are grouped into two categories (aggregates and binders).
- Aggregates are sands and gravels and binders are silts and clays.

- When mixed together in a definite proportion, a soil possessing required internal friction and cohesion is obtained. When properly placed and compacted, the material becomes mechanically stable.



- SOIL MIXERS

MECHANICAL SOIL STABILIZATION

- In this techniques the stability of soil is increased by blending the available soil with imported soil or aggregate so as to obtain a desired particle-size distribution , and by compacting the mixture to the desired density. Compacting a soil at an appropriate moisture content is itself a form of mechanical stabilization

PRINCIPLE OF MECHANICAL STABILIZATION

- Mechanical stabilization is achieved by intelligently blending locally occurring material so as to obtain a desired grading. compaction of soil is also a form of Mechanical stabilization. (It is well known as a dense, well graded mass offers high resistance to lateral displacement under a load).

- If well graded material is compacted , densification of the mass takes place. The mechanical strength of mass is due to the internal friction and the cohesion. (internal friction is supplied by the coarser particles gravels, sand, silts where as cohesion is due to the clay friction.)

Cement stabilization

- It is ideal for granular soil mixed with fines will require less amount of cement.
- Clayey soils require high quantity of cement to stabilize.
- A well graded sandy soil require 5% cement whereas poorly graded about 9%.for clayey soils 13% may be required.
- The quantity of water used for hydration must be sufficient for hydration and workable mix.
- Admixtures such as lime ,calcium chloride ,sodium carbonate can also be used.

CEMENT STABILISATION

1. MOST COMMONLY USED FOR ROAD CONSTRUCTION.
2. HEAVY CLAYS ARE DIFFICULT TO PULVIRIZE AND NOT SUITABLE.
3. WELL GRADED SAND AND GRAVEL MIXTURES WITH UPTO 10% FINE BINDER MATERIAL (PASSING#200SIEVE).
4. QUANTITY OF CEMENT TO BE DETERMINED ON TRIAL BASIS IN LAB. (MINIMUM STRENGTH REQUIRED 3.5N/mm2—7 DAYS CUBE STRENGTH.
5. Compaction to be completed within two hours after laying mixing with water.

a. <u>CENTRAL PLANT METHOD:</u> Faster construction, expansive, dry mix and then wet thoroughly, spreading and compaction.

b. <u>MIX IN PLACE METHOD:</u> Similar to agriculture rotary cultivator, firstly soil is pulverized then dry cement is spread over, then water sprinkled in layers, again remixed and shaped to camber., compacted using rollers.

LIME STABILIZATION

There are basically five types of lime:

- High Calcium, quick lime (CaO)
- Hydrated, high calcium lime [$Ca(OH)_2$]
- Dolomite lime ($CaO+MgO$)
- Normal, hydrated dolomitic lime [$Ca(OH)_2+MgO$]
- Pressure, hydrated dolomitic lime [$Ca(OH)_2+Mg(OH)_2$]

—The quick lime is more effective than the hydrated lime, but the latter is more safe and convenient to handle. Generally, hydrated-lime is used. It is also known as slaked lime.

—The higher the magnesium content of the lime, the less is the affinity for water and the less is the heat generated during mixing.

—The amount of lime required varies between 2 to 10% of the soil.


D. GUTZWILLER
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Soil stabilisation cement-

Area	Soil Class (a)	Type of stabilizing additive recommended	Restriction on LL and PI of soil	Restriction on percent passing No. 200 sieve (a)	Remarks
1A	SW or SP	(1) Bituminous (2) Portland cement (3) Lime-cement-fly ash	 PI not to exceed 25		
1B	SW-SM or SP-SM or SW-SC or SP-SC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not to exceed 12 PI not to exceed 25		
1C	SM or SC or SM-SC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 (b) PI not less than 12 PI not to exceed 25	Not to exceed 30% by weight	
2A	GW or GP	(1) Bituminous (2) Portland cement			Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve.
2B	GW-GM or GP-GM or GW-GC or GP-GC	(1) Bituminous (2) Portland cement (3) Lime (4) Lime-cement-fly ash	PI not to exceed 10 PI not to exceed 30 PI not less than 12 PI not to exceed 25		Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve.
2C	GM or GC or GM-GC	(1) Bituminous (2) Portland cement	PI not to exceed 10 (b)	Not to exceed 30% by weight	Well-graded material only. Material should contain at least 45% by weight of material passing No. 4 sieve.
3	CH or CL or MH or ML or OH or OL or ML-CL	(1) Portland cement (2) Lime	LL less than 40 and PI less than 20 PI not less than 12		Organic and strongly acid soils falling within this are are not susceptible to stabilization by ordinary means

(a) Soil classification corresponds to MIL-STD-619B. Restriction on liquid (LL) and plasticity index (PI) is in accordance with Method 103 in MIL-STD-621A

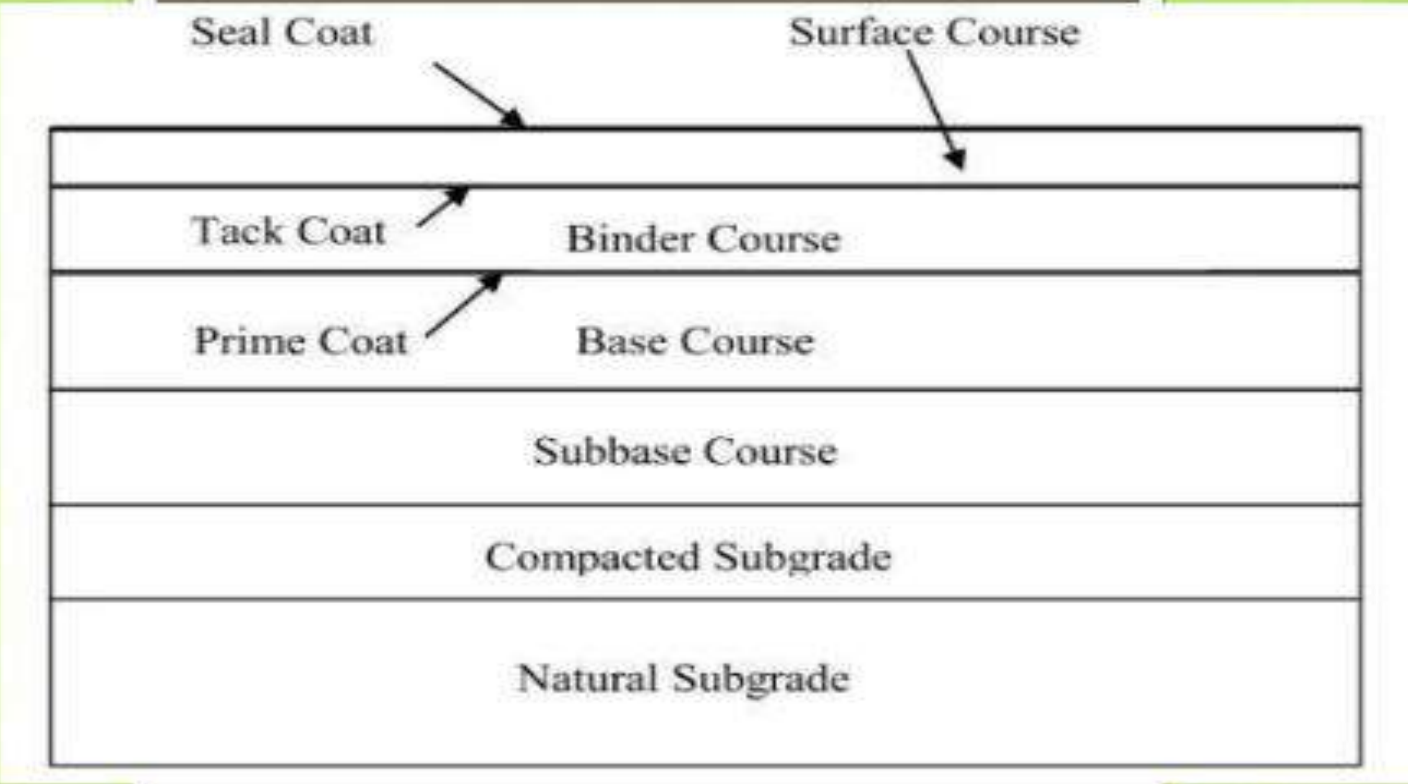
(b) PI $\leq$ 20 + (50 – percent passing No. 200 sieve)/4

INTERFACE TREATMENT

The surface of the existing pavement layer is to be cleaned to remove dirt and dust and thin layer of bituminous binder is to be sprayed before the construction of any type of bituminous layer over this surface. This treatment with bituminous material is called interface treatment.

INTERFACE TREATMENTS

- Prime Coat
- Tack Coat
- Seal coat




Prime coat
Seal coat

Prime Coat

- Prime coat is define as application of low viscosity liquid bituminous material over an existing porous or adsorbent pavement material like WBM base course.

➢ **Purpose Of Prime coat:-**

- To plug the capillary voids.
- To coat and bond loose materials on the surface.
- To harden or toughen the surface.
- To promote adhesion between granular and the bituminous layer.

Prime coat material

Prime Coat	Type
MC-30 (Medium Curing)	Cutback
AEP (Asphalt Emulsion Prime)	Emulsified Cutback
EC-30 (Eco Cure)	Emulsion-Non bituminous
CSS-1H (Cationic Slow Setting Hard Base)	Emulsion
SS-1H (Slow-Setting Hard Base)	Emulsion
TP - (Terra Prime)	Polymer based Emulsion

Prime coat material

- Prime coat materials mainly consist of cutback asphalt, emulsified asphalt or polymer based chemicals.
- Cutback asphalt is manufactured by blending asphalt cement with petroleum solvent.
- emulsified asphalt consists of a suspension of asphalt cement in water.
- The most commonly used prime coat materials are MC-30, AEP, EC-30, CSS-1H and SS-1H.
- The most historically utilized prime material, worldwide, has been MC-30 (before 1984).
- However, MC-30 contains **petroleum solvent which emits volatile organic compounds** (VOCs) and therefore causes pollution to the environment.
- Now, MC-30 has been banned or restricted from use.
- For this reason, emulsions and polymer based materials are becoming more and more popular due to their less harmful effects on the environment.

Prime coat application methods

Spray prime

- Typically MC-30 or AEP cutback
- Sprayed on compacted base using asphalt distributor
- If the prime will have a traffic ,blotting material (sand or crushed stone)applied.

Worked-in (Cut-in) Prime

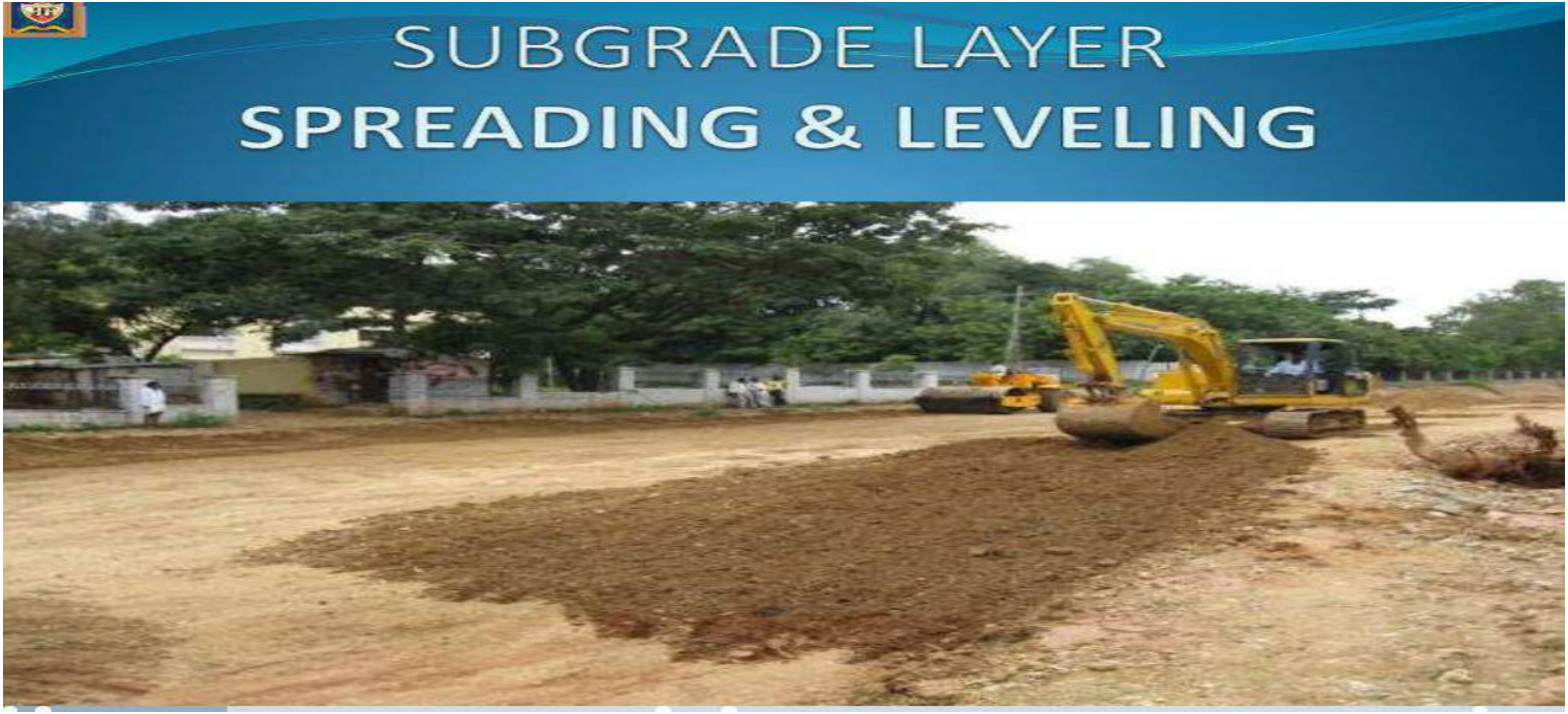
- Diluted emulsified asphalt sprayed on finished base covered with thin coating fines .
- Work from side to side using mortar grader

Inverted or covered prime

- Typically RC-250
- Sprayed on to finished base using asphalt distributor and covered by using grade 5 stone
- Use for significant traffic

EARTH WORK

- SOIL FILLING
- SPREADING & LEVELING
- COMPACTION



COMPATION OF SUBGRADE

I LAYER :200mm   II ,III LAYER :150mm

GRANULAR SUB BASE

- MATERIAL
- LAYERS
- DEPTH
- COMPACTION

Sub Base Layer

IMPORTANT PROPERTIES OF PRIME COAT:

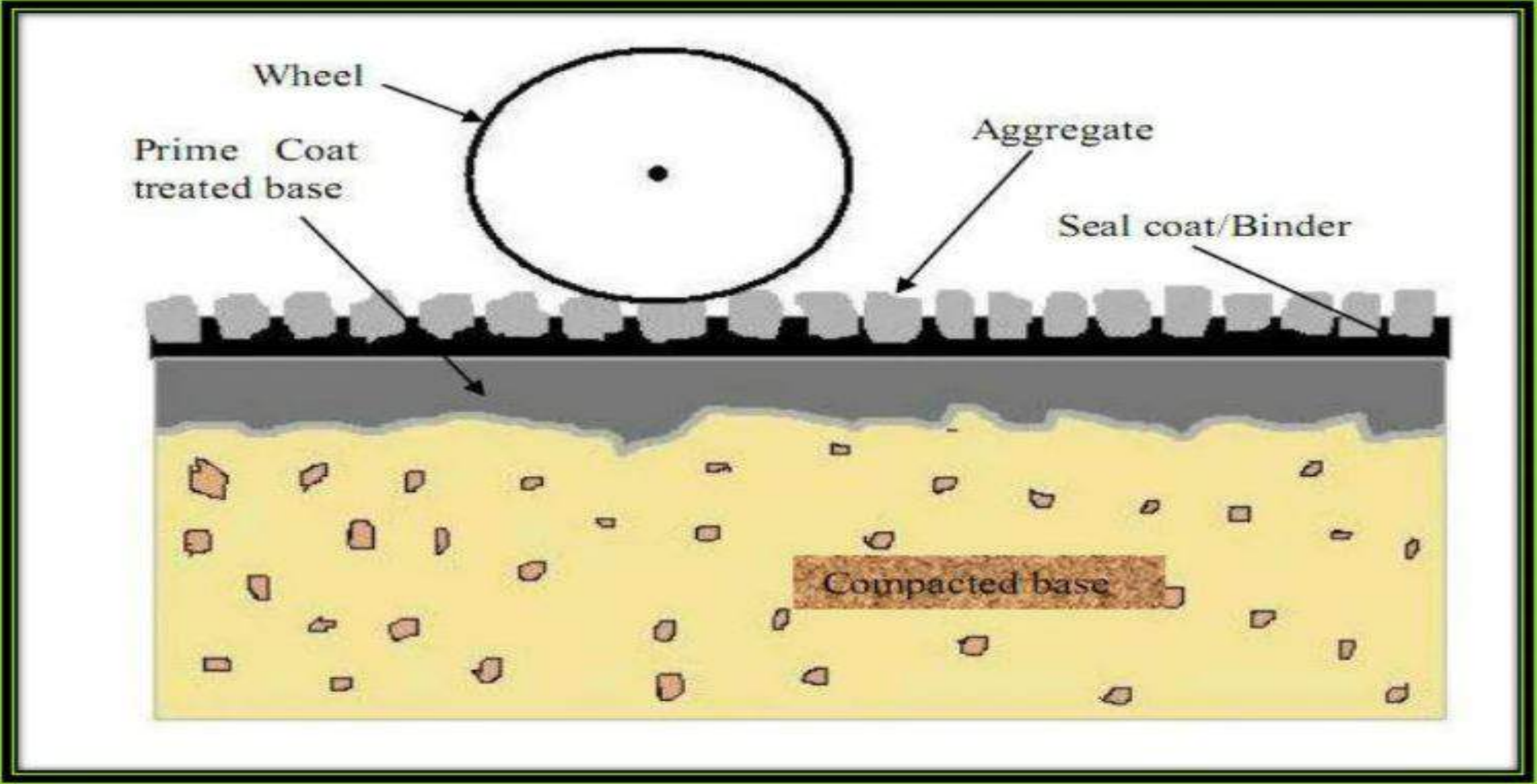
1) Penetration depth
2) Curing time
3) Strength
4) Impermeability
5) Environmental impact

1. Penetration of prime coats

- One of the main purposes of the prime coat is to provide a good bond between surface treatment and base. The binders used in surface treatment courses do not have a viscosity low enough to penetrate the base layer.
- A prime coat, which is a low viscosity binder, when applied will act as an intermediary between the base and the surface coat so as to ensure a good bond between both. Thus, it is clear that **adequate penetration** is necessary for a prime coat to serve its purpose.

Good Surface, Good Penetration

Good Surface, Poor Penetration



Pavement section showing penetration of prime coat

Penetration Test

- Penetration is important as it determines how effectively and efficiently a prime coat can perform.
- Sand penetration tests were conducted according to the procedures that are commonly used by TxDOT (Texas department of transportation)

Cutting through the surface of the specimen to determine penetration depth

Cross section of the cut specimen depicting the penetration

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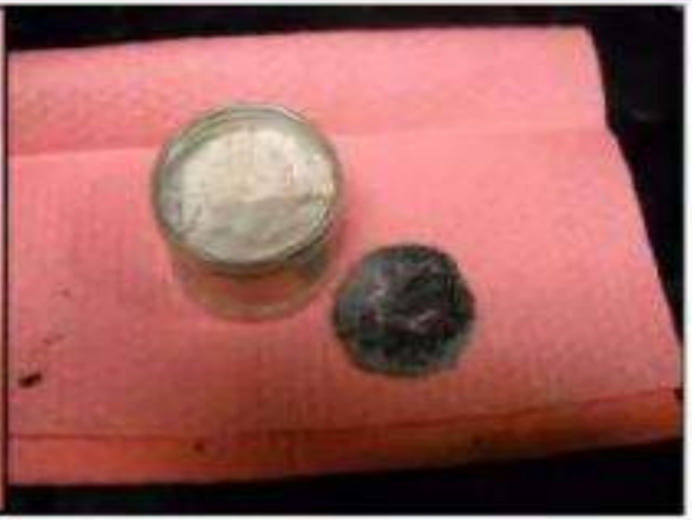


Penetration shown by asphalt emulsion

Penetration shown by cutback asphalt

Emulsions have very little penetration when compared to cutbacks or polymer based prime coats. It just cover the surface without penetrating into the base.

CURING TIME TEST

- Proper curing of prime coat is an important construction phase because an **uncured prime coat can cause more base movement than an unprimed base**.
- Prime coat is said to be cured completely when all of its solvent has evaporated.
- Thus, the amount of solvent evaporated verses time is studied in this research.
- The researcher also tracked the strength growth of primed base sample regularly and draw curves depicting weight loss and strength growth with time.

Material used:

- Base material: crushed limestone passing through sieve No.10 (2.36mm)retained on sieve No.40(.425mm), and passing through sieve No.40 were mixed to make the base material.

Specimen preparation procedure:

1. Prepare Circular Can.

2. Put 300 g of base material into the can.

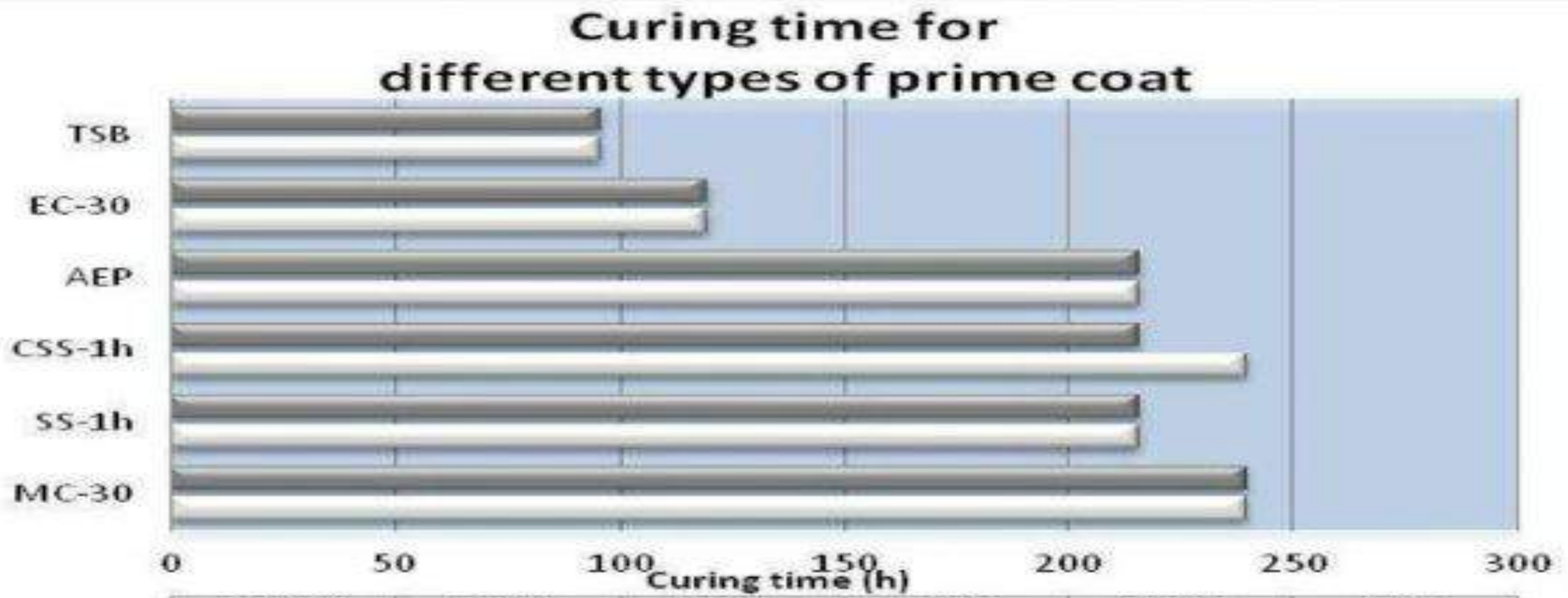
3. Compact the soil.

4. Spray or mixed-in prime coat.

5. Expose the specimen to weather to cure.

6. Run analysis.

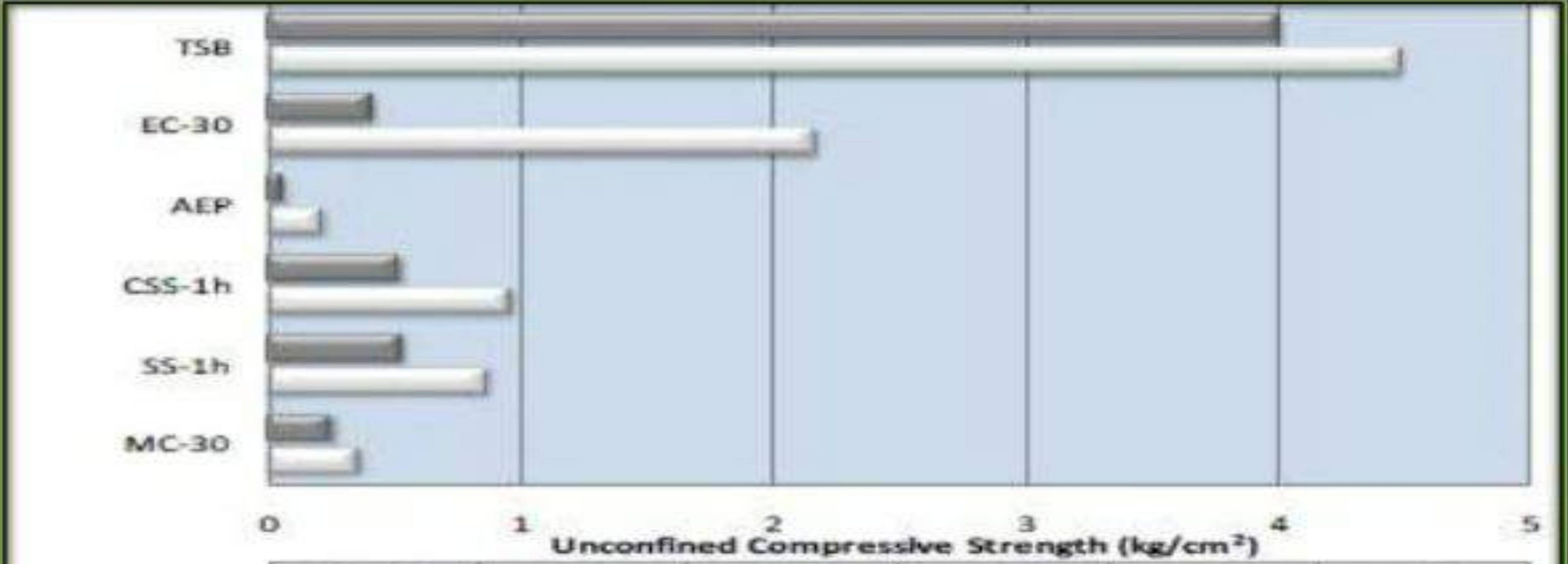
- For each prime coat, samples were prepared using two application methods : spray and mixed-in.
- The curing of prime coat is assumed to end when the weight drops below 0.1 gram, or when the strength reaches its maximum value, whatever occurs later.



	MC-30	SS-1h	CSS-1h	AEP	EC-30	TSB
Sprayed-on	240	216	216	216	120	96
Mixed-in	240	216	240	216	120	96

Strength Test

- The pocket penetrometer was used to determine the strength of cured specimens so that a comparative study of the strength of the prime coats could be performed.
- Application methods have significant impact on unconfined compressive strength normally mixed-in type application has higher strength than sprayed-on type application.
- This is because by mixing prime coat with base soil, the pores inside the base are filled more effectively and a strong adhesive bond between fines and prime coat is formed and thus improving its load resistance.

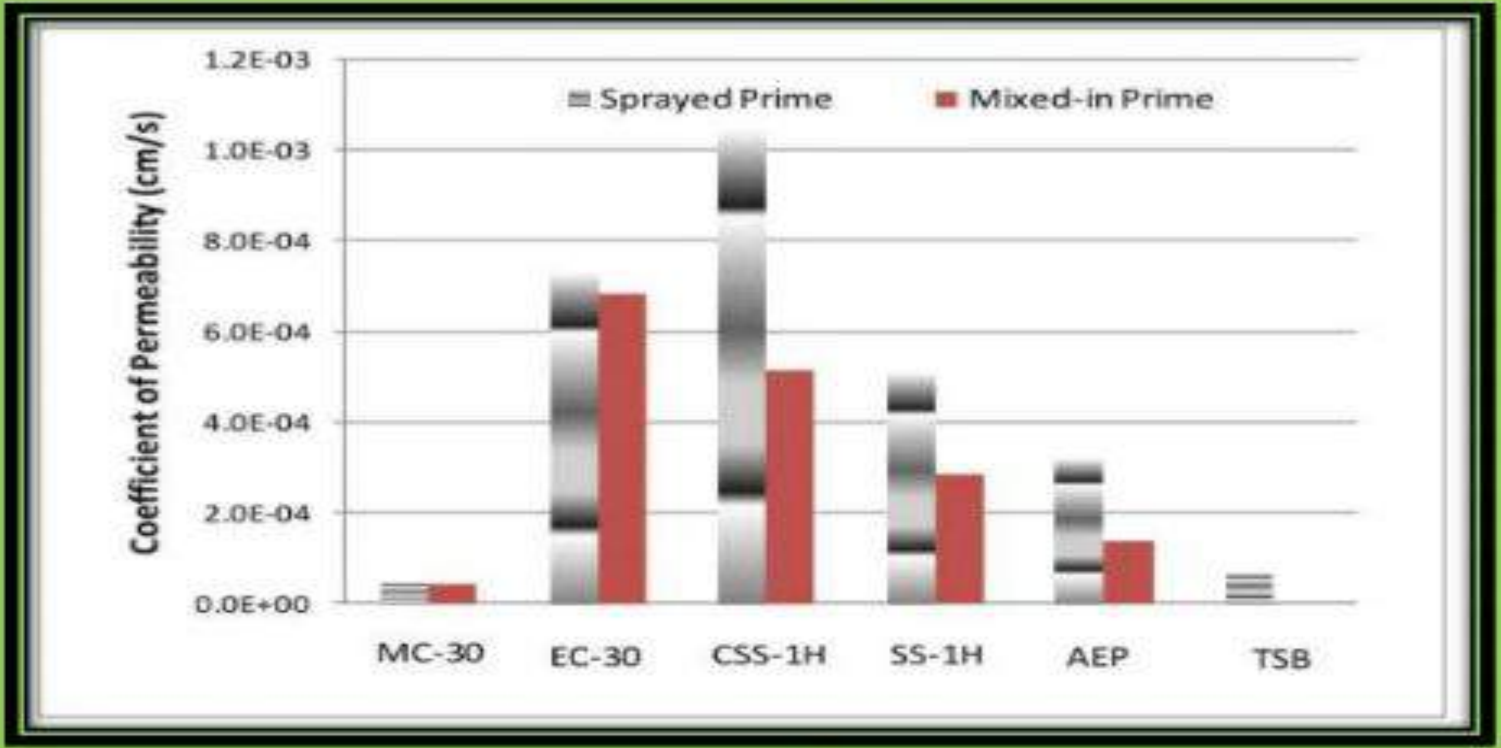


	MC-30	SS-1h	CSS-1h	AEP	EC-30	TSB
Sprayed-on	0.275	0.55	0.54	0.08	0.43	4.02
Mixed-in	0.375	0.88	0.98	0.23	2.18	4.5

- For sprayed type of application, the unconfined compressive strength of tested prime coats increases in the following order: AEP<MC-30<EC-30<CSS-1H<SS-1H<TSB
- For mixed-in type of application, the strength of tested prime coats increases in the following order: AEP<MC-30< SS-1H<CSS-1H< EC-30<TSB.

Permeability Test

- One of the main purposes of prime coat is to seal the surface pores in the base and stop the moisture coming into the base.
- This study looks into how effectively each prime coat prevents water from penetrating into the base material.
- Assuming the hydraulic gradient to be constant,
- Coefficient of permeability (cm/s), k, = V/At



TACK COAT

- **What is tack coat?**

  Tack coat is bitumen emulsion that is sprayed on existing pavement surface which is relatively **impervious** like an existing bituminous surface or a cement concrete pavement or a pervious surface like the WBM which has already been **treated by a prime coat.**(higher viscosity then prime coat)

There are three essential requirements for a successful tack coat application:

1) Existing pavement surface must be dry and thoroughly cleaned.
2) Proper tack coat rate must be applied.
3) A uniform coverage of tack must be placed over the entire area to be paved.

EXISTING SURFACE PREPARATION

- Existing surface must be thoroughly clean and dry. The existing surface also should be:
- Swept with a mechanical broom to ensure surface is free of dust and foreign material
- At an atmospheric temperature of 35 degrees Fahrenheit or higher

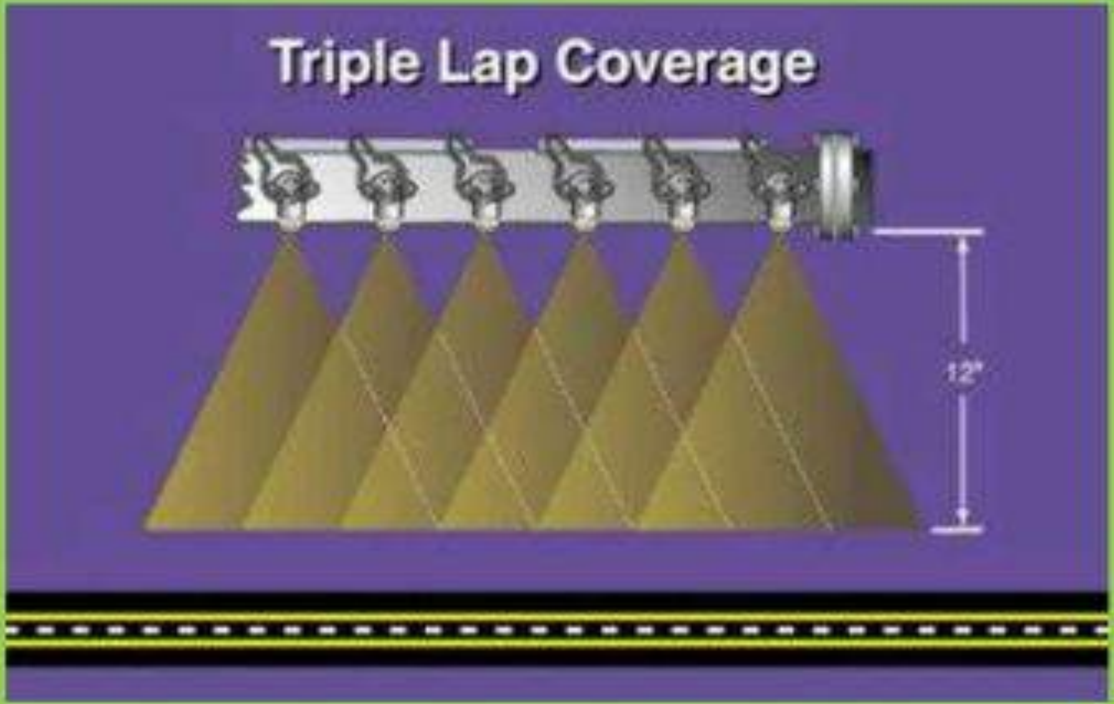
RECOMMENDED QUANTITIES OF MATERIAL FOR TACK COAT

Type of Surface	Quantity in kg per m2 area
Bituminous Surface	0.20 to 0.25
Dry and hungry bituminous surfaces	0.25 to 0.30
Primed granular surface	0.25 to 0.30
Unprimed granular base	0.35 to 0.40
Cement concrete pavement	0.30 to 0.35

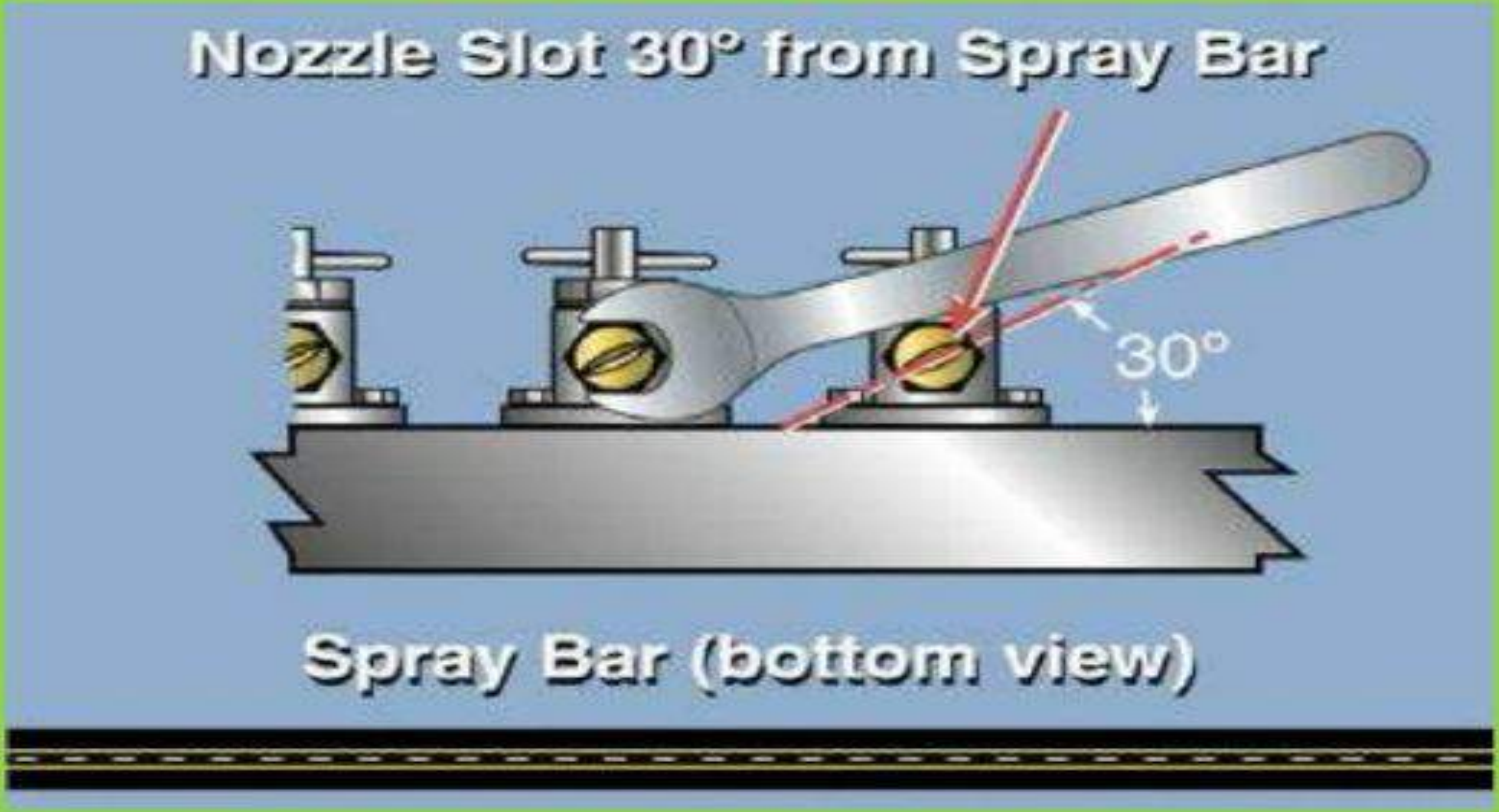
MECHANICAL PRESSURE SPRAYER FOR PRIME/TACK COAT

IMPORTANT APPLICATION PARAMETER

- **Spray Bar Height**: Recommended height is 11 to 12 inches from surface and application at triple lap coverage.



- **Nozzle:** Use a tack nozzle set 30 degrees from spray bar to allow stream to pass by the adjacent nozzle stream.



SEAL COAT

- Seal coating consists of the application of liquid asphalt material to the roadway followed immediately by the application of the aggregate.
- Seal coats are applied to HMA or concrete surfaces to:

1) Seal out moisture and air
2) Rejuvenate dry weathered surfaces
3) Improve skid resistance of the pavement
4) Improve visibility of delineation between the traveled way and the shoulders

- Seal coats applied directly to roadways with aggregate surfaces provide a smooth, dust-free traveled way which eliminates the need for periodic regrading of the surface. This method of construction is normally used only **for low-volume roads.**

TYPES OF SEAL COAT

A. Liquid Seal Coat:

comprising of a layer of binder followed by a cover of stone chipping Stone chips shall be of 6.7mm size defined as 100 percent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic meter per 10 square meter area.

B. Premixed Seal Coat:

A thin application of fine aggregates premixed with bituminous binder The quantity of bitumen shall be 9.8 kg and 6.8 kg per 10 m2 area for type A and type B seal coat respectively.

LAYING PROCEDURE

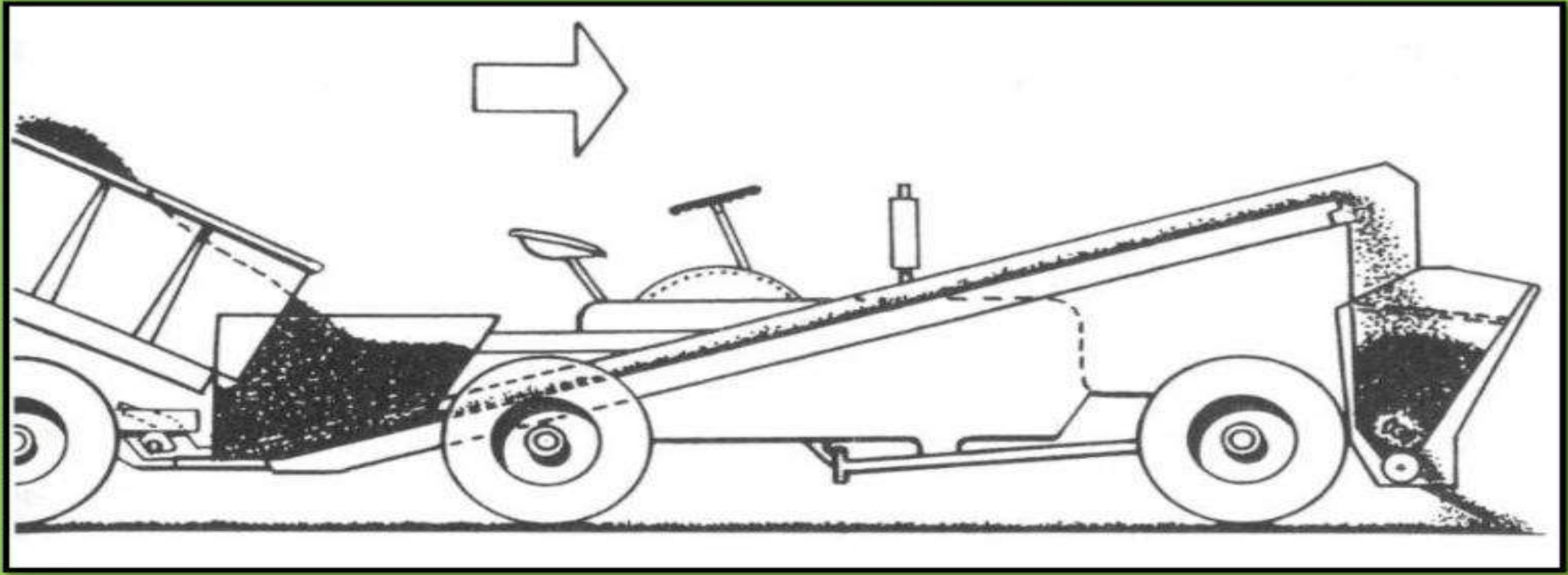
- Four major pieces of Contractor equipment are required for seal coating: a distributor, a chip spreader, a pneumatic-tired roller, and a rotary power broom.

1. DISTRIBUTOR

- The uniform application of the asphalt material at the designated rate is essential to achieve a quality seal coat.
- The proper nozzles, nozzle angles, spray bar height, pump speed, and pump pressure are items that are required to be checked.

2. CHIP SPREADER

- The chip spreader receives the aggregate from the haul trucks and deposits the material uniformly over the full width of the asphalt material applied by the distributor



3. PNEUMATIC-TIRE ROLLER

The purpose of rolling with a pneumatic-tire roller is to embed the aggregate into the asphalt material.

A smooth, uniform operation of the roller is essential. Excessive breaking or sharp turns dislodge the cover aggregate from the asphalt material.

4. ROTARY POWER BROOM

A power rotary broom is required for cleaning the surface prior to seal coating and may be needed to remove excess cover aggregate after the curing period. Typical power brooms are mounted on the front of tractors, although some manufacturers make special machines for this purpose.

: Site Clearance – Clearing and Grubbing for Highway Construction

Quality Control Tests for Granular Sub Base:

- The Quality control tests shall be conducted on the GSB material at the source before transportation.
- At the GSB location, after the completion of the compaction operation following tests are pertinent.

Sl no	Test	Code	Frequency
1	Gradation	Table 400.1	1 test per 200 cum.
2	Atterberg limits	IS:2720 (Part-5)	1 test per 200 cum.
3	Moisture content	IS:2720 (Part-2)	1 test per 250 cum.
4	Density	IS:2720 (Part-8)	1 test per 500 sqm
5	Deliterious content	IS:2720 (Part-27)	As required
6	CBR	IS:2720 (Part-16)	As required

FACTORS AFFECTING SELECTION OF PAVEMENT

- Type and intensity of traffic
- Availability of fund for the construction and maintenance of highway
- Sub grade soil and drainage condition
- Availability of construction material
- Availability of equipment, skilled and unskilled labors etc
- Atmospheric conditions like amount of rainfall, snowfall etc
- Time available for the completion of the project
- Level of the area above mean sea level

FUNCTION OF PAVEMENT COMPONENTS

- The various components of pavement are as below:

1. Subgrade
2. Sub base
3. Base course
4. Wearing course or surface course

FACTORS AFFECTING SELECTION OF PAVEMENT

- **Subgrade :**
- The soil sub grade is a layer of natural soil prepared to received the layers of pavement materials placed over it.
- The loads on pavements are ultimately received by the soil subgrade for dispersion to the earth mass. It is essential that at no time, the subgrade soil is overstressed.
- The pressure on the subgrade should not exist its elastic limits. Therefore it is desirable that at least top 50 cm layers of the sub grade soil is well compacted under controlled conditions of the optimum moisture content (OMC) and maximum dry density (MDD).

FACTORS AFFECTING SELECTION OF PAVEMENT

- **Sub base :**
- A layer of broken stones, sand, gravel, moorum, etc of about 30 cm thickness is laid over the compacted sub grade. This layer is called sub base.
- Sometimes in sub base course a layer of stabilized soil or selected granular soil is also used. In some places, boulder or bricks are also used as sub base course.

FACTORS AFFECTING SELECTION OF PAVEMENT

- **Base course:**
- The layer immediately below the wearing course of pavement is called base course.
- The bases courses consists of local soft aggregates, stabilized soil, WBM, bricks, slag etc.
- Its thickness varies from 7.5 cm to 10 cm. The width of base course is normally kept 30 cm more than the width of wearing course on each side.

FACTORS AFFECTING SELECTION OF PAVEMENT

- **Wearing course or surface course :**
- The upper most layer of the pavement is called wearing course.
- It should be impermeable.
- It consists of low-cost surface, bituminous surface or cement concrete surface.

(CE622PE) HIGHWAY CONSTRUCTION AND MANAGEMENT

- UNIT-II
  BITUMINOUS CONSTRUCTIONS: Types of bituminous layer constructions: SDBC, BC, BM, DBM, Slurry seal and micro surfacing. Selection of wearing course under different climatic and traffic conditions, IRC specifications, construction procedures, tests on various bituminous mixes, Construction equipment's, Quality Control during and post construction of bituminous pavements and IRC specifications

Types of Bituminous binder

- Types of Bituminous binders used in Flexible pavement construction

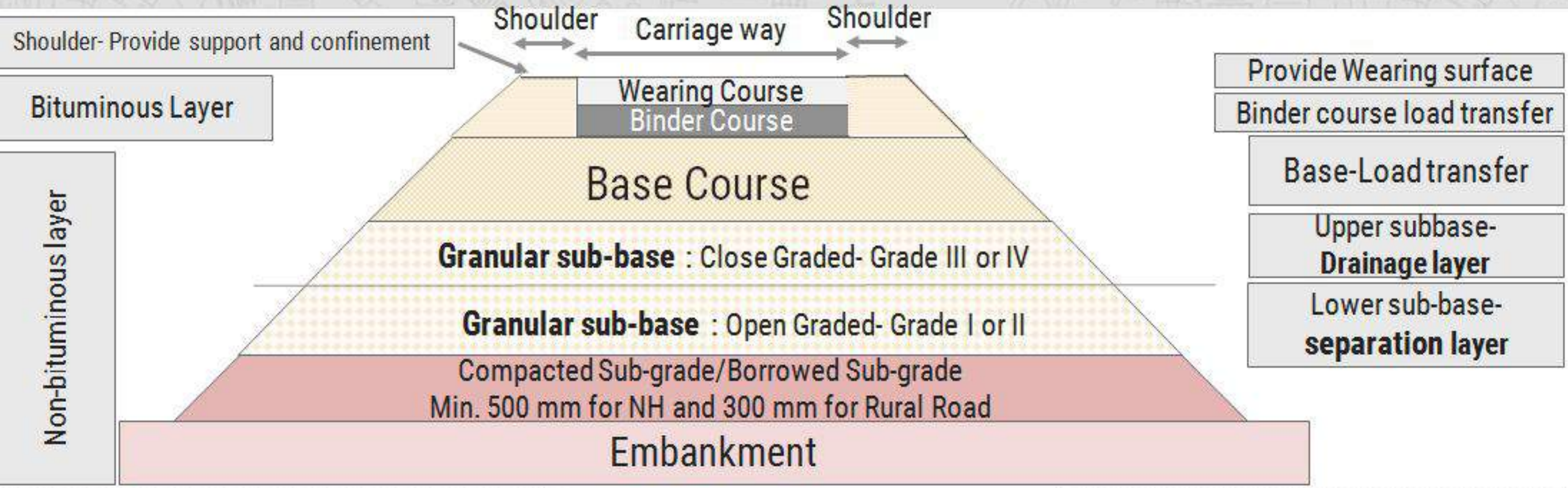
1. **Paving grade bitumen**
   a) Viscosity grade bitumen- **VG 10, VG 20, VG 30, VG 40**
2. **Modified bituminous binder**
   a) Polymer modified bitumen -PMB
   b) Crumb rubber modified bitumen - CRMB
3. **Cutback bitumen**
   a) Rapid curing cutback (RC)
   b) Medium Curing cutback (MC)
   c) Slow curing cutback (SC)
4. **Bitumen Emulsion**
   a) Rapid Setting emulsion (RS)
   b) Medium Setting emulsion (MS)
   c) Slow Setting emulsion (SS)

Semi dense bituminous concrete (SDBC) is a continuously graded mix, which can be used as binder course or wearing course in a flexible pavement. Cold SDBC technology is a highly engineered solution for construction of layer of 25-40 mm thickness.

Explanation: Semi-dense bituminous concrete (SDBC) is a type of asphalt concrete that is commonly used in road construction and pavement surfacing. SDBC is a mixture of aggregates (such as crushed stone, gravel, or sand) and bitumen (a black, sticky substance that is derived from crude oil

It is obtained either as a residue from the distillation of petroleum or from natural deposits. Asphalt consists of compounds of hydrogen and carbon with minor proportions of nitrogen, sulfur, and oxygen.

Cross section of Flexible pavement



Surface/Wearing course -Name

- **BC**-Bituminous Concrete
- **SDBC** Semi Dense Bituminous Concrete
- **OGPC** Open graded pre-mix carpet
- **PC** Premix carpet

Binder course-Name

- **BM**-Bituminous macadam
- **DBM**-Dense Bituminous Macadam
- **BUSG**- Built Up Spray Grout

Base course

- **WBM**-Water bound Macadam
- **WMM**-Wet Mix Macadam

Difference between Bitumen and Tar …..GTU

Sr. No	BITUMEN	TAR
01	Produced from fractional distillation of petroleum crude	Produced from coal by destructive distillation
02	Less temperature susceptible*	High temperature susceptible*
03	Used in road construction	Not used in road construction
04	Sp. Gravity range 0.97 to 1.02	Sp. Gravity range 1.10 to 1.25
05	More resistance to water	Less resistance to water
06	Soluble in Carbon disulphide CS_2 and carbon tetra chloride CCl_4	Soluble in Toluene- C7H8
07	Free carbon content is less	More Free carbon content

*Temperature susceptible means effect of variation in temperature

Difference between Bitumen-Tar-Emulsion-Cutback

Sr. No	Bitumen	Tar	Emulsion	Cutback
01	Produced from fractional distillation of petroleum crude	Produced from coal by destructive distillation	Prepared by dispersing bitumen in the form of fine globules suspended in WATER with the help of suitable EMULSIFIER	Prepared by diluting a paving grade bitumen with volatile solvent such as **KEROSENE**
02	Less temperature susceptible	High temperature susceptible	Used for Prime coat and Tack coat and other cold mix	Currently not used in road construction activity
03	Used in road construction	Not used in road construction	Available in Rapid setting, Medium setting and Slow setting	Available in Rapid setting, Medium setting and Slow setting
04	Sp. Gravity range 0.97 to 1.02	Sp. Gravity range 1.10 to 1.25		

Desirable properties of bitumen

1. It should be FLUID ENOUGH at the time of mixing to coat the aggregate evenly by a thin film.
2. It should have LOW TEMPERATURE SUSCEPTIBILITY
3. It should show UNIFORM VISCOSITY characteristics
4. Bitumen should have GOOD AMOUNT OF VOLATILES in it
5. The bitumen should be DUCTILE AND NON BRITTLE
6. The bitumen should be CAPABLE OF BEING HEATED to the temperature at which it can be easily mixed WITHOUT ANY FIRE HAZARDS
7. The bitumen should have GOOD AFFINITY TO THE AGGREGATE and should not be stripped off in the continued presence off water

SEMI DENSE BITUMINOUS CONCRETE (SDBC)

- ❖ Wearing course on roads carrying moderate traffic, generally less than 10 msa
- ❖ Lesser binder content when compared to BC

THE GRADING REQUIREMENTS OF SDBC

Grading	I	II
Nominal Aggregate Size	13.2 mm	10 mm
Layer Thickness	35-40 mm	25-30 mm
IS Sieve (mm)	Per cent Passing	
19.0	100	-
13.2	90-100	100
9.5	70-90	90-100
4.75	35-51	35-51
2.36	24-39	24-39
1.18	15-30	15-30
0.6	-	-
0.30	9-19	9-19
0.15	-	-
0.075	3-8	3-8
Bitumen content per cent by wt of total mix	Min 4.5	Min 5.0
Bitumen grade	65*	65*

Selection of data for SDBC mix Design

I) Aggregates Physical Properyies Requirments As per MORTH Table 500-14

S.No.	Test Description	Test Method	Test Results	Specification Limits	Remarks
1	Grain Size Analysis	IS:2386 Part-1	0	Max 5% passing 0.075mm sieve	
2	Flakiness and Elongation Index (Combined)	IS:2386 Part-1	23.5	Max 30%	
3	Loss Angeles Abrasion Value*	IS:2386 Part-4	21.6	Max 35%	
4	Aggregate Impact Value*	IS:2386 Part-4	18.9	Max 27%	
5	Sodium Sulphate	IS:2386 Part-5		Max 12%	
6	Magnesium Sulphate	IS:2386 Part-5		Max 18%	
7	Water Absorption (Combined)	IS:2386 Part-3	1.58	Max 2%	
8	Coating & Stripping of Bitumenous Aggregate	IS:6241	100	Min. retained coating 95%	
9	Water sensitivity** Retained Tensile Strength	AASHTO T283**		Min. 80%	

DESIGN REQUIREMENTS FOR SDBC

Minimum Stability (kN at 60°C),	8.2
Flow	2-4
Compaction level (Number of blows)	75 on each face
Per cent air voids	3-5
Per cent voids in mineral aggregate (VMA)	VMA Table
Per cent voids filled with bitumen (VFB)	65-78
Loss of stability on immersion in water at 60°C (ASTM D 1075)	Minimum 75 %

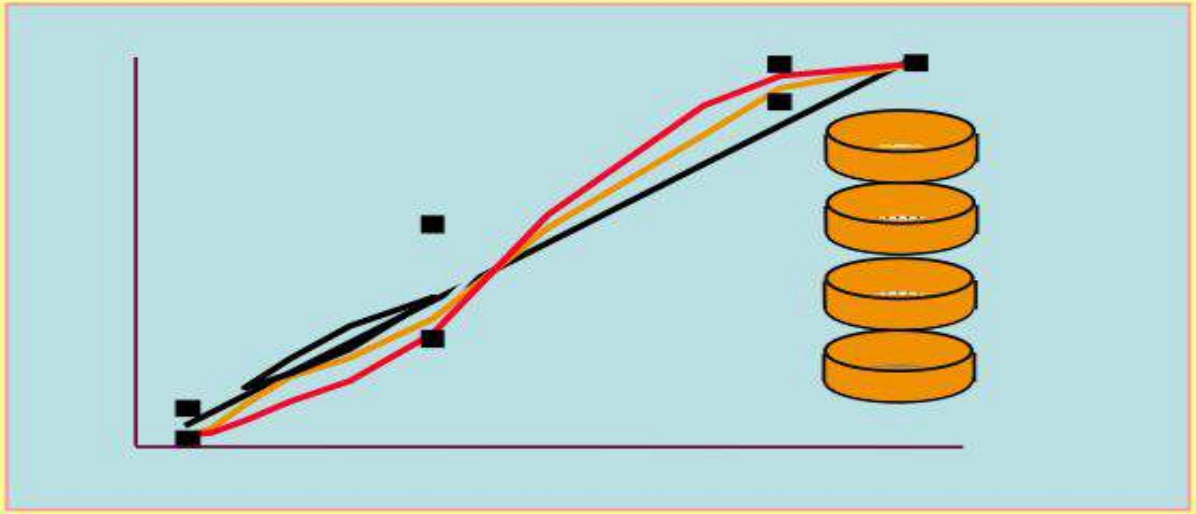
SDBC LAYER

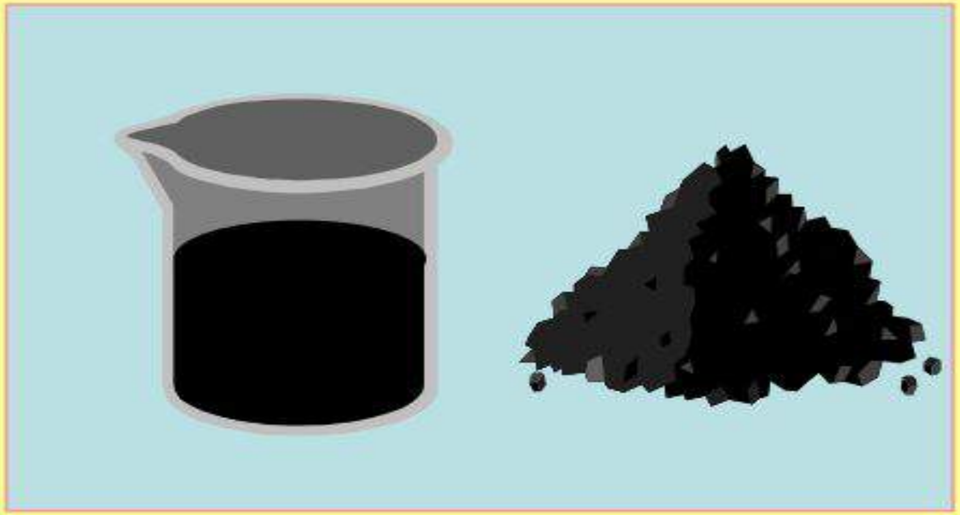
BITUMINOUS CONCRETE (BC)

- BC is a Dense Graded Bituminous Mix used as Wearing Course for Heavily Trafficked Roads

BITUMINOUS CONCRETE (BC)

- BC Mix consists of Coarse Aggregates, Fine Aggregates, Filler and Binder blended as per Marshall Mix Design





GRADING REQUIREMENTS OF BC

Sieve Size mm	I	II
	50-65 mm	30-45 mm
26.5	100	-
19	79-100	100
13.2	59-79	79-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	42-58
0.60	15-27	26-38
0.30	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content per cent by mass of total mix	5.0-6.0	5.0 – 7.0

BITUMINOUS CONCRETE (BC)

Quality control operations involved are:

- Design of mix in laboratory, and control of mixing, laying and rolling temperatures
- Density, Marshall Stability, Flow, Air Voids, Retained Stability, Bitumen Content, Gradation of aggregates are controlled
- Riding quality is a control

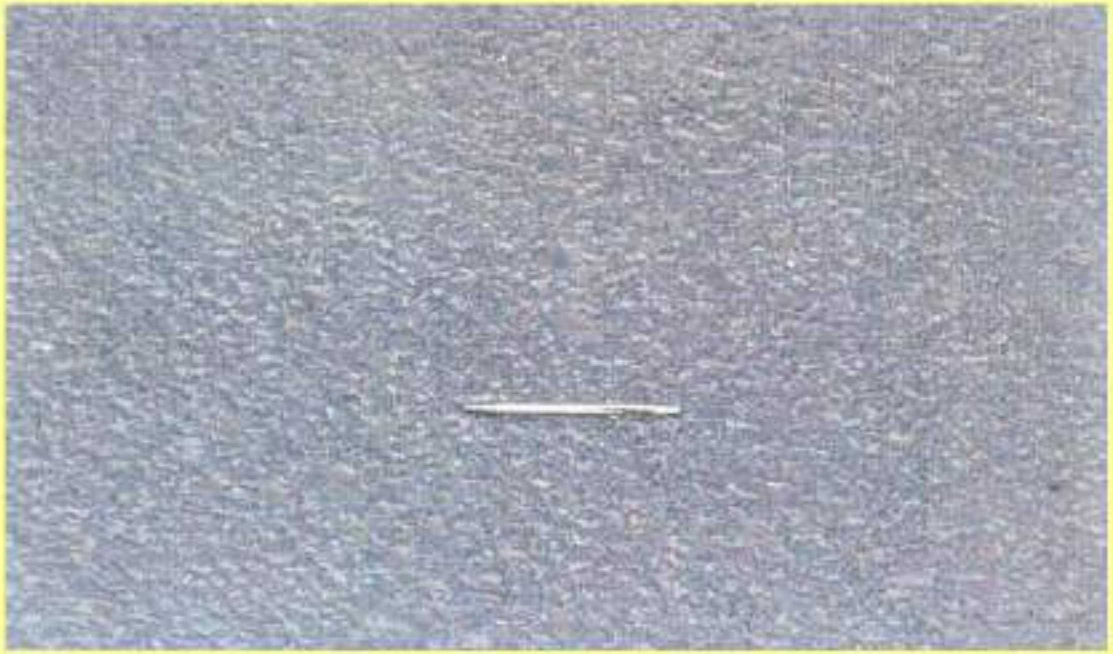
DENSE MIXES

Nominal Maximum Particle Size (mm)	Minimum VMA, per cent Related to Design Air Voids, Per cent		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

DESIGN REQUIREMENTS FOR BC

Minimum Stability (kN at 60°C)	9.0
Flow	2-4
Compaction Level (Number of blows)	75 on each face
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	VMA Table
Per cent voids filled with bitumen (VFB)	65-75
Loss of stability on immersion in water at 60°C (ASTM D 1075)	Minimum 75 %

Freshly Laid BC layer



BC Layer after Traffic
Movement

BITUMINOUS PAVEMENT CONSTRUCTION

Bituminous construction are classified into four categories

- Interface Treatments
- Thin Bituminous surface Courses
- Bituminous Surface Courses
- Bituminous Binder Courses

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INTERFACE TREATMENTS

- Prime Coat
- Tack Coat
- Crack Prevention Courses
  - SAM and SAMI

- **Purpose Of Priming:**
  - To plug the capillary voids
  - To coat and bond loose materials on the surface
  - To harden or toughen the surface
  - To promote adhesion between granular and the bituminous layer
- **Choice of Primer**
  - The primer shall be bitumen emulsion, complying with IS 8887 of a type and grade as specified (SS-1)
  - The use of medium curing cutback as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications

REQUIREMENT FOR PRIMING MATERIAL

Porosity	Type of Surface	Viscosity at 60^0 C (centistokes)	Quantity per 10 m^2 (Kg)
Low	WMM, WBM	30-60	6-9
Medium	Gravel base	70-140	9-12
High	Cement Stabilised soil base	250-500	12-15

TACK COAT

Purpose of Tack Coat:

- To ensure a bond between the new construction and the old surface

Material for Tack Coat:

- The primer shall be bitumen emulsion, complying with IS 8887 of a type and grade as specified (RS-1)

Use of Cutback:

- It should be restricted for sites at subzero temperatures or for emergency applications

RECOMMENDED QUANTITIES OF MATERIAL FOR TACK COAT

Type of Surface	Quantity in kg per m^2 area
Bituminous Surface	0.20 to 0.25
Dry and hungry bituminous surfaces	0.25 to 0.30
Primed granular surface	0.25 to 0.30
Unprimed granular base	0.35 to 0.40
Cement concrete pavement	0.30 to 0.35

WRONG PRACTICE OF TACK COAT

INSUFFICIENT TACK COAT

SPRAYER FOR PRIME/TACK COAT

MECHANICAL PRESURE HAND SPRAYER FOR PRIME/TACK COAT

Properly Done Tack Coat

20-30% more quantity of tack coat for milled surface

SEAL COAT

A. Liquid Seal Coat:

comprising of a layer of binder followed by a cover of stone chipping

Stone chips shall be of 6.7mm size defined as 100 per cent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area.

B. Premixed Seal Coat:

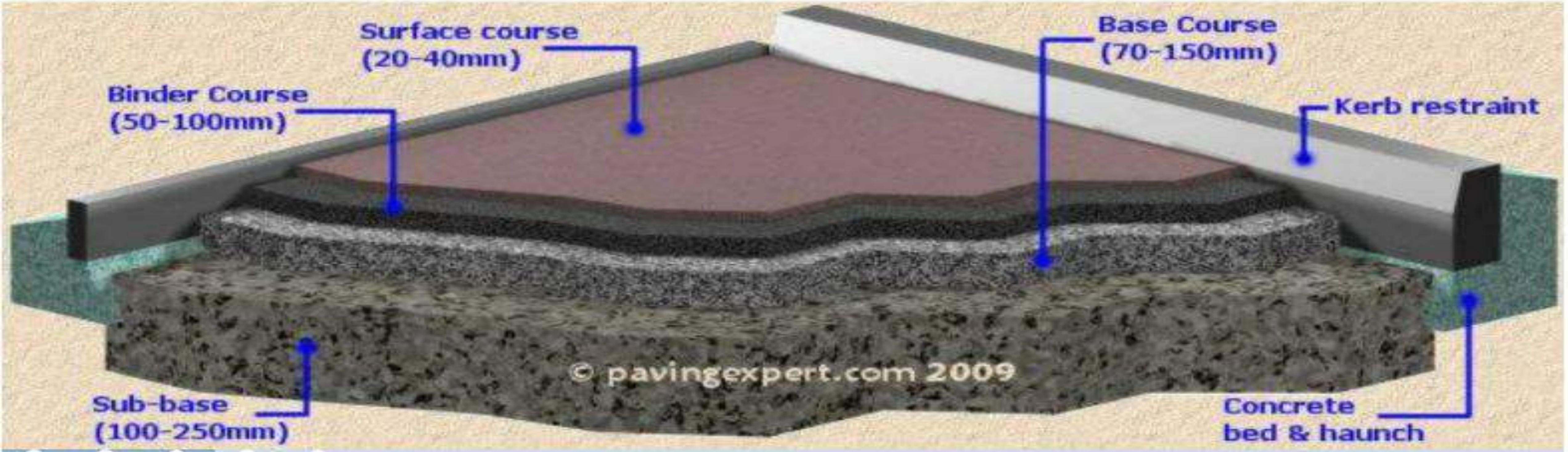
a thin application of fine aggregates premixed with bituminous binder

The quantity of bitumen shall be 9.8 kg and 6.8 kg per 10 m^2 area for type A and type B seal coat respectively

Dense Bituminous Macadam

Introduction:

- **Dense Bituminous Macadam** (DBM) is a binder course used for roads with more number of heavy commercial vehicles and a close-graded premix material having a voids content of 5-10 per cent.



Why DBM?

- This material has increased in popularity due to durable surface which performs almost well as in all situations.

- Suitable for all pavement layers and for all traffic conditions.

- DBM provides a good quality smooth surface and improved skid resistance.

DESIGN CRITERIA(IRC:94-1996):

- Due to high cost of DBM it should be properly designed according to standard design method so as to satisfy certain criteria needed to assure adequate stability and durability.

SR No.	Designation	Requirement
(I)	Number of Compaction blows on each end of Marshall specimen	75
(II)	Marshall Stability in Kg.(Minimum)	340
(III)	Marshall flow in mm	2-4
(IV)	VMA	5-10
(V)	VFB	55-75
(VI)	Bitumen content percent by weight of total mix	4.5-6.0

CONTI..

Sieve Size(mm)	Grading Number	
	1(For Layer thickness ≤50mm)	2(For Layer thickness ≥50mm)
	(Percentage Passing)	
37.5	-	100
26.5	100	85-100
19	85-100	71-95
13.2	63-82	58-82
9.5	52-74	52-72
4.75	39-54	35-50
2.36	28-43	28-43
0.60	15-27	15-27
0.3	7-21	7-21
0.15	5-15	5-15
0.075	2-8	2-8

Coarse Aggregate (retained on 2.36mm sieve):

- Preferably it should be hydrophobic and of low porosity.
- If hydrophilic aggregates are to be used the bitumen shall be treated with antistripping agents.
- In case of more porous aggregates extra bitumen for absorption by aggregates shall be provided to satisfy design criteria.

CONTI..

Test	Maximum percent
Aggregate impact value	35
Los Angeles Abrasion Value	40
Flakiness Index	35
Stripping Value	25
Soundness:	
I)Loss with sodium sulphate-5 cycles	12
II)Loss with Magnesium sulphate-5 cycles	18
Water Absorption	2

Fine Aggregate (passing on 2.36mm and retained on 75µm):

- Crushed Screenings, natural sand or mixture of both.
- Shall be clean, hard, durable dry and free from organic substances.

Filler (passing 75 µm):

- Stone dust, cement, hydrated lime, fly ash or other non-plastic mineral matter.

- Normally Filler requirement is met by the material passing through 75 µm sieve in fine aggregate, if fine aggregate is deficient then extra filler is added. Extra filler should be as following:

CONTI..

Sieve	% passing
600 μm	100
150 μm	At least 90
75 μm	>70

BITUMEN:

- The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard specification IS:73.

JOB MIX FORMULA:

- While the laboratory mix design gives the different proportions of the mineral aggregate combinations in terms of individual sieve sizes, for actual operational purposes in the field, blending of two or more sizes of aggregate in terms of weight or volume would be necessary.

- This blending ratio can be on a weight basis by giving percent weight of the CA, FA and filler needed to give the aggregate gradation.

- It can also be proportioned on a volumetric basis based on the unit weight or bulk density of the aggregate supplied.

CONTI..

- The mineral aggregate content with Optimum Binder Content as determined in the laboratory constitutes the job-mix formula.

- Mix design shall be carried out, based on a correct and truly representative sample of the materials that will actually be used in the specific construction project.

CONSTRUCTION:

– PREPARATION OF BASE:

- The base on which dense bituminous macadam is to be laid shall be prepared to the specified dimensions.
- The surface shall be thoroughly swept and free from dust and other materials.
- If the base is irregular and wavy then proper corrective course of adequate thickness is provided to rectify the profile.

CONTI..

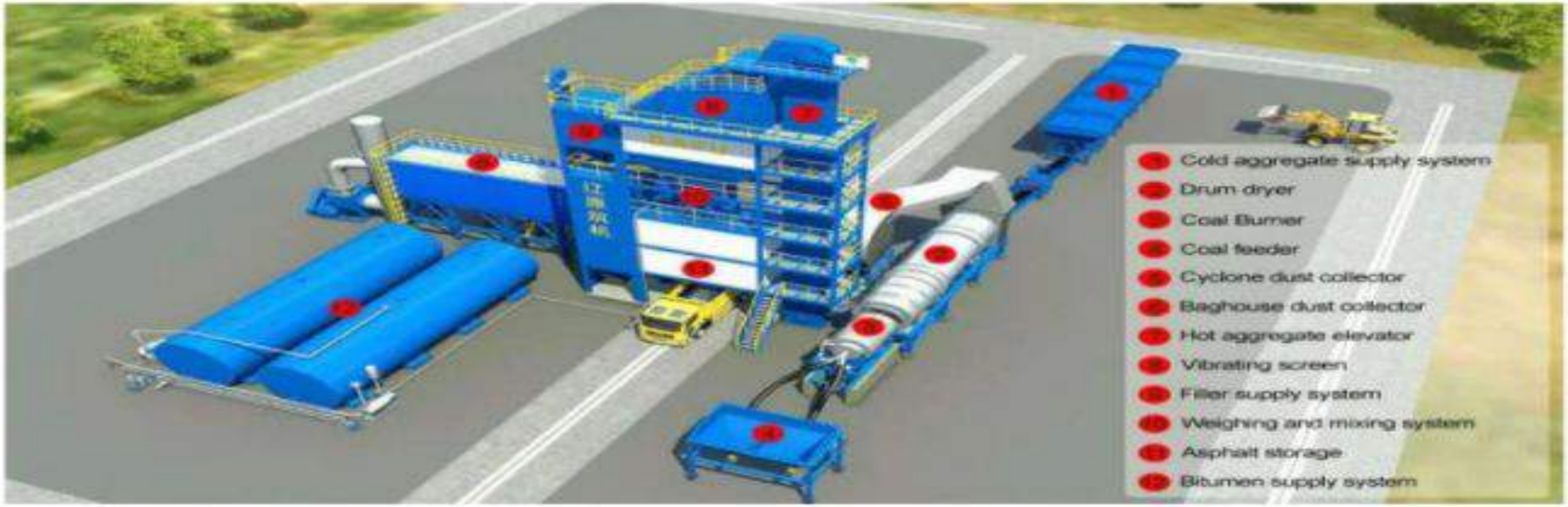
- After that Tack coat(asphalt applied before a road is laid to form an adhesive bond) is provided as per type of surface as follows:

Rate	Surface
6 to 7.5 Kg per 10 square meter	Dry
5 to 5.5 Kg per 10 square meter	Normal bituminous surface
7.5 to 10 Kg per 10 square meter	Non-bituminous surface

CONTI..

- PREPARATION OF MIX:

- Preparation of mix is carried out in Hot Mix Plant of adequate capacity.
- Plant may be either batch type or a continuous type.



CONTI..

-SPREADING OF THE MIX:

- The Mix shall be transported by tipper truck and spreading done by mechanical paver.
- It should be spread in such a manner that after compacting required thickness binder course is uniformly laid.

CONTI..

-COMPACTION:

- The Mix after spreading shall be compacted by rolling by a set of rollers at a speed not more than 5km/hour.
- Typical roller position used in compaction is:

  1) Initial or break down rolling » By 8 to 12 tonnes, three wheel steel roller

CONTI..

2) Intermediate rolling

» By 15 to 30 tonnes, smooth wheel pneumatic roller

3) Finished rolling

» By 8 to 10 tonnes, tandem roller

CONTI..

- Wheel of rollers should be kept moist to prevent the mix from adhering to them. Rolling shall commence from longitudinally from edge and proceed towards centre. Rolling shall be continued till desired density is achieved.

CONTI..

-OPENING TO TRAFFIC:

- Traffic can be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature.

Slurry Seal

A slurry seal is a homogenous mixture of slow setting cationic Bitumen emulsion, water, well-graded mineral aggregate and additive (if required) that has a creamy fluid-like appearance when applied.

Slurry seals are used to fill existing pavement surface defects as either a preparatory treatment for other maintenance treatments or as a wearing course. It is a preventive and renewal treatment as substitute of surface dressing, open graded premixed carpet and MSS for low volume roads.

Application Limitations

- Slurry seal is used only on existing bituminous surface, which is otherwise structurally sound.
- Surface should have satisfactory riding quality
- There should be no severe distress or wide and deep cracks in the surface
- Slurry seal can be used for low traffic conditions only.
- Slurry seal can be used for preventive maintenance as well as periodic renewals.
- Can be used to treat minor surface defects like cracks and polished surface.
- Can also be used for delay of reflection cracking as Cap Seal
- The expected life is 3-4 years

Slurry Seal

Type I (fine with a layer thickness of 2-3 mm). This type has the finest aggregate gradation (most are smaller than the 2.36 mm sieve) and is used to fill small surface cracks (less than 1 mm) and provide a thin covering on the existing pavement. Type I aggregate slurries are generally limited to low traffic areas

Type II (general, with a layer thickness 4-6 mm). This type is coarser than a Type I slurry (it has a maximum aggregate size of 6.3 mm) and is used to treat existing pavement that exhibits moderate to severe ravelling due to aging or to fill cracks of 1-3 mm width or to improve skid resistance. Type II aggregate slurry is the most commonly used up to a traffic volume of 450 CVPD.

Slurry Seal

Type III (coarse, with layer thickness of 6-8 mm). This type has the most coarse gradation and is used to treat severe surface defects like surface cracks of 3–6 mm and also for preventive or renewal treatment.

Because of its aggregate size, it can be used to fill slight depressions to prevent water ponding and to reduce the probability of vehicle hydroplaning. This treatment is suggested for traffic up to 1500 CVPD.

Different types of Slurry Sealing

Items	Type I (2-3 mm)	Type II (4-6 mm)	Type III (6-8 mm)
Applications	For filling hair cracks on surface less than 1 mm	For filling surface cracks 1 – 3 mm, and preventive/renewal treatment (up to 450 CVPD)	For filling surface cracks 3 – 6 mm and preventive/renewal treatment (up to 1500 CVPD)
Quantity of slurry (kg/m^2)	4.3 to 5.6	8.4 to 9.8	10.1 to 12
Residual binder (% by weight of dry aggregates)	10 to 16	7.5 to 13.5	6.5 to 12

Slurry Seal

Binder – Cationic Bitumen Emulsion of SS-2 type conforming to IS 8887

Aggregates – mineral aggregates of crushed stone free from dust, organic matter, or any other deleterious substances

Sand Equivalent Value	**= 50 (minimum)**
Water Absorption	**= 2 % (Max)**
Soundness with	
Sodium sulphate (5 cycles)	**= 12 % (max)**
Magnesium Sulphate (5 cycles)	**= 18 % (Max)**

Grading of aggregates

Sieve size, mm	Type I (2 – 3 mm)	Type II (4 – 6 mm)	Type III (6 – 8 mm)
9.5			100
6.3		100	90 – 100
4.75	100	90 – 100	70 – 90
2.36	90 – 100	65 – 90	45 – 70
1.18	65 – 90	40 – 70	28 – 50
0.600	40 – 65	30 – 50	19 – 34
0.300	25 – 42	18 – 30	12 – 25
0.150	15 – 30	10 – 21	7 – 18
0.075	10 – 20	5 – 15	5 – 15

Filler – ordinary Portland Cement – in the range of 0.5 to 2 % by weight of dry aggregates

Water – potable, free from harmful salts and contaminants. The pH value 6 to 7

Additive – chemical additive to accelerate or retard the break-set time of the slurry. Quantity as per mix design

Design of Slurry Seal Mix

Compatibility of aggregates, filler, emulsion and additive shall be verified by mix design. Design criteria are given below.

Mixing Time	=	180 s (Min)
Consistency	=	3 cm (Max)
Wet cohesion (within 60 min)	=	20 kg.cm (min)
Wet stripping	=	10 % (Max)
Wet track abrasion loss (one hour soak)	=	800 g/m^2 (max)

1. Mixing Time of Slurry Seal

Take one kg of graded aggregates + needed cement in a bowl

Add required quantity of water + additive (if needed)

Mix it vigorously to get a homogenous paste

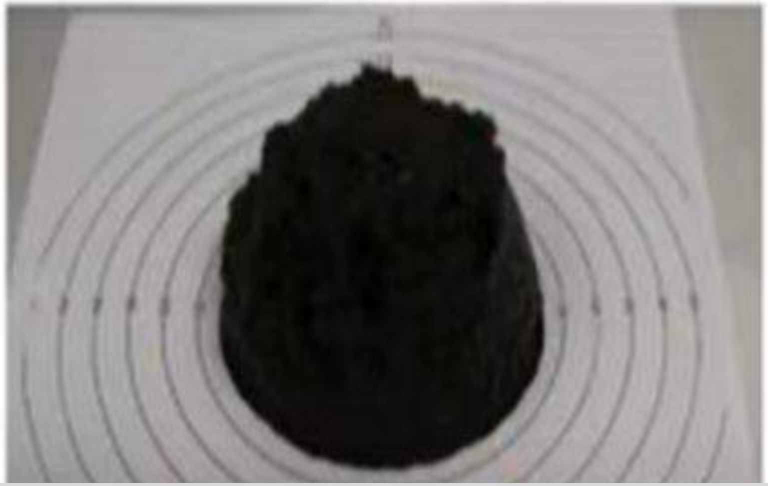
Add required quantity of emulsion and mix again till the emulsion starts breaking and mix loses its workability

The time required for breaking the emulsion is the Mixing Time.

The minimum time required for initial breaking of emulsion is reported as the Maximum Mixing Time

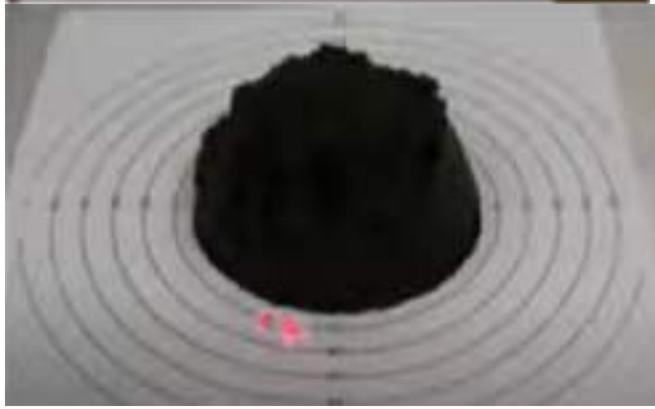
2. Consistency

A mold in the form of a frustum – dia at top = 38 mm and at bottom = 89 mm, height = 76 mm



Flow scale with seven concentric circles printed on a sheet of paper and supported by a rigid surface. The centre circle is equal to the diameter of the large opening of the cone. Each additional circle is 1 cm greater in radius than the previous one.

The mixture is place in the sand absorption cone, the cone removed, and the flow of the slurry is allowed to flow over the inscribed circles until flow of the slurry stops. The outflow if the slurry is measured at 4 points 90^0 apart and the average is recorded as the slurry consistency in cm.



3. Wet cohesion test

- A suitable number of identical specimen are cast.
- After setting of the slurry mat, it is placed beneath the pneumatically actuated rubber foot of the cohesion tester.
- Apply a pressure of 193 kPa
- The twisting torque is measured on five samples of the same material at different intervals after casting

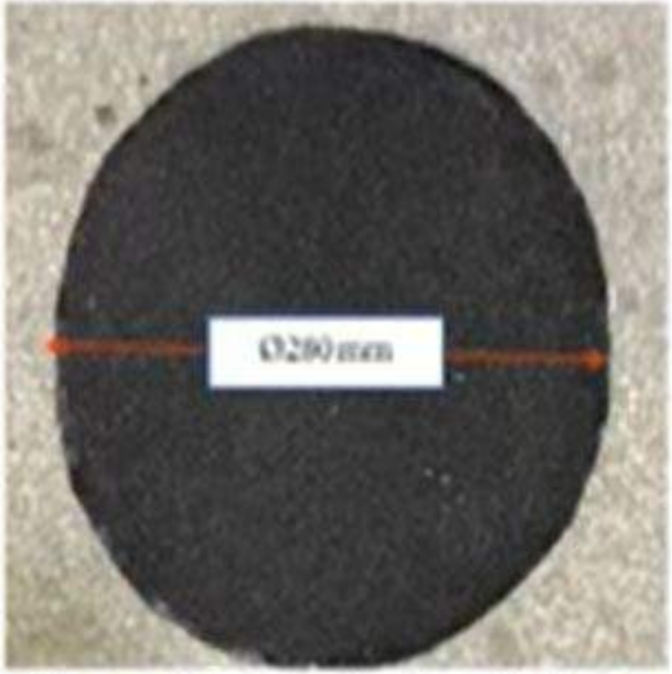
Time required to reach constant and maximum torque is recorded as the cohesion value.

4. Wet stripping test

The test method is used to determine compatibility of slurry seal system with given aggregates.

- Take 400 ml of tap water in a 600 ml beaker
- Boil the water on a hot plate
- Drop 10 gm mixture of cured slurry in boiling water for 3 minutes
- Remove the beaker from the hot plate and cool the water to room temperature
- Add cold water on the surface of the beaker so that free bitumen flows over the sides of beaker
- Drain the water and remove the content from the beaker and place on a white absorbent paper.
- Examine for uncoated areas and report

5. Wet track abrasion loss test



Planetary type mechanical stirrer equipped with a weighted rubber hose holding devise having free up and down movement in the shaft sleeve,

Flat bottom metal pan to secure a 280 mm diameter specimen to bottom of pan

Metal circular mold of 280 - 285 mm diameter and 6 mm thick

Take the sufficient quantities of individual components (aggregates, filler, water, bitumen emulsion) as per design to obtain a sample of 1000 g

Mix well and prepare the specimen in the mold. Place the molded specimen in the oven for 24 h at 60 C to obtain the constant weight.

Cool at room temperature and determine its weight, then test it.

WEATHER LIMITATIONS

- Slurry seal will not be laid if either the pavement temperature or air temperature is below 10^0C
- During a dry spell, it can be laid in rainy season also, even if the surface is wet but there is no stagnant water on the pavement surface.

Quality Control

item	Frequency
Quality of aggregate	One per source/site
Quality of emulsion	One per lot of 20 ton as per IS:8887
Aggregate Moisture	Two per day
Aggregate Gradation	Two per day at site
Binder Content	Two per lane per km
Calibration of Machine	Once per Project
Quantity of Slurry (By weight of aggregate)	Daily

MICRO SURFACING

Micro surfacing is an advanced form of slurry seal that uses the same basic ingredients (emulsified asphalt, water, fine aggregate and mineral filler) and combines them with advanced polymer additives. Figures 1 through 4 show a micro surfacing slurry seal.

Figure 1: Ignition method major equipment.

Figure 2. Microsurfacing placement.

Figure 3. Microsurface close-up.

Figure 4. Finished microsurface.

Micro Surfacing and Slurry Sealing Equipment

SELECTION OF WEARING COURSE UNDER DIFFERENT CLIMATIC AND TRAFFIC CONDITIONS,

Wearing Course. This is the layer in direct contact with traffic loads. It is meant to take the brunt of traffic wear and can be removed and replaced as it becomes worn.

3.1 Bitumen

3.1.1

The bitumen for mastic asphalt shall be a industrial grade 85/25 bitumen meeting the requirement given in **Table 1.**

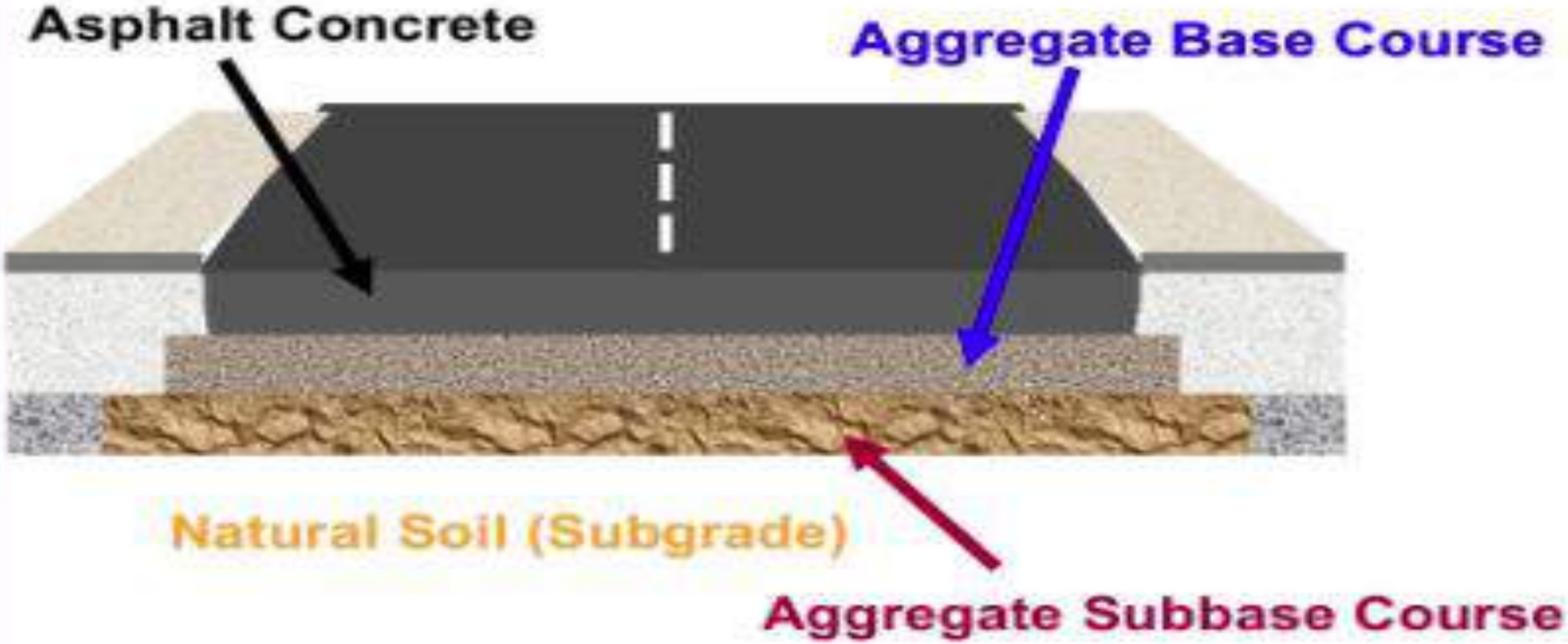
Table 1 Physical Properties of Bitumen

S. No.	Characteristic	Requirement	Method of Test
1)	Penetration at 25°C in 1/100 cm	20 to 40	IS:1203-1978
2)	Softening point (ring and ball method)	80-90°C	IS:1205-1978
3)	Ductility at 27°C, Min, cm	3	IS: 1208-1978
4)	Loss of heating, percent, (Maximum)	1	IS: 1212-1978
5)	Solubility in trichloro Ethylene percent (Minimum)	99	IS:1216-1978

1. Basic Principles of Asphalt
Performance Requirements of Asphalt

- Resistance to permanent deformation (ie rutting)
- Resistance to fatigue
- Durable
- Workable (for placement)
- Good Skid resistance.
- Specialist mixes that have added performance properties such as low noise, low spray generation, or increased resistance to cracking or rutting

Flexible Pavements



1. Basic Principles of Asphalt - Binder

- Binder is the 'glue' that holds all of the asphalt mix components together.

- Can be Class 170, 320, 600 or multigrade bitumen.
- Class 320 most commonly used

- Can include polymer modified binders to enhance the performance properties of the bitumen and is commonly used in high performance mixes such as SMA and OGA

1. Basic Principles of Asphalt - Aggregate

- Coarse aggregate (larger than 4.75mm)
- Fine aggregate (between 4.75mm and 0.075mm)
- Less than 0.075mm material is called "filler"
- Aggregates need to be hard, clean and durable rock with minimal unsound stone
- VicRoads Specification 407 and 831 cover the various requirements for asphalt aggregates

1. Basic Principles of Asphalt - Filler

- Filler materials are particles that are smaller than 0.075mm.

- Can include
  - natural or manufactured sand
  - crushed material (crusher dust)
  - hydrated Lime, Slag, Fly ash, ground limestone, cement, kiln dust

- The actual filler materials vary between mixes and rely on the mix design and available materials

2. Use and Types of Asphalt
Use of Asphalt

- Structural part of the pavement – deep lift asphalt, typically >150mm depth
- Wearing (top) surface of the pavement – typically <40mm
- Patching of failed pavement areas
- Regulation to improve ride quality and remove depressions

2. Use and Types of Asphalt
Types of Asphalt

- Hot asphalt, cold asphalt, warm mix, warmix and premix
- Asphalt for wearing surfaces
- Asphalt for structural layers
- Various sizes of asphalt mix -7mm, 10mm, 14mm, 20mm, 28mm
- Binders
  - Bitumen, Emulsion, Polymer Modified Binder

2. Use and Types of Asphalt
Types of Asphalt

- Different types of asphalt wearing surfaces
  - DGA Dense Graded Asphalt
  - SMA Stone Mastic Asphalt
  - OGA Open Graded Asphalt
  - UTA Ultra Thin Asphalt (UTA, Novachip)
  - RGG Regulation Gap Graded Asphalt

REQUIRED TESTING TO CHECK ITS SUITABILITY (As per IS/ASTM/IRC)

	Test	MEASURE
1	Penetration test	Hardness or softness
2	Ductility test	Adhesiveness
3	Viscosity Test	Fluidity
4	Softening point test	Temperature susceptibility
5	Specific Gravity test	Quality
6	Flash and Fire Point test	Hazardous temperature
7	Loss on heating test	Amount of volatiles
8	Solubility test	Purity/ Quality

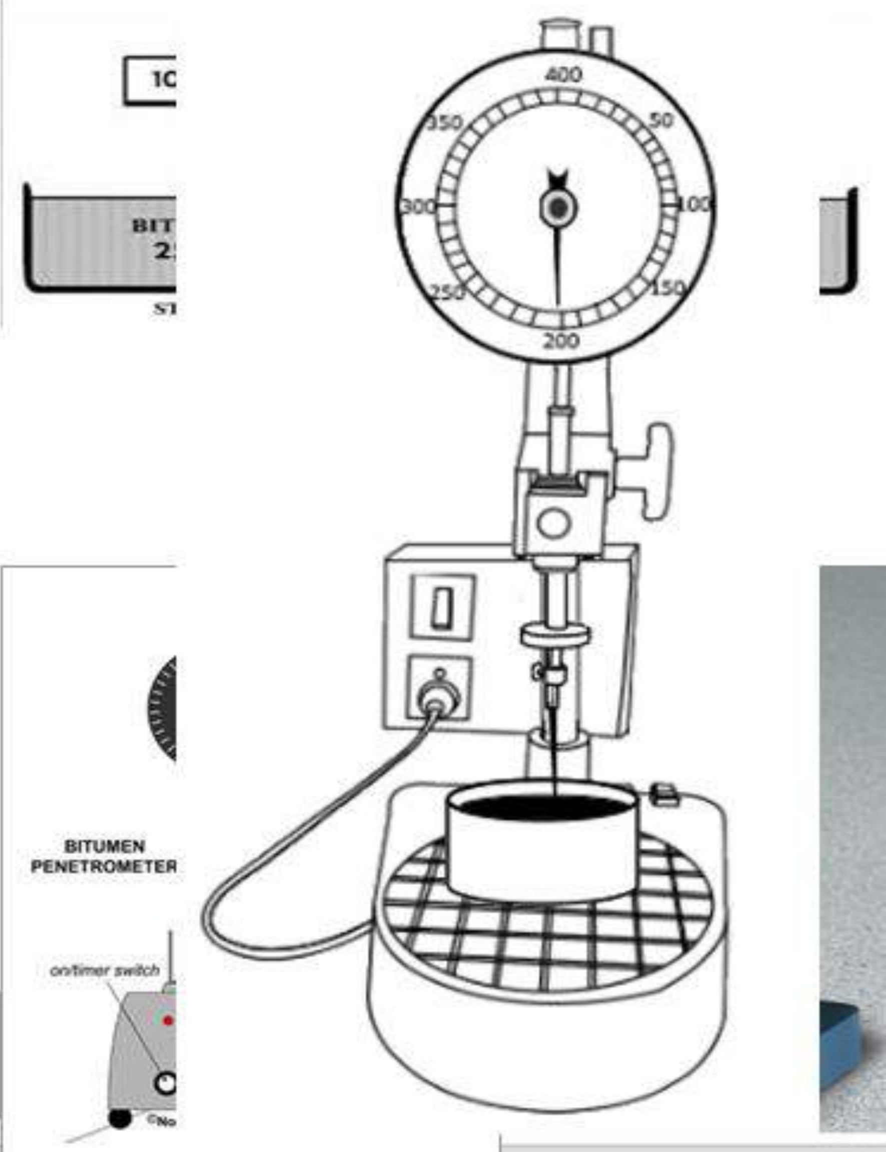
1. Penetration test(old grading system)……………………GTU

- **It** MEASURES **the** HARDNESS OR SOFTNESS of bitumen by measuring the depth in tenths of a millimeter (1/10 mm) to which a standard loaded needle will penetrate vertically in 5 seconds.

- The penetrometer consists of a **needle assembly with a total weight of 100 g** and time of application of load being 5 seconds

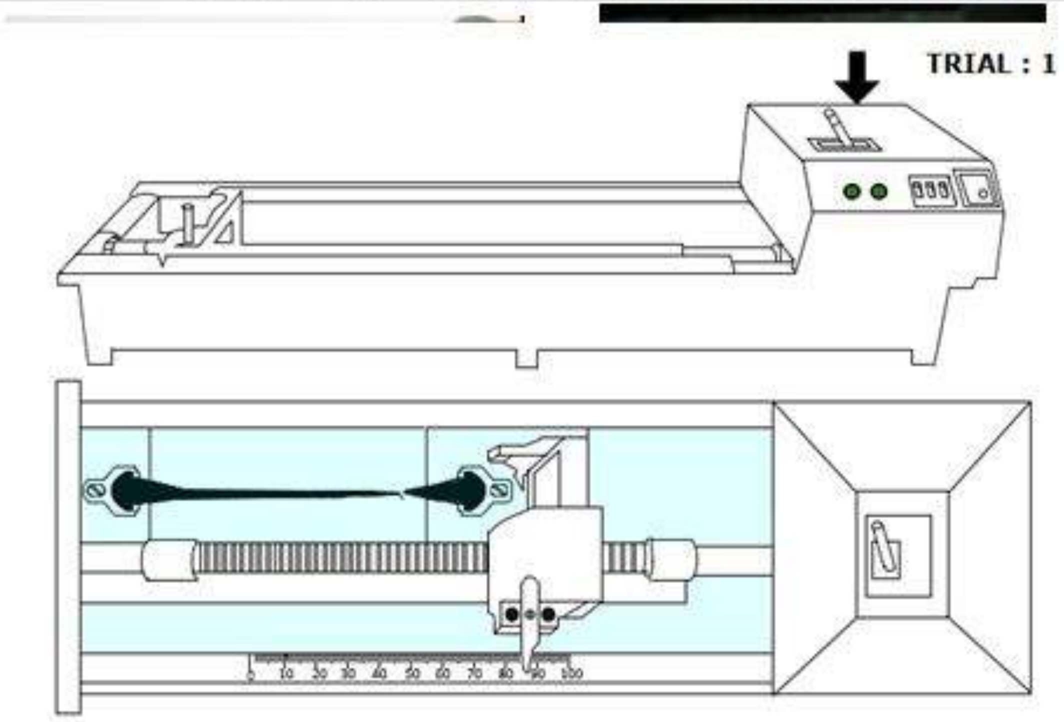
- The test should be conducted at a specified **temperature of 25°C**.
- A grade of 60/70 bitumen means the penetration value is in the range 60 to 70 at standard test conditions.
- In hot climates, a lower penetration grade is preferred.

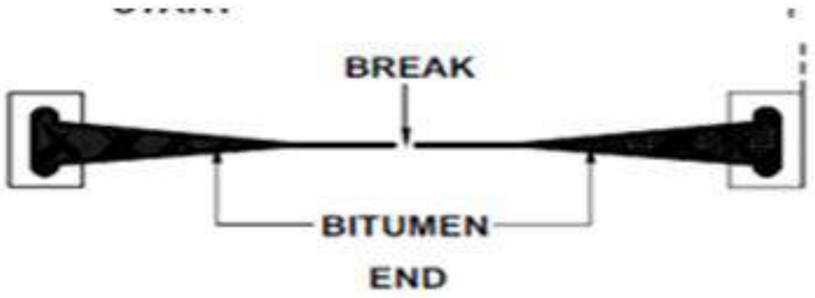
	VG 10	VG 20	VG 30	VG 40	
Penetration at 25°C, 100 g, 5 s, 0.1 mm, Min	**80**	**60**	**45**	**35**	**IS 1203**



2. Ductility Test…..GTU

- Bitumen should be sufficiently ductile and capable of being stretched without breaking
- Ductility is measured as the distance in cm to which standard briquette of size 10 * 10 mm can be stretched before the thread breaks at a standard temperature of 27° C and the rate of elongation is 50 mm/ minute
- Ductility is a **measure of adhesiveness and elasticity of bitumen**
- Minimum ductility value as per IS 73: 2013 is 40 cm on residue from rolling thin film oven -RTFOT for **VG 30** grade of bitumen





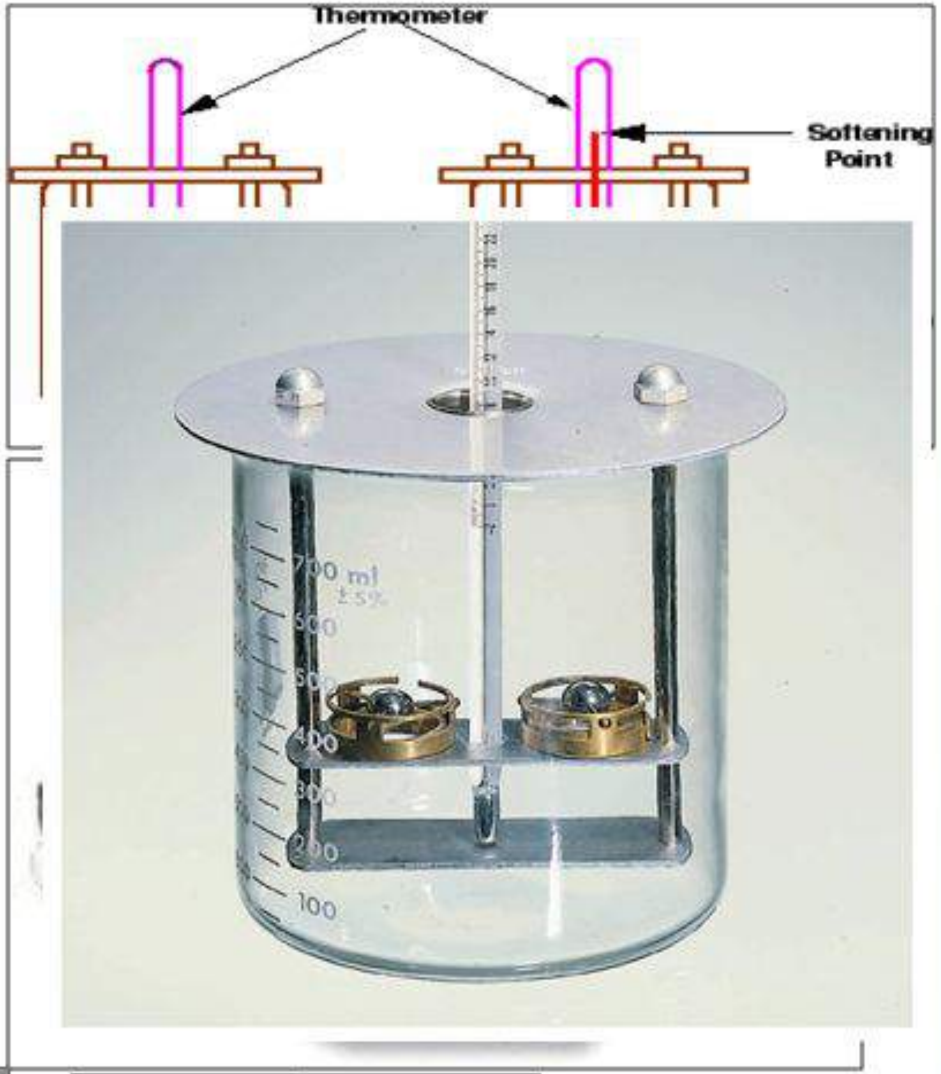
	VG 10	VG 20	VG 30	VG 40	
Ductility at 25°C, cm, Min. on residue from TFOT	**75**	**50**	**40**	**25**	**IS 1208**

3. Viscosity Test(New Grading system-Viscosity Grade)

- Viscosity is defined as inverse of fluidity.
- It is also defined as the shear stress applied to a sample of bitumen in Pascal divided by the shear rate per second
- Viscosity denotes the fluid property of bituminous material and it is a measure of resistance to flow.
- At the application temperature, this characteristic greatly influences the strength of resulting paving mixes.
- Low or high viscosity during compaction or mixing has been observed to result in lower stability values.
- At high viscosity, it resist the compactive effort and thereby resulting mix is heterogeneous, hence low stability values.
- And at low viscosity instead of providing a uniform film over aggregates, it will lubricate the aggregate particles.
- The basic unit of viscosity is the Pascal seconds (Pa s).
- The **absolute or dynamic viscosity** of bitumen measured in **poise , 1Pa s = 10 p (Poise)**. Kinematic viscosity measured in **Centi stoke (cSt)**

4. SOFTENING POINT TEST

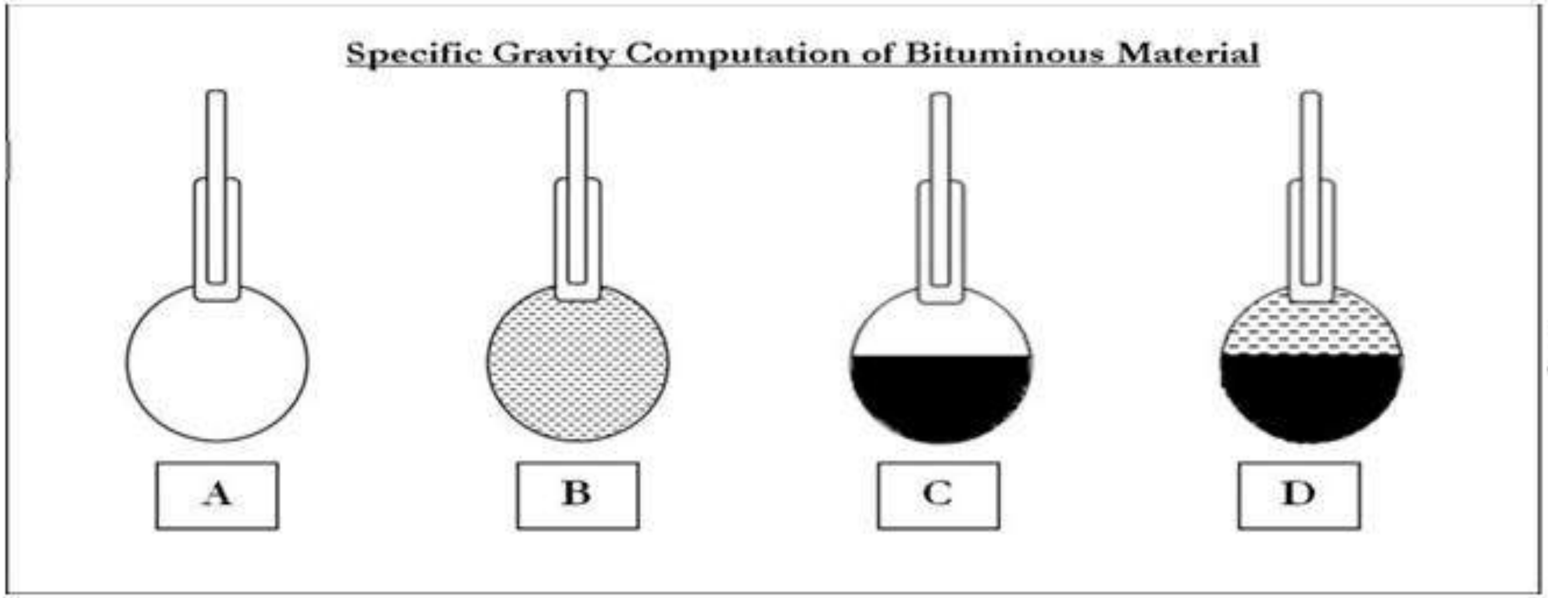
- Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test.
- The test is conducted by using **Ring and Ball apparatus.** A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature.
- A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5°C per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below.
- Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.



	VG-10	VG-20	VG-30	VG-40	
Softening point (R&B), °C, Min	**40**	**45**	**47**	**50**	**IS 1205**

5. Specific gravity test

- The density of bitumen is greatly influenced by its chemical composition.
- The specific gravity of bitumen is defined as the ratio of mass of given volume of bitumen of known content to the mass of equal volume of water at 27°C.
- The specific gravity can be measured using either pycnometer / density bottle / preparing a cube specimen of bitumen in semi solid or solid state
- The specific gravity of bitumen varies from 0.97 to 1.02.



$$Specific\ Gravity = \frac{(C-A)}{(B-D)-(A-C)}$$

6. Flash and Fire Point test

- At high temperatures depending upon the grades of bitumen materials leave out volatiles and these volatiles catch fire causing a flash.
- This condition is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade.
- BIS defined the flash point as the **lowest temperature** at which the **vapour of bitumen** momentarily catches fire in the form of flash under specified test conditions.
- The fire point is defined as the **lowest temperature** under specified test conditions at which the **bituminous material gets ignited and burns**.
- **Pensky martens closed cup apparatus** or **open cup** used for testing.

Temperature is noted, Flash point **220°C Min**

Close cup

Open cup

Bituminous Pavement – Typical Cross section

Bituminous Pavement Construction

Bitumen

- Distillation of petroleum crude oil
- Hydrocarbon of high molecular weight
- Form can be gaseous, liquid, semisolid or solid

Tar

- Destructive distillation of coal or wood
- More temperature sensitive than bitumen
- Carcinogenic material

6.BITUMINOUS ROAD CONSTRUCTION

What is Bitumen?

The primary use (70%) of asphalt/**bitumen** is in **road** construction, where it is used as the glue or binder mixed with aggregate particles to create asphalt concrete.

Preparation of the existing base course layer

- The existing surface is prepared by removing the pot holes or rust if any. The irregularities are filled in with premix chippings at least a week before laying surface course.
- If the existing pavement is extremely way, a bituminous leveling course of adequate thickness is provided to lay a bituminous concrete surface course on a binder course instead of directly laying it on a WBM.

Application of Tuck Coat

It is desirable to lay AC layer over a bituminous base or binder course. A tack coat of bitumen is applied at 6.0 to 7.5 kg per 10 sq.m area, this quantity may be increased to 7.5 to 10 kg for non-bituminous base.

Preparation and placing of Premix

- The premix is prepared in a hot mix plant of a required capacity with the desired quality control. The bitumen may be heated upto 150 – 177 deg C and the aggregate temperature should not differ by over 14 deg C from the binder temperature.
- The hot mixed material is collected from the mixture by the transporters, carried to the location is spread by a mechanical paver at a temperature of 121 to 163 deg C.
- the camber and the thickness of the layer are accurately verified. The control of the temperatures during the mixing and the compaction are of great significance in the strength of the resulting pavement structure.
- **Rolling**
- A mix after it is placed on the base course is thoroughly compacted by rolling at a speed not more than 5km per hour.

- The initial or break down rolling is done by 8 to 12 tonnes roller and the intermediate rolling is done with a fixed wheel pneumatic roller of 15 to 30 tonnes having a tyre pressure of 7kg per sq.cm. the wheels of the roller are kept damp with water.
- The number of passes required depends on the thickness of the layer. In warm weather rolling on the next day, helps to increase the density if the initial rolling was not adequate. The final rolling or finishing is done by 8 to 10 tonne tandem roller.

General Construction Procedure

1. Formation of subgrade soil
   - Soil exploration to check the dry density of soil
   - For week soil up to 50 cm depth should be replaced with good soil (2 layers of 25 cm thick is compacted)
   - Criteria –95 % of proctor density should be achieved
   - Proper longitudinal slope for drainage
   - Proper camber is provided

General Construction Procedure (Contd)

2. Preparation of Sub-base course
   - Granular Sub-Base (GSB)
     - Broken stone (60 mm down), quarry dust and water
     - 100 mm to 150 mm
   - Wet Mix Macadam (WMM)
     - Broken stone (40 mm down), quarry dust and water
     - Properly mixed, laid and compacted
     - 150 mm to 200 mm

   Static compactors are used

General Construction Procedure (Contd)

3. Preparation of base course
   - Prime Coat
   - Tack Coat
   - Bituminous Macadam
4. Preparation of wearing course
   - Tack Coat
   - Seal coat or Bituminous Concrete

Explained in next slides

Bituminous pavement construction techniques

Interface treatment
- Prime coat
- Tack coat

Grouted or penetration
- Penetration Macadam
- Built up spray grout

Premix pavement
- Bituminous Macadam
- Bituminous Concrete
- Mastic Asphalt

Surface dressing
- Seal coat
- Bituminous Concrete

Types of bituminous construction

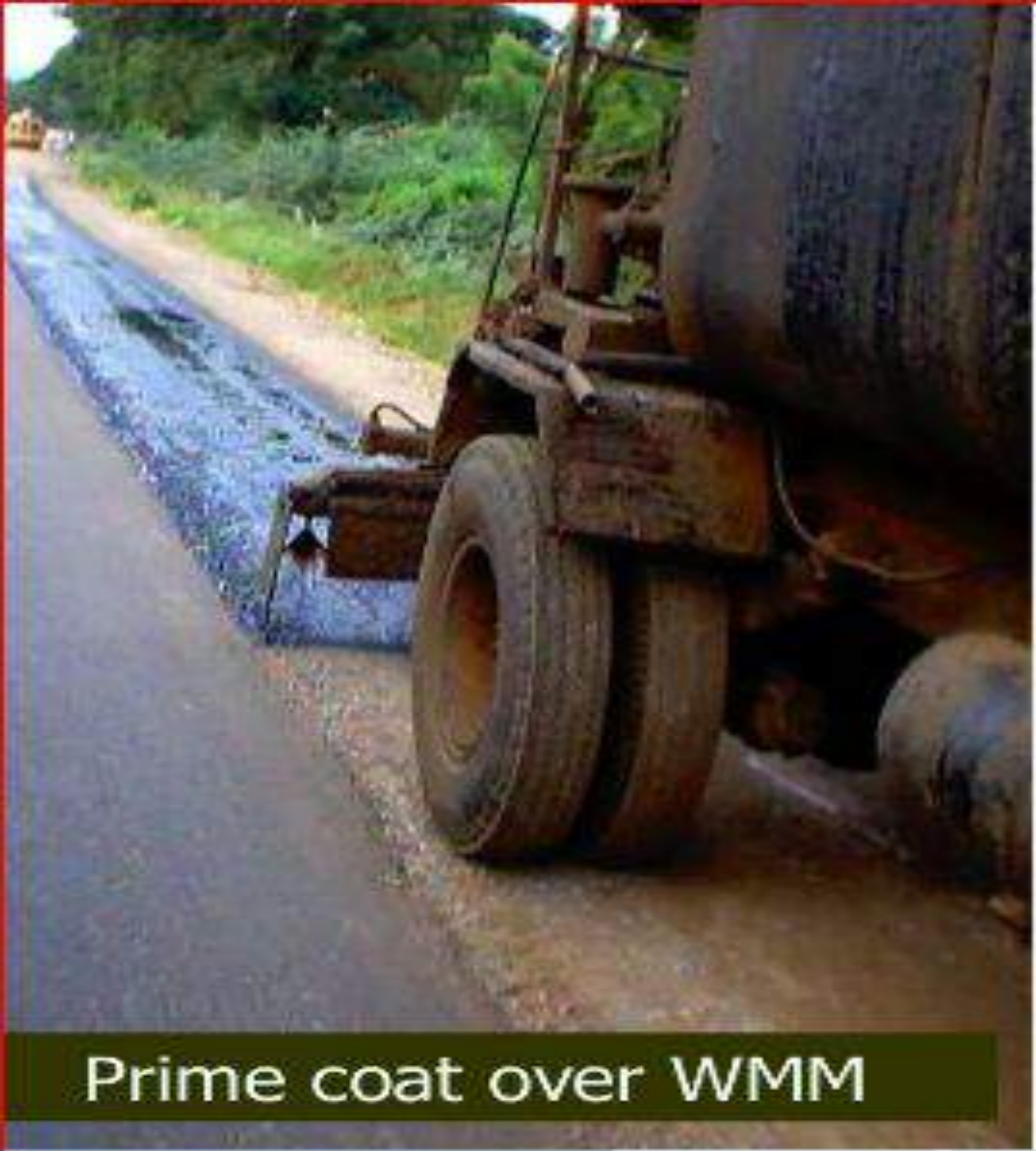
- Interface treatment
  - Prime Coat
  - Tack Coat

Interface treatment

To provide necessary bond between old and new pavement layers

a) Prime Coat

- First application of low viscosity bitumen is used
- To plug the capillary voids
- To bind loose mineral particles on the **existing porous pavement**
- 24 hours curing
- Rate of application is 7.3 to 14.6 kg/10m^2


Prime coat over WMM


Check for rate of spread

Interface treatment (Contd)

b) Tack Coat

- Viscous bituminous material over existing impervious pavement surface (bituminous or CC)
- Rate of application is 4.9 to 9.8 $kg/10m^2$

Bituminous pavement construction techniques

Interface treatment

- Prime coat
- Tack coat

Grouted or penetration

- Penetration Macadam
- Built up spray grout

Premix pavement

- Bituminous Macadam
- Bituminous Concrete
- Mastic Asphalt

Surface dressing

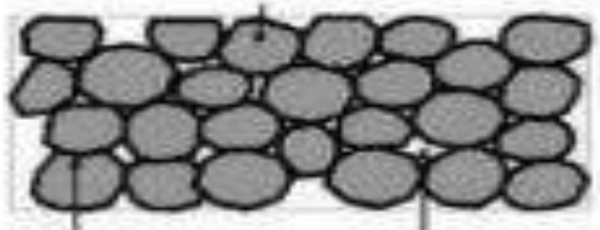
- Seal coat
- Bituminous Concrete

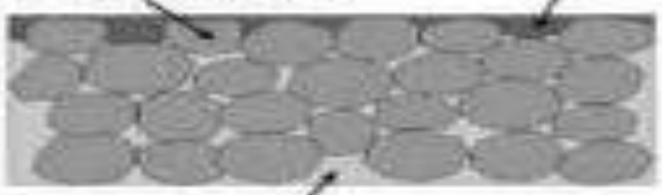
Penetration Type

Penetration Macadam

- Used as a base course
- Broken stones are dry compacted
- Hot bituminous binder is sprayed at the top
- Bitumen penetrate into the voids of aggregates and bind the aggregates together

- Full grout and Half grout





Penetration Type

Built-up spray grout

– Two layers of composite construction rolled aggregates

– Each layer of compacted crushed stone is applied with bituminous binder at a rate of 12.5 to 15 kg/m^2

– After the second application of binder, key aggregates are spread and rolled

– An initial tack coat is applied before the first layer of coarse aggregates

Quality control of bituminous concrete construction

- The routine checks are carried out at site to ensure the quality of the resulting pavement mixture and the pavement surface.
- Periodical checks are made for,
- a) Aggregate grading
- b) Grade of bitumen
- c) Temperature of aggregate
- d) Temperature of paving mix during mixing and compaction.

At least one sample for every 100 tonnes of the mix discharged by the hot mix plant is collected and tested for above requirements. Marshall tests are also conducted. For every 100 sq.m of the compacted surface, one test of the field density is conducted to check whether it is atleast 95% of the density obtained in the laboratory. The variation in the thickness allowed is 6mm per 4.5m length of construction.

UNIT-III

TYPES OF PAVEMENT CONSTRUCTION PROCEDURE: Construction of Cement Concrete pavement Constructions (IRC:15). Introduction to continuously reinforced, Prestressed and Steel Fiber Reinforced (SFRC) Pavements, Methods of construction of joints in concrete pavements, IRC and MORTH specifications, Pavement and overlay construction. Construction techniques and Construction equipment’s, Quality control tests during and post construction of concrete pavements

- **Rigid pavement:**
- Rigid pavement refers to a type of road surface that consists of a solid layer of concrete. It is commonly used for highways, airports, and other high-traffic areas due to its ability to withstand heavy loads and provide a durable driving surface.
  - **Types of Transverse Joints:**

  Contraction joints
  Expansion joints
  Warping joints
  Construction joints.

- **Purpose of joints in rigid pavement:**

Joints can be considered as intentional cracks and are provided where the cracking is most likely. These joints relieve stresses, thus preventing uncontrolled cracks. Provisions are made at the joints to provide wheel load transfer.

Role of IRC :

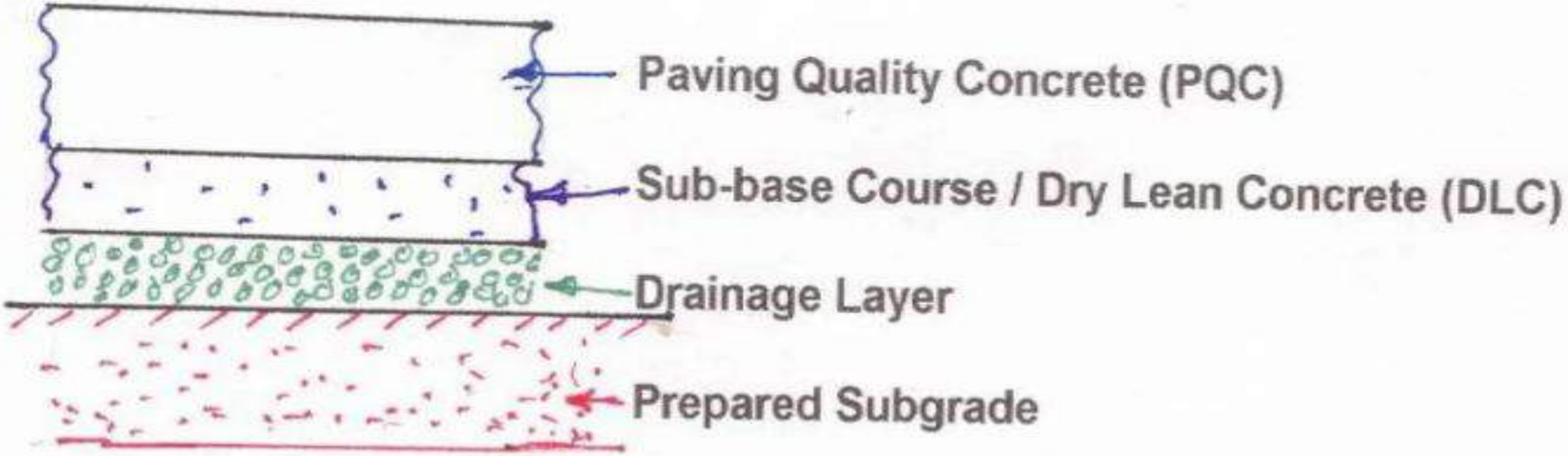
- ✓ It provides a channel for expression of collective opinion of its members for all matters affecting the planning, construction and maintenance of roads in India.
- ✓ It promotes the use of the standard specification and to propose specification.
- ✓ It provides the suggestion for the better methods of planning, designing, construction, administration and maintenance of roads.
- ✓ It conducts periodical meeting to discuss technical problems regarding roads and thus disseminate technical knowledge of experiences amongst highway engineers.
- ✓ It makes the laws for the development, improvement and protection of the roads.
- ✓ It furnishes and maintains libraries and museums for promoting and encouraging the science and practice of building, operation and maintenance of roads.
- ✓ It advice regarding education, experiment and research connected with roads.
- ✓ It publishes or arrange for the publication of proceedings, journals, periodicals, and other literature for the promotion of the objective of the IRC.
- ✓ It provides dimensions and weight of road vehicles, route marker signs for national highway and also types of stones for boundary walls.
- ✓ It recommends practice for the design and layout of cycle tracks.
- ✓ It also pays attention to the environment, cost of roads, road safety, sight distance, design speed, road drainage and width of the roads.

Introduction

CC Pavement

- Cement concrete pavements are generally constructed using plain cement concrete slab.
- CC pavement serves good & durable wearing surface as well as an effective and strong base course.
- The routine and periodic maintenance cost is very low as maintenance of joints only required .
- The life cycle cost of CC pavement are much lower then flexible pavements.
- CC pavements are generally designed and constructed for 30 years.

Components of CC pavement



Components of Cement Concrete Pavement

MATERIALS FOR CONSTRUCTIONS

- Portland cement
- Coarse aggregate
- Fine aggregate
- Water
- Steel bars
- Admixtures etc.

AGGREGATE

- Coarse aggregates used for construction shall fulfill the following requirements :

1) Los Angeles abrasion value - < 35%
2) Flakiness & Elongated index - < 35%
3) Water absorption - < 3%

✓ max size 31.5 mm

- Fine aggregates shall be :

1) Well graded.
2) 100% passing 10mm sieve.

COMPONENTS OF CC PAVEMENT

- Sub grade
- Drainage layer
- Sub base coarse

  dry lean concrete (DLC) layer to support cc slab & better drainage.
- Separation membrane

  prevent sticking b/w new concrete(cc slab) and old concrete (DLC).
- Pavement slab

  to withstand over flexural stress.

PREPARATION OF CONCRETE

Recommended water content and workability

- W-C ratio shall not exceed 0.45.
- Slump of concrete mix compacted by vibration shall be in range 25 ± 10 mm.
- Generally M40 concrete is used in cc road for which approximate w-c ratio is 0.38.

MIXING

- Mixing of concrete is done by two methods. These are as following.

a. Hand mixing
b. Machine mixing

TRANSPORTING AND PLACING

FORMWORK

CONSTRUCTION STEPS

- Construction of sub-grade.
- Construction of drainage layer.
- Construction of sub-base course.
- Laying of separation membrane.
- Construction of CC pavement slab.

CONSTRUCTION OF CC SLAB

Operations involved in it

1. Spreading the prepared concrete mix to desire thickness
2. Compacting
3. Curing
4. Cutting of joints

COMPACTING

Internal vibrator

Surface vibrator

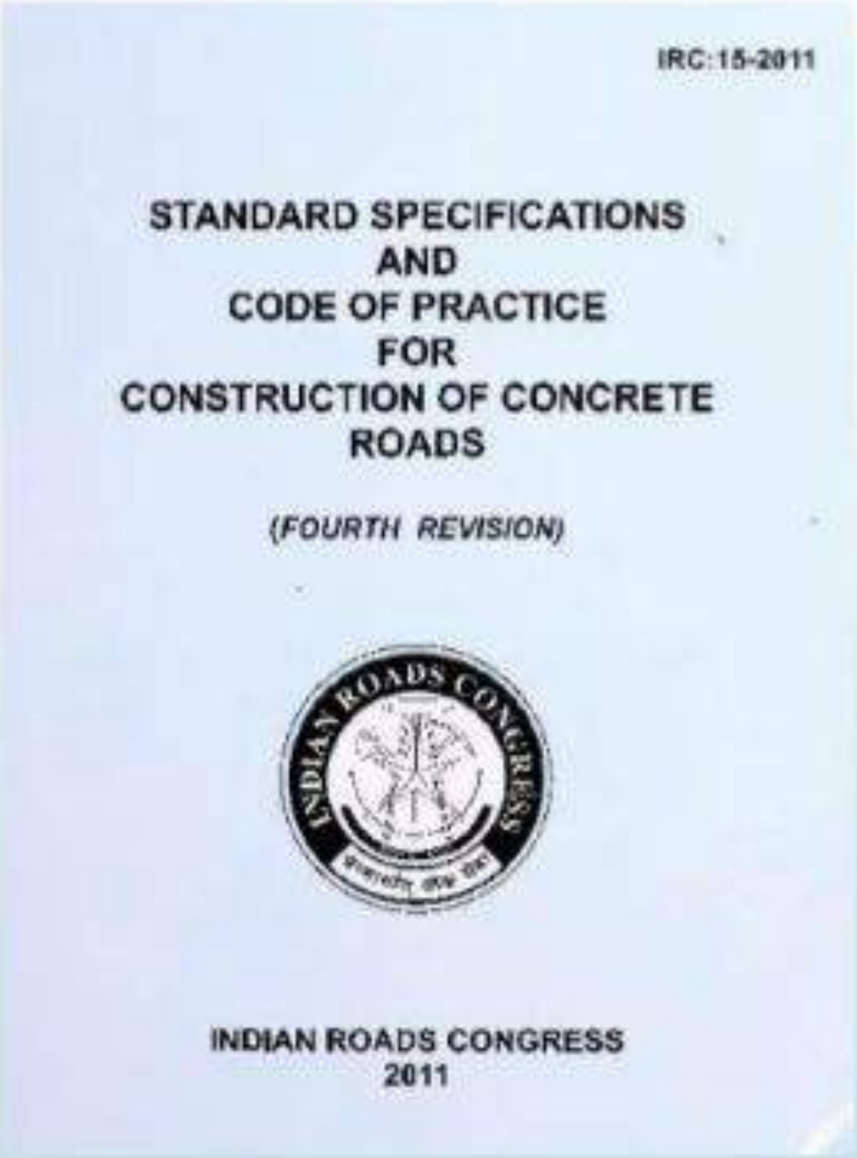
CURING

- Curing is the term used for the job of keeping the fresh concrete wet till desired purpose of ensuring complete setting and hardening of cement in the concrete is achieved.

- Curing of concrete is contain many steps:
  a) Objects of curing.
  b) Methods of curing.
  c) Time required for curing.

PONDING CURING

IRC – 015


IRC:15-2011

STANDARD SPECIFICATIONS
AND
CODE OF PRACTICE
FOR
CONSTRUCTION OF CONCRETE
ROADS

(FOURTH REVISION)

INDIAN ROADS CONGRESS
2011

IRC:15 refers to the Indian Roads Congress (IRC) code for the construction of cement concrete pavements.

- Site Preparation:

The site should be cleared of any vegetation, debris, and loose soil.
The subgrade should be compacted to the required density and profile to support the pavement structure.
Subgrade preparation may include grading, compaction, and moisture control.

- Base and Sub-base Preparation:

The base course provides additional support and stability to the pavement structure.
The sub-base, if required, is placed and compacted to the specified density.
The base and sub-base materials should meet the specified gradation and quality requirements.

- Formwork and Reinforcement:

Formwork is erected to define the shape and dimensions of the pavement.
Reinforcement, such as steel bars or fibers, may be used to enhance the tensile strength and crack resistance of the concrete pavement, especially in heavy traffic areas.

- Concrete Mix Design:

The concrete mix design is crucial for achieving the desired strength, durability, and workability of the pavement.
The mix design includes selecting appropriate cement, aggregates, water-cement ratio, admixtures (if needed), and proportions to meet the specified requirements.

- Concrete Placement:

Before concrete placement, the formwork should be inspected and cleaned to ensure proper adhesion and finish.
Concrete is typically placed using equipment like concrete mixers, pumps, or trucks.
Proper consolidation techniques, such as vibration, are employed to eliminate voids and achieve uniform density.

- Finishing and Texturing:

After concrete placement, the surface is leveled and finished using screeds and floats.
Texturing techniques, such as brooming or tining, are applied to enhance skid resistance and drainage.

- Curing:

Curing is essential to maintain moisture and temperature conditions favorable for concrete hydration and strength development.
Various curing methods, such as water curing, curing compounds, or curing membranes, may be used based on project requirements.

- Joint Construction:

Joints are installed to control cracking and accommodate thermal expansion and contraction.
Types of joints include contraction joints, construction joints, and expansion joints, each serving specific purposes.

- Quality Control and Testing:

Quality control measures, including sampling and testing of materials, concrete mix, and finished pavement, are implemented throughout the construction process.
Testing methods may include slump tests, compressive strength tests, flexural strength tests, and thickness checks.

- Protection and Maintenance:

Once the pavement is constructed, it should be protected from traffic until it gains sufficient strength.
Regular maintenance, such as crack sealing, joint repair, and surface treatments, is crucial for extending the pavement's service life.

Specifications for construction procedure of pavements.

- IRC – Indian Road Congress
- ACI – American Concrete Institute
- MORTH – Ministry of Road Transport and Highways

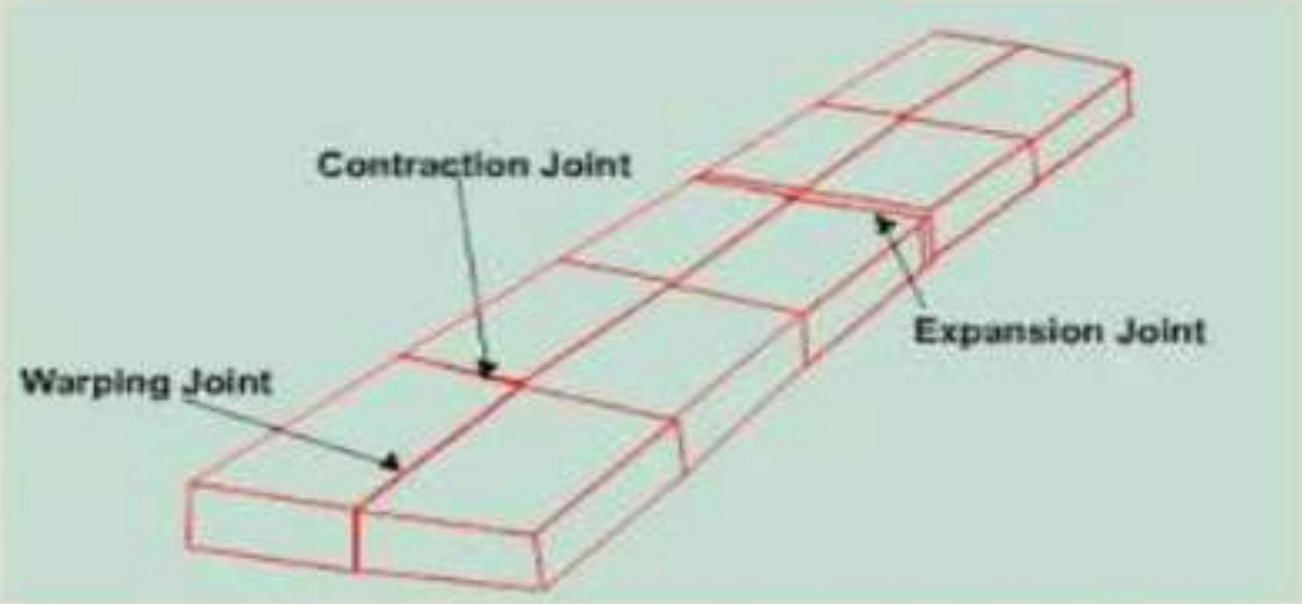
IRC

https://law.resource.org/pub/in/bis/manifest.irc.html

- IRC 015 - Standard Specifications and Code of Practice for Construction of Concrete Roads (Fourth Revision)
- IRC 043 - Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction
- IRC 063 - Tentative Guidelines for the Use of Low Grade Aggregates and Soil Aggregates Mixtures in Road Pavement Construction
- IRC 072 - Recommended Practice for Use and Upkeep of Equipment, Tools and Appliances for Bituminous Pavement Construction
- IRC 088 - Recommended Practice for Lime Flyash Stabilised Soil Base/Sub-Base in Pavement Construction
- IRC SP 046 - Guidelines for Design and Construction of Fibre Reinforced Concrete for Pavements (First Revision)
- IRC SP 062 - Guidelines for the Design and Construction of Cement Concrete Pavement for Low Volume Roads (First Revision)

JOINTS IN CEMENT CONCRETE PAVEMENT

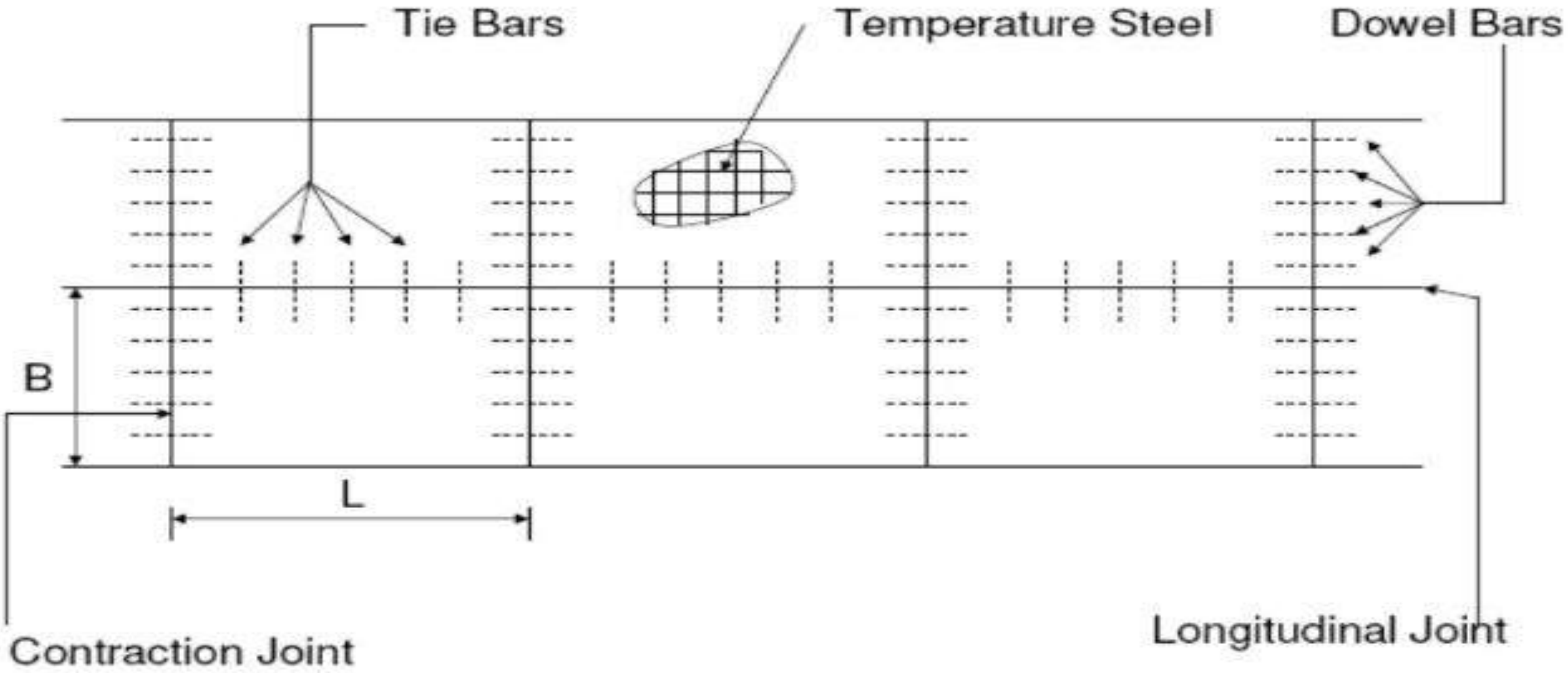
- Types of joints in cement concrete pavement are :
- Expansion joints
- Contraction joints
- Warping joints
- Construction joints

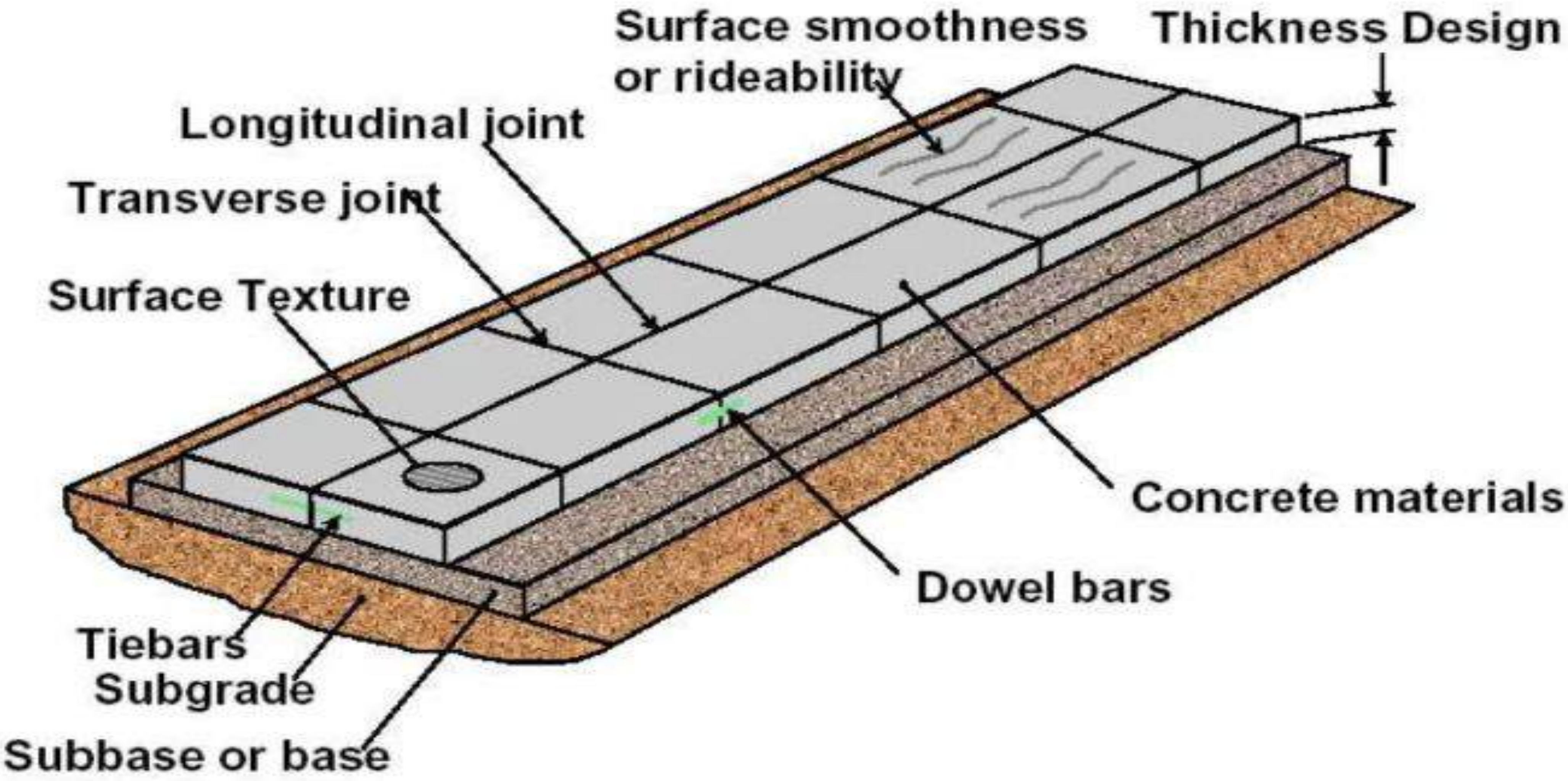


Purpose of joints in Concrete Roads

1. To absorb expansion & contraction due to variation in temperature. (horizontal movements of slabs)
2. To avoid warping of slab edges
3. To grant facility in construction .

Jointed CC Pavement





Surface smoothness
or rideability
Thickness Design
Longitudinal joint
Transverse joint
Surface Texture
Concrete materials
Dowel bars
Tiebars
Subgrade
Subbase or base

JOINTS IN CEMENT CONCRETE PAVEMENT

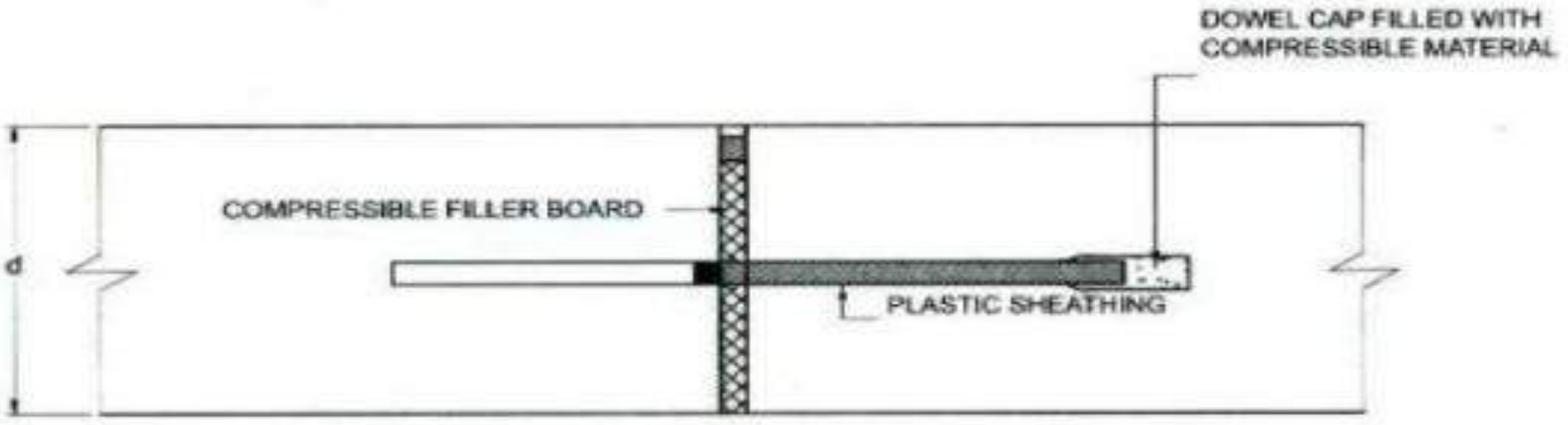
- **Expansion joints :**
- These are provided to allow for expansion of the slabs due to rise in slab temperature above the construction temperature of the cement concrete.
- Expansion joints also permit the contraction of slabs.
- Expansion joints in India are provided at interval of 50 to 60 m for smooth interface laid in winter and 90 to 120 m for smooth interface laid in summer.

Expansion joints

- There are full-depth joints provided transversely into which pavement can expand, thus relieving compressive stresses due to expansion of concrete slabs, and preventing any tendency towards distortion, buckling, blow-up and spalling.
- The current practice is to provide these joints only when concrete slab abuts with bridge or culvert.
- They allow expansion of slabs due to temperature
- They permit contraction of slabs Normal Details of these joints are given in IRC:SP62.
- They are about 20 mm in width
- A joint filler board of compressible material conforming to IRC:SP:62 is used to fill the gap between the adjacent slabs at the
- joint.
- The height of the filler board is such that its top is 23-25mm below the surface of the pavement.
- The joint groove is filled by a sealant .

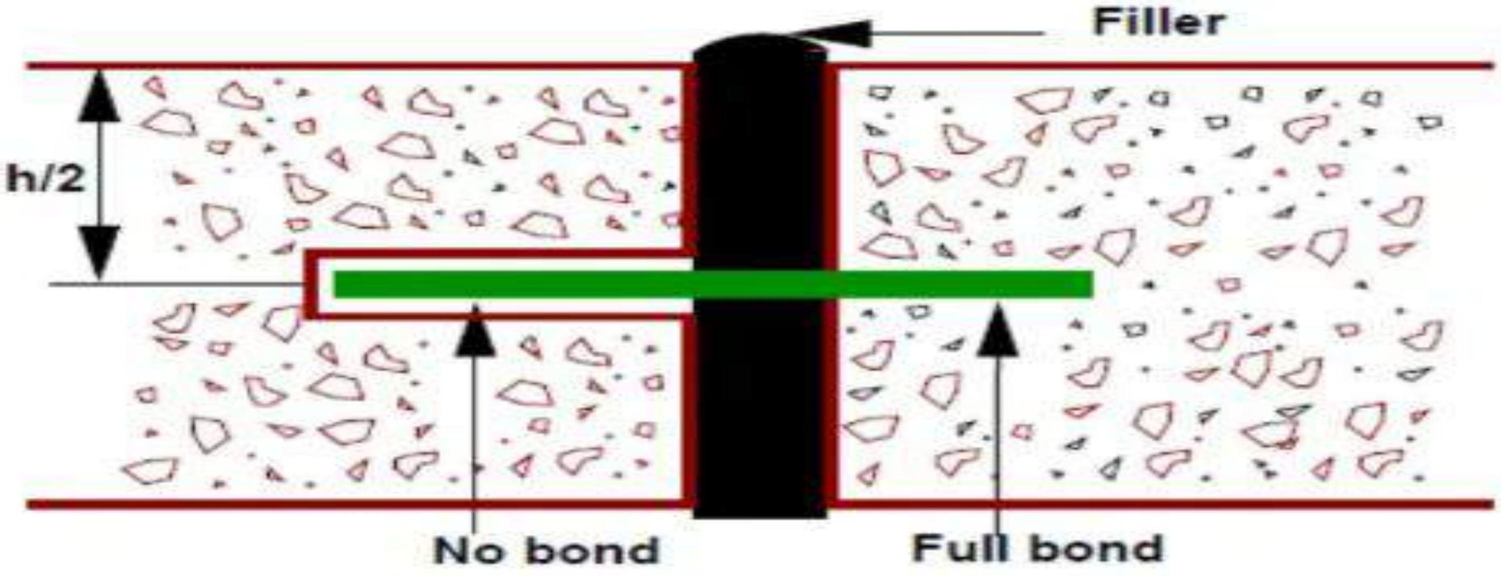
Expansion Joint

Dowels: 25mmdia., 500mm long and spaced at 250mmc/c



EXPANSION JOINT WITH DOWEL

Filler board: compressible Joint filler 20mm ± 1.5mm
Filler depth 25mm ± 3mm lower than slab thickness
Dowel bars (MS rounds) to be covered with plastic sheathing for ½ length +50mm


Filler
h/2
No bond
Full bond

JOINTS IN CEMENT CONCRETE PAVEMENT

- **Contraction joints :**
- Construction joints are provided to permit the contraction of the slab, due to fall in temperature. This joints are spaced closer than expansion joints.
- Load transfer at the joints is provided through the physical interlocking by the aggregates projecting out of the joint faces. As per IRC specification the maximum spacing of contraction joints in unreinforced CC slabs is 4.5 m and in reinforced slab thickness is 14 m.

CONTRACTION JOINTS

- These are purposely made weakened planes which relieve the tensile stresses in the concrete
- Caused due to changes in the moisture content (Drying shrinkage) and/or temperature and
- Prevent the formation of irregular cracks due to restraint in free contraction of concrete .
- They are also provided to

1))Relieve stresses due to warping

2) To permit the contraction of the slab

Details of the contraction joints are given in IRC:SP 62

- They are formed initially by sawing a groove of 3-5 mm with up to about one-fourth to one-third the slab Details of the contraction joints are given in IRC:SP 62. They are formed initially by sawing a groove of 3-5 mm with up to about one-fourth to one-third the slab thicknesses. This facilitates the formation of a natural crack at this location extending to the full depth.
- In order to seal the joint, the top 10-20 mm of this groove is widened to 610 mm.
- Spacing of contraction joints may be kept at 2.50m to 3.75m.
- Length of panel shall not be more than width of panel.

LONGITUDINAL JOINTS

- Lanes are jointed together by joint known as Longitudinal joint
- Longitudinal joints are provided in multilane pavements and also when the pavement is more than 4.5 m wide.
- They are provided normally at 3.5m c/c to
- 1) Relieve stresses due to warping.
- 2) To allow differential shrinkage & swelling due to changes of sub grade moisture
- 3) To prevent longitudinal cracking

Procedure of construction

- Initially joint is cut to a depth 1/3rd slab Initially joint is cut to a depth 1/3rd slab thick ± 5mm. Tie bars are provided at the joints not for load transference but for keeping the adjoining slabs together. The details of such joints are given in IRC:SP 62.
- The top 15-20 mm of the joint is sawn to a width of 6-8 mm for sealing

JOINTS IN CEMENT CONCRETE PAVEMENT

- **Warping joints :**
- The warping joints are provided to relive the warping stress developed in the pavement in order to permit free warping in the longitudinal direction, the transverse warping joints of the weakened plane may be suitably provided.
- These are also known as hinged joints.

JOINTS IN CEMENT CONCRETE PAVEMENT

- **Construction joints :**
- When the placing of concrete is suspended at the end of day or for more than 30 minutes, it becomes necessary to provide construction joints.
- It is thus clear that there will be no necessity of the construction joints, if the work is discontinued at transverse, expansion or contraction joints with the advanced planning.

Construction joints

The need for such joint arises when construction work is required to be stopped at a place other than the location of contraction or an expansion joint, due to some breakdown of the machinery or any other reason.

Such joints are of butt type and extend to the full depth of the pavement.

The sealing of such joints shall be done in the same manner as for contraction joints, by cutting a groove 10-12 mm wide and 20-25 mm deep.

Generally, such joints are avoided in highways. The work is normally terminated at a contraction or expansion joint

Mild steel dowell rods with sheathing and caps. Groove cutting in progress

(CE622PE) HIGHWAY CONSTRUCTION AND MANAGEMENT

UNIT-IV

HILL LANDSIDES: Causes and control measures: Hill road construction practices, Construction of bituminous and cement concrete roads at high attitudes, Hill road drainage. Construction techniques and Construction equipment’s, Quality control tests during and post construction of Hill Roads.

Landslides are a natural phenomenon, but it involves many human activities which lead to the mass movement of landmass. In recent times we find the causes of landslides increasing day by day and the primary cause is deforestation. To survive, one needs to keep a check on these human activities.

Types of Landslides

They can occur because of various reasons. We can classify them into four categories which are mentioned below:

- **Falls Landslides**

  It means falling of some material or debris or rocks etc., from a slope or a cliff which leads to a collection of this debris at the base of the slope.

(Image will be Uploaded soon)

- **Topple Landslides**

  These can occur because of some fractures between the rocks and the tilt of the rocks because of gravity without collapsing. Here, we see the forward rotational movement of the material.

- **Slides**

  It is a kind of landslide when a piece of the rock slides downwards and gets separated from it.

- **Spread**

  It happens on flat terrain and gentle slopes and can occur because of softer material.

Causes of Landslide

Landslides are caused by various factors, which are mentioned below:

- It can be caused because of heavy rain.
- Deforestation is also one of the main reasons for landslides because trees, plants, etc., keep the soil particles compact and due to deforestation, the mountain slopes lose their protective layers because of which the water of the rain flows with unimpeded speed on these slopes.
- It can be caused by earthquakes as well.

For example, in the Himalayas, the tremor occurred because earthquakes unstabilized the mountains, which led to landslides.

- Volcanic eruptions in specific regions can also cause landslides.
- Landslides often occur in mountain regions while making roads and construction; a large number of rocks has to be removed, which can cause landslides over there.
- In the regions of North East India, landslides occur because of shifting agriculture.
- Due to the increasing population, a large number of houses are being created, which leads to the creation of a large amount of debris which can cause landslides.

Effects of Landslide

Let us look at the effects of landslides in points:

Landslides can disturb the social and economic environment with the number of other damages which are mentioned below:

Short Term Impacts

- The natural beauty of the area is damaged.
- Loss of life and property
- Roadblocks
- Destruction of railway lines
- Channel blocking because of the falling of rocks.
- It leads to the diversion of river water, which can cause floods as well.

Long Term Impacts

- Landscape changes can be permanent.
- The loss of fertile land or cultivation land.
- Erosion and soil loss can lead to environmental problems.
- Population shifting and migration.
- Effects on the sources of water.
- Some roads can be damaged or closed permanently.

Prevention and Mitigation

The following measures can be taken in this regard:

- The country should identify the vulnerable areas and actions should be taken in this regard on a priority basis.
- Early warning systems and monitoring systems should be there.
- Hazard mapping can be done to identify the areas which are more prone to landslides.
- Restriction on the construction in the risky areas should be imposed.
- Afforestation programs should take place.
- Restricting development in landslide areas and protecting the existing ones.
- The country should specify codes or standards etc. For the construction of the buildings and other purposes in such areas of risk.
- Insurance facilities should be taken by the people to deal with the loss.
- Terrace farming should be adopted in hilly areas.
- Response teams should be quick to deal with landslides if they occur.

What are hill roads?

The term hill road can be explained with reference to the cross slope, i.e., the slope approximately perpendicular to the centerline of the ***highway alignment***. Thus a road is termed as a hill road if it passes through a terrain with a ***cross slope of 25% or more*** and it is characterized by widely differing elevations, deep gorges, a number of watercourses, and steep slopes. The hill roads are also sometimes referred to as ***ghat roads***.

IMPORTANCE OF HILL ROADS

There are possibly two modes of transport for mountainous or hilly areas, namely, roads and railways. The choice between the two should be based on the relative economics and the following factors are certainly in favour of hilly roads:

(1) Development in stages: A road of small width involving less expenditure can open out the area of immediate economic development and the improvements in the roadway system can be carried out as and when the traffic develops.

(2) Initial cost: There is no doubt that the initial cost of construction of railways is much more than that of roads in hilly areas.

(3) Length: The roads can be constructed with comparatively steeper grades which will result in the reduction of the length of road as compared to the length of the railway track required with milder slopes for rail traction for the same height.

The importance of hill roads can be imagined by understanding the following purposes which they serve:

BASIC PRINCIPLES OF PLANNING OF HILL ROADS

In a broad sense, the main aim of planning a hill road is to establish the shortest, most economical and safe route between the obligatory points, and to achieve this purpose successfully, the following basic principles are to be observed in the planning of hill roads:

(1) Construction work

(2) Existing routes

(3) Intensity of traffic

(4) Master plan

(5) Natural climatic conditions

(6) Use of contours.

(1) Construction work: The construction of hill roads requires considerable period and greater funds as compared to the roads in plains because it involves items such as parapets to demarcate

the roadway boundary, rock cuttings in difficult regions, provision of erosion control measures, greater number of drainage crossings, etc. It is therefore advisable to plan the construction work in stages over a number of years in such a way that each stage of construction improves upon the previous construction stage so as to bring it upto the requirements of the developing traffic.

(2) Existing routes: The existing pedestrian and mule tracks or good animal beaten tracks present the most convenient routes for further improvements and extension and hence, it is one of the essential principles in hill road planning that maximum use should be made of such existing routes. They may however be suitably modified as the traffic requirements increase.

(3) Intensity of traffic: For the purpose of planning, the hill roads may be categorized as jeepable roads and motorable roads from the view point of intensity of traffic. These roads may then be converted into National Highways, State Highways, etc. depending upon the relative importance in the whole set up of planning. The jeepable roads are narrow in width, have comparatively sharper bends and steeper grades and they can be traversed by jeep cars only. The motorable roads can be used by the commercial vehicles in the hilly area. It may be a good policy to aim at jeepable roads first and to provide motorable roads at a later stage after studying the possibility of providing necessary standards of geometric design and construction.

(4) Master plan: It is advisable to draw a master plan for the development of the whole hilly area and work out the priorities instead of starting the work haphazardly. It may avoid the tremendous economic loss in the form of more construction and operation costs due to greater lengths covered by the haphazard planning.

(5) Natural climatic conditions: It is necessary to explore the natural climatic conditions of the hilly area before the planning of road alignment. It is observed that the sunny side of the hills above a height of about 4500 m and the shady side of the hills above a height of about 3600 m are covered with snow. Now the snow melts quickly on the sunny sides as compared to the shady sides of the hills. It is therefore advisable, as far as possible, to align the road on the sunny side of the hills. In a similar

(6) Use of contours: When a virgin hilly area is to be explored, the use of contour maps should also be made. It should always be kept in mind that whatever height has been gained should never be lost. For instances, let us say that a ridge has to be crossed to go to a valley beyond it. It is then essential to touch the most convenient lowest points on the ridge to have the minimum length of road.

Method of surveying For Hill Road

The conventional surveying methods of reconnaissance survey, preliminary survey and final location survey may also be adopted for hilly areas. But they prove to be time consuming, depending on the type of country and the nature of project. Some other drawbacks of these methods of surveying are as follows:

(1) **Delay in work:** The surveying work may have to be withheld during rainy or unfavourable climatic conditions.

(2) **Details of area:** The details to be collected relates to a number of aspects and it is generally found that there is always a possibility of a few details being missed.

(3) **Information:** The information from maps may only relate to the time or period when the maps were prepared and it is quite likely that considerable changes might have taken place between the time the maps were prepared and the time of carrying out the project. The information as such may not also be comprehensive and lack of comprehensive information may involve a few difficulties at a later stage.

(4) **Man-power:** These surveys require lot of man-power to work in the field and co-ordination of work in the difficult sections of the whole project is difficult to achieve.

(5) **Remote areas:** For areas which are inaccessible and remote from habitations, it becomes necessary to establish special camps with facilities of tents, rations for party, guards to protect against wild animals, medical kit, transport arrangements, etc. The quick and most modern method of surveying for hilly areas is the use of aerial photographs. These photographs are obtained by special automatic cameras fitted in the aeroplanes flying at a constant height and they represent the exact images of the objects on the ground.

ALIGNMENT OF HILL ROADS

The success and utility of a **hill or ghat road** depend on its proper alignment. It is, therefore, necessary to exercise great care in fixing the alignment of hill roads. ***A good alignment has the following feature***s:

(i) It achieves the minimum costs of construction and maintenance.

(ii) It allows comfortable travel and the expenditures on motive power, as well as wear and tear of vehicles, are also greatly reduced.

(iii) It contains sharp curves having small radius.

(iv) It gives a stable and safe road.

(v) It grants the easiest, shortest, and most economical line of communication between the obligatory points or important centers to be connected by the hill road.

(vi) It has the gradient as easy as possible.

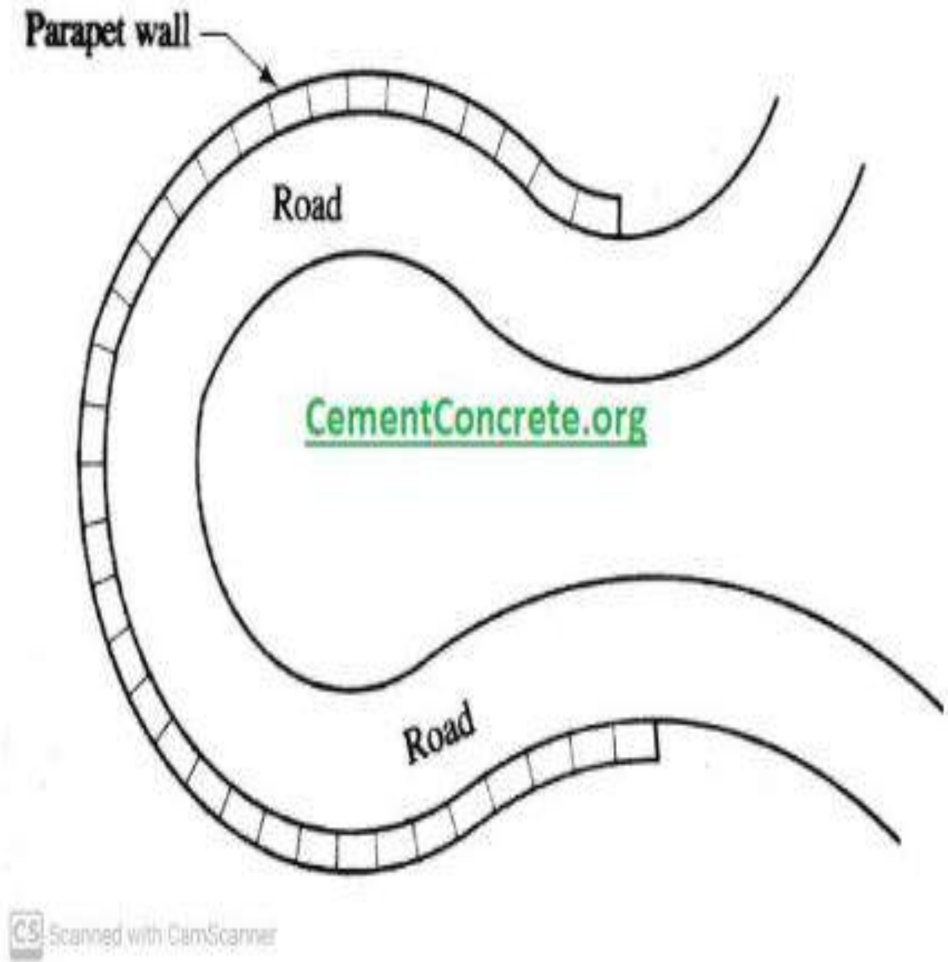


Fig.1. Hairpin Bend used for Hill road

In general, it can be stated that the best and most convenient alignment will be the one having the minimum of cutting and filling; and a minimum of walling and bridging. In many cases, the alignment of the hill road contains two types of sharp curves known as hairpin bends and corner bends. Fig. 1 shows the hairpin bend and fig. 2 shows the corner bend.


HAIR PIN
BEND

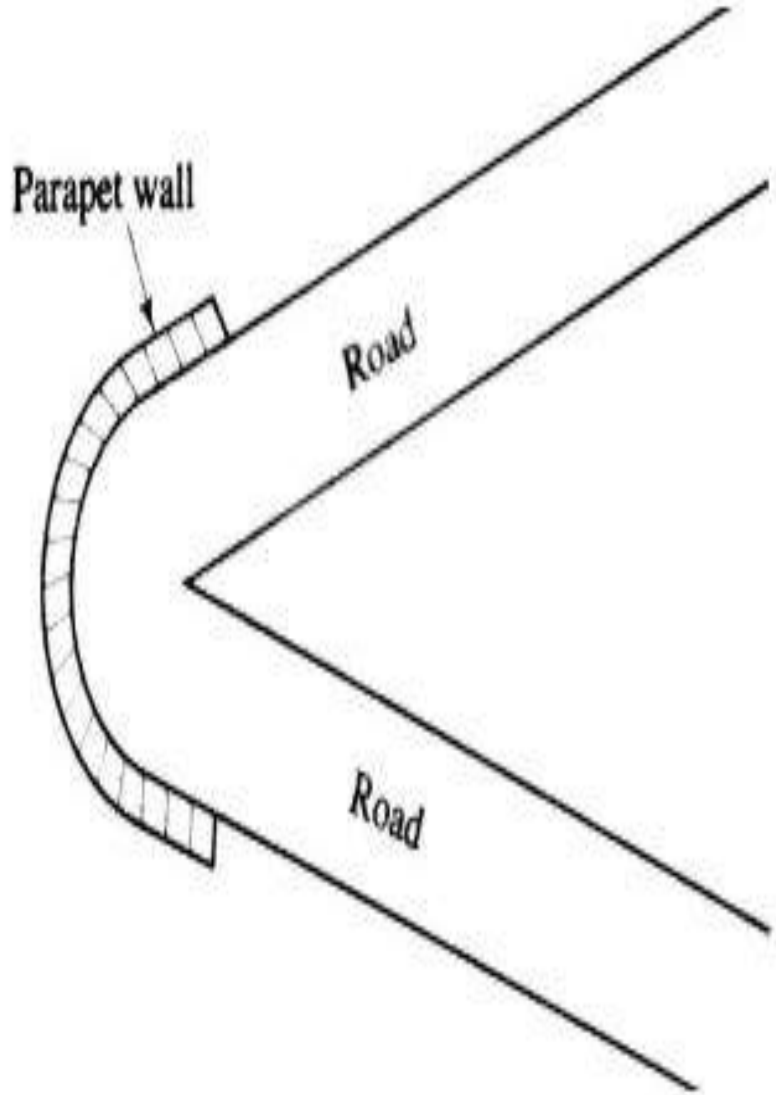


Fig.2. Corner bend used in Hill road design

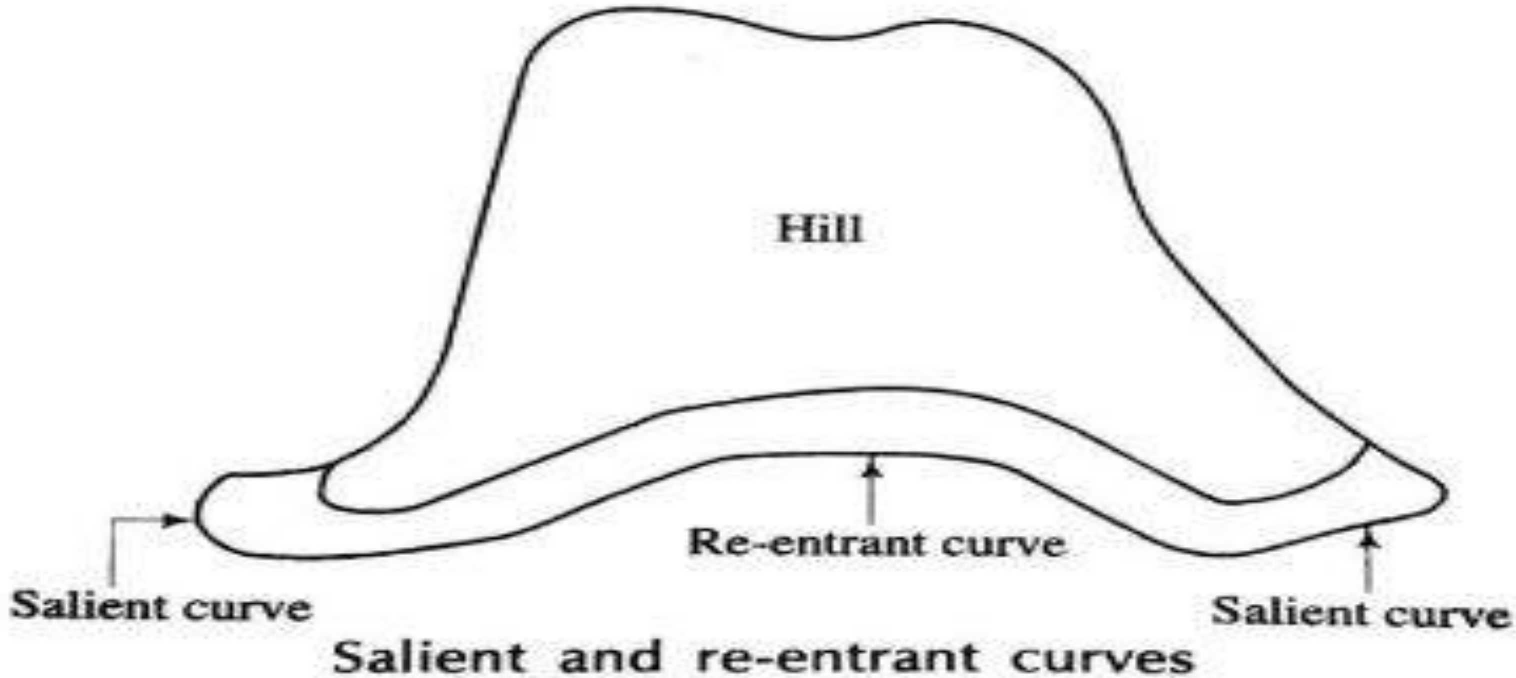


Fig.3. Salient and re-entrant curve used in hill road design

If the side of hill contains ridges and valleys, it will have to be provided with salient and re-entrant curves. A salient curve is a convex curve with its convexity on the outer edge of the road at the ridge of hillside. A re-entrant curve is a concave curve at the valley of the hillside. Fig. 3 shows the salient and re-entrant curves. Due to these ridges and valleys, the visibility on a hill road is less and the traffic has to be very careful while negotiating the salient and re-entrant curves in succession. Otherwise, there are chances of fatal accidents to occur at these points. To improve the visibility at a salient curve, some portions of the hill may even be cut down.

GEOMETRIC STANDARDS OF HILL ROADS

The roads in the hilly areas require special attention in fixing up the standards for geometric design because of various factors, such as types of vehicles using the road, total daily tonnage, difficulty in construction, type of surface to be provided, topography of the area, etc.

The **geometric standards of hill roads** are to be considered with respect to the following aspects:

(1) Widths of carriageway, shoulder, roadway and land

(2) Camber

(3) Stopping sight distance

(4) Overtaking sight distance

(5) Gradients

(6) Super-elevation

(7) Radius of horizontal curve

(8) Widening at curves

(9) Transition curves

(10) Hairpin bends

(11) Cut slopes

(12) Setback distance

(13) Passing places

(14) Vertical clearance

(15) Lateral clearance.

(1) Widths of carriageway, shoulder, roadway and land for hill road:

(i) The roadway widths are exclusive of side drains and parapets. These should be considered separately, when necessary.

(ii) In hard rocky stretches, the shoulders may be reduced by 400 mm on either side on two-lane roads and by 200 mm in other cases.

(iii) The minimum setback for building line beyond the right of way should be 5 m in normal cases and 3 m in exceptional circumstances.

(iv) For roads subjected to heavy snowfall, the roadway width may be increased by 1.5 m

Highway Classification	*Carriage width in m*	*Shoulder Width in m*	*Roadway width in m*
NH and SH or DR			
Single lane	3.75	2 x 1.25	6.25
Double Lane	7.00	2X 0.90	8.80

(2) Camber:

The steeper camber or cross-slope is adopted for hill roads and table 10-2 shows its recommended values. However, if the road has a longitudinal gradient greater than 1 in 20, a flatter camber may be provided.

TABLE 2. CAMBER FOR HILL ROADS

No.	*Type of surface*	*Camber, per cent*
1	Subgrades, earth roads and shoulders	3.0 to 4.0
2	Gravel and W.B.M. surface	2.5 to 3.0
3	Thin bituminous surfaces	2.5
4	High type bituminous surface and cement concrete surface	2.0

(3) Stopping sight distance for hill roads:

The stopping sight distance (SSD) is calculated from the following expression:

Length of SSD = v2(254 f) + 0.278 Vt

Where,

V = Design speed in km p.h.

t = Total reaction time to be taken as 3 seconds,

f = Coefficient of friction to be assumed as 0.4.

Table 3. shows the values of SSD for various design speeds on hill roads as recommended by the I.R.C.

TABLE 3. VALUES OF SSD FOR HILL ROADS

No.	***SSD in m***	***Design speed in km p.h.***
1	20	20
2	30	25
3	35	30
4	50	40
5	70	50

(4) Overtaking sight distance for Hill roads:

The overtaking sight distance (OSD) is calculated from the following expression:

Length of OSD = [d_1 + d_2 + d3]

Where,

= [0.278 V_2t+ (0.278 V2 to + 2 s) + 0.278 Vto]

V = Speed of overtaking vehicle in km p.h.

V2 = (V – 16)

= Speed of overtaken vehicle in km p.h.

t = Reaction time of driver = 2 seconds

s = (0.2 V_2 + 6) Spacing of vehicles

to = (14.4 s/ A)^0.5 = Overtaking time in seconds

A = Acceleration in km p.h./sec. to be taken as 4.72, 4.45 and 4.0 for speeds of 30 km p.h.. 40 km p.h. and 50 km p.h. respectively.

(5) Gradients for Hill roads:

Depending upon the type of terrain and height above mean sea level, suitable values of ruling gradient, limiting gradient and exceptional gradient are to be adopted and grade compensation may be provided on chapter of horizontal curves.

(6) Super-elevation for Hill road:

The super-elevation on hill roads is to be provided by adopting the following formula:

$e = V2 / 225 R$

Where,

e= Rate of super-elevation

V= Design speed in km p.h.

R = Radius of curve in m.

It is recommended that the super-elevation should not exceed 7 per cent in sections of hill roads which get snow bound and 10 per cent in other places.

(10) Hairpin bends:

A hairpin bend is a sharp curve and it is located on a hill side having the minimum slope and maximum stability. It must also be safe from the viewpoint of landslides and groundwater. For reducing the construction problems and expensive protection works, the hairpin bends should be provided with long arms and farther spacing. A hairpin model is shown in fig1.

A hairpin bend is designed as a circular curve with transition curves at each end. Following are the design standards of a hairpin bend:

1. Minimum design speed 20 km p.h.
2. Minimum radius of the inner curve 14 m.
3. Minimum length of transition curve 15 m.
4. Minimum gradient = 1 in 200.
5. Maximum gradient 1 in 40.
6. Super-elevation in circular portion of the curve = 1 in 10.
7. Minimum width of carriageway at apex of the curve = 11.5 m for NH and SH having two lanes of traffic

= 9 m for NH and SH having one lane of traffic

= 7.5 m for MDR and ODR = 6.5 m for VR.

- Minimum straight length between two successive hairpin bends 60 m.
- The approach gradient should not be steeper than 5 per cent for 40 m.
- The island portion of the hairpin bend should be cleared of trees, etc. for good visibility.

HILL ROADS

Introduction:

- Roads constructed in mountains region is called hill roads.
- There are different considerations while designing hill roads as compare to plain area roads.
- Types of curve used in hill roads is of different than plain road.
- All geometric parameters will gets changes while designing hill roads such as- Curves, Super elevation, SSD, OSD, Extra Widening, etc.

Components parts of Hill Roads

1. Road Bed
2. Side Drain
3. Parapet Drain
4. Catch Water Drains
5. Brest Wall
6. Retaining Wall
7. Cross Drains

PROTECTIVE WORKS FOR HILL ROADS

In order to give stability and a sense of safety to the hill roads, the following three types of protective works are provided:

(1) Retaining walls

(2) Breast walls

(3) Parapet walls.

- ***Retaining walls:***

> The formation of a hill road is generally prepared by the excavation of the hill and the material which is excavated is dumped or stacked along the cut portion. The retaining wall is constructed on the valley side of the roadway to prevent the sliding of backfilling as shown in fig.5. Thus the main function of a retaining wall for hill roads is to retain the back filling and it is provided at the following places:
>
> - at all re-entrant curves;
> - at places where the hill section is partly in cutting and partly in embankment; and
> - at places where the road crosses drainage.

- ***Breast walls:***

The cut portion of hill is to be prevented from sliding and the wall which is constructed for this purpose is known as breast wall. See fig. 5. The breast walls are provided with a front batter of 1 in 2 and a back batter of 1 in 3. The back batter may be provided either in one straight batter or in the form of projections. If the height of the wall is less than 2 m, the entire section is made in random rubble stone masonry. If the height of wall exceeds 2 m, the top portion of 2 m height alone is made in random rubble masonry and the remaining portion is constructed in cement mortar of proportion (1:6).

The weep holes, as in case of retaining walls, are provided with slope outwards and sometimes, the vertical gutters connecting the weep holes to the side drain are provided.

- ***Parapet walls:***

The parapet walls are usually provided all along the valley side of the road except where the hill slope is very gentle. They are constructed immediately above the retaining wall, as shown in fig.5 and they prevent the wheels of the vehicles from coming on the retaining wall. It is to be noted that the construction of a parapet wall merely gives a sense of security to the driver and the passengers and it is very rare unless constructed in stone masonry with cement mortar that they act as protecting structures in the event of an accident.

The parapet walls are usually of wall type with uniform thickness of 600 mm and height of 600 mm above the berm level. They can also be constructed of R.C.C. posts of 150 mm x 150 mm section with 1 m height above ground level and 450 mm below ground level and spaced at 1 m centre to centre. In case of hard rocky stratum, the parapet walls may be replaced by the railing of cast-iron.

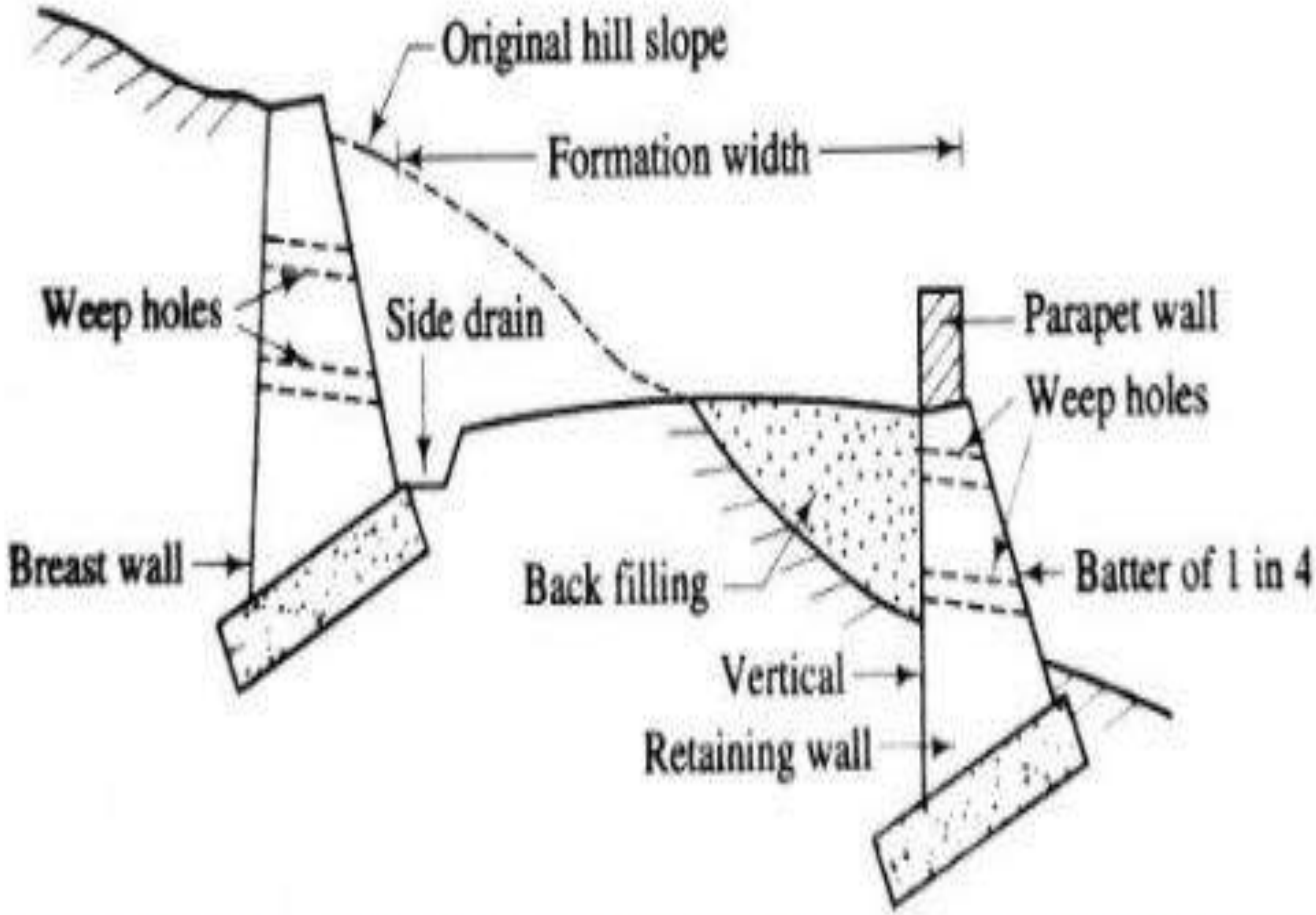


Fig.5. Retaining wall and breast wall for protective works for hill road

7. Cross Drains

Road Bed

- The pavement potion of hill road is called road bed.
- **Function:** To resist stresses developed due to moving traffic.

Side Drain

- Drain provided on the sides of road is called side drain.
- Side drains runs parallel to the length of road.
- **Function:** To collect and drain off rain water collected from camber of road.

Parapet Wall

- Wall which is provided above the formation level in the down side slope is called parapet well.
- **Function:** Protection to the traffic against falling down the hill slope.

Catch Water drain

- It is drain provided on higher slope running parallel to the length of road.
- **Function:** To make intercept for runoff coming from top of hill and divert water in to nearby cross drains.

Brest Wall

- The wall constructed to upside slope is called retaining wall.
- **Function:** Protect road from sliding of upside slope.

Retaining Wall

- The wall constructed to down side slope of road is called retaining wall.
- **Function:** To protect down slope from sliding.

Cross Drains

- The drain which is laid along width of road is called cross drains.
- **Function:** To drain off rain water collected in side drains and catch drains.

Image of Hill Road

CONSTRUCTION STAGES

STAGE 1- PLANNING

↓

STAGE 2- CLEARING

↓

STAGE 3- CONSTRUCTION

↓

STAGE 4- OPEN FOR TRAFFIC

PLANNING

A ROAD PROJECT BEGINS WITH EVALUATING THE TRANSPORTATION SYSTEM INCLUDING MAP STUDY AND SURVEYING OF THE LAND .

- ENVIRONMENTAL ISSUE
- UTILITIES AFFECTED
- FUNDS NEEDED

CLEARING

FOR THE CONSTRUCTION OF HILLY ROAD ,THE REQUIRED ROAD SPACE IS OBTAINED THROUGH CLEARING AND EXCAVATION OF SOIL MASS BY BACK HOE

ALL WORK OF ROAD CUTTING SHALL BE CARRIED OUT TRUE TO LINES, GRADES ,SIDE SLOPES, WIDTH, CAMBER, SUPER-ELEVATION AND LEVELS AS SHOWN ON THE DRAWINGS OR AS DIRECTED BY THE ENGINEER .

BACK HOE

EXCAVATOR

AGGREGATE USED

- **Coarse aggregates** are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter

- **Fine aggregates** generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve.

Construction Procedure

- 1. Preparation of Sub Grade
- 2. Preparation of Base Course
- 3. Intermediate Layer
- 4. Wearing Surface
- 5. Shoulders

STEPS

1. THE SUBGRADE (10-20 CM) THOROUGHLY CONSISTS OF SUB SOIL WHICH ARE LEVELLED.
2. WATER IS SPRAYED ON THE SUBGRADE & IT IS COMPACTED AFTER DRYING.
3. THE BASE COURSE (10CM) CONSISTS OF COARSE AGGREGATE.
4. THE INTERMEDIATE COURSE CONSISTS OF FINE AGGREGATE (9.5MM) WHICH ARE MAINLY SAND .

4.THE WEARING COURSE (5CM) IS THE FINAL COURSE WHICH CONSISTS OF 2 LAYERS . A THIN LAYER OF HOT BITUMEN IS SPRAYED OVER THE INTERMEDIATE COURSE TO ACT AS A BINDER MEDIUM.

5. AFTER THIS A LAYER OF BITUMEN AND AGGREGATE MIXTURE WHICH IS HEATED AND MIXED THROUGHOUT IS LAYED AND COMPACTED BY ROLLERS .

6.A SHOULDER , OFTEN SERVING AS AN EMERGENCY STOPPING LANE CONSISTS OF COMPACTED EARTH FILLINGS .

ROAD METALLING

MIXER
-65%(COARSE)
-35%(HOT BITUMEN)

SITE PHOTOS

SPREADING

COMPCTING

AFTER COMPACTION

ACCIDENT

LANDSLIDE PROTECTION

RETAINING WALL

BREAST WALL

OPEN FOR TRAFFIC

At 19,300 ft, Umling La is literally perched on top of the world. Constructing a road there could pose unimaginable challenges.

Man and machine working in tandem to blacktop the world's highest motorable road in Eastern Ladakh at 19,024 ft.

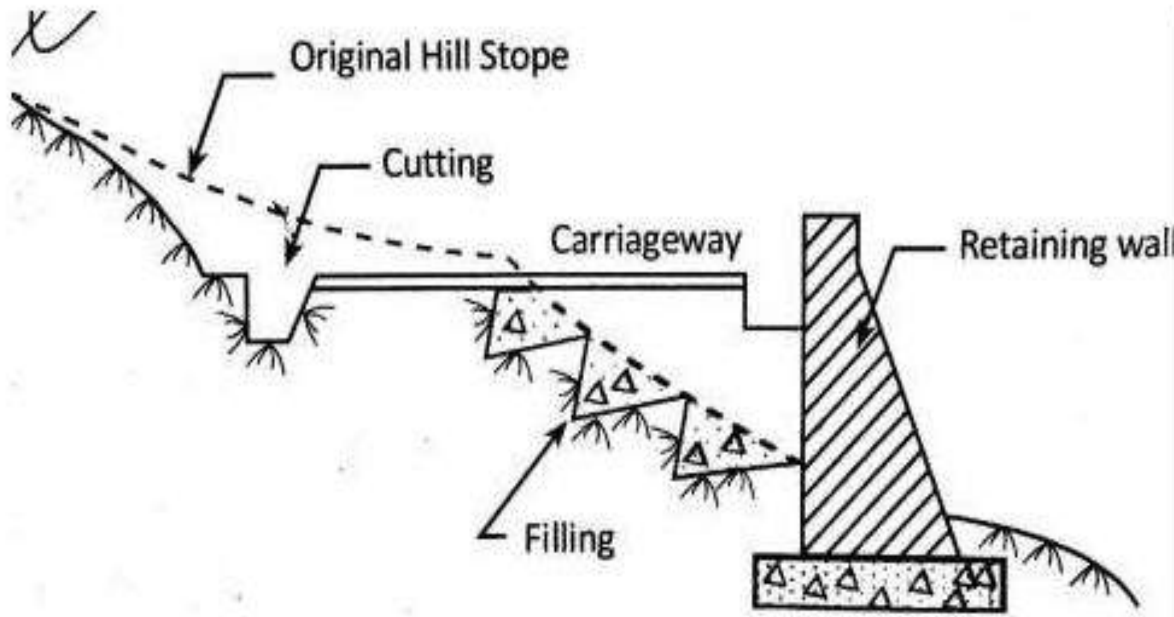
Paving of roads using M50 grade concrete blocks at Sela top (13680 ft).

The most significant challenge in infrastructure development in these areas relates to the execution of civil engineering construction works. Restricted and frequently-interrupted working seasons, limited availability of skilled manpower in remote locations, challenging weather and terrain conditions, coupled with a significant diurnal variation in temperature, make the execution of both cementitious and bituminous works even more challenging. Some of the innovative and new techniques utilized by BRO to overcome these challenges are described below.

Typical cross-sections hill road :-

The cross section of a road in a hilly terrain is determined by the original ground slope of the site, the slope of the road formation, width of roadway, side drain size, and shape and so on. Various types of road cross-section are:

1. Cut and fill
2. Bench type
3. Box cutting
4. Embankment with retaining walls
5. Semi bridge
6. Semi tunnel
7. Platforms



Typical Cross Sections of Hill Road

DRAINAGE IN HILL ROADS

The rain falls very heavily on the hills and as the slopes of hills are quite steep, the water reaches the roadside very quickly and creates drainage problems. The water thus collected should be disposed-off in a proper way through the well-planned and designed drainage system.

(1) Sub-surface drainage:

The seepage flow of water on hills creates problems during and after monsoons. The level of seepage water may be at, above, or below the road level depending upon several factors such as depth of hard stratum and its inclination, the quantity of underground flow of water, etc. The seepage flow also causes the weakening of the roadbed and the pavement and it also causes problems of slope stability. It is, therefore, necessary to control the seepage flow by adopting the suitable method of the sub-surface drainage system.

(2) Surface drainage:

For carrying the surface water, the side drains are provided only on the hill side of the road, as shown in fig. 5. There is limitation in the formation width of road and hence, these drains are constructed of such a shape that the vehicles could utilize the space of side drains in case of an emergency for crossing or parking. The side drains are usually of the following three types:

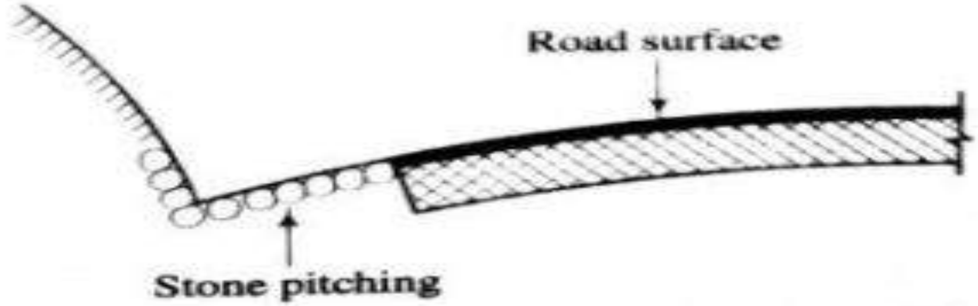


Fig.6. Angle side drain for hill road drainage works

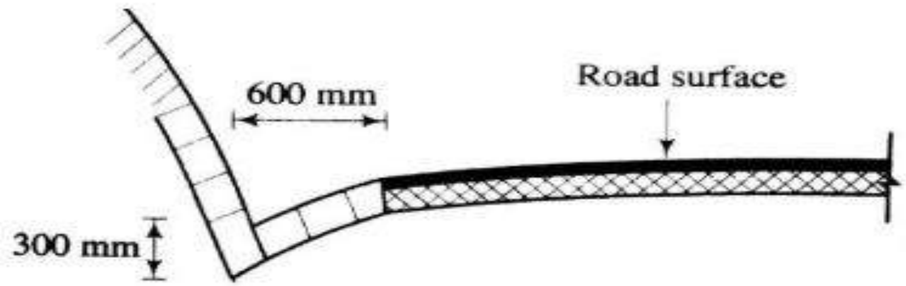


Fig.7. Kerb and channel side drain

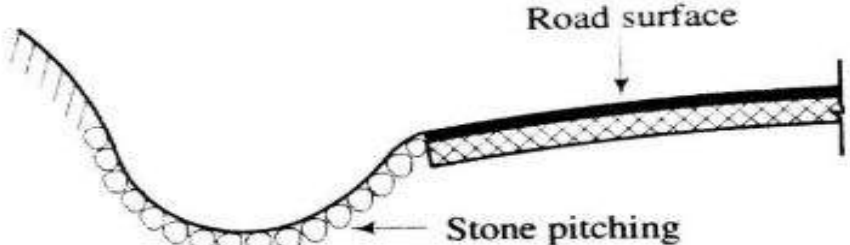
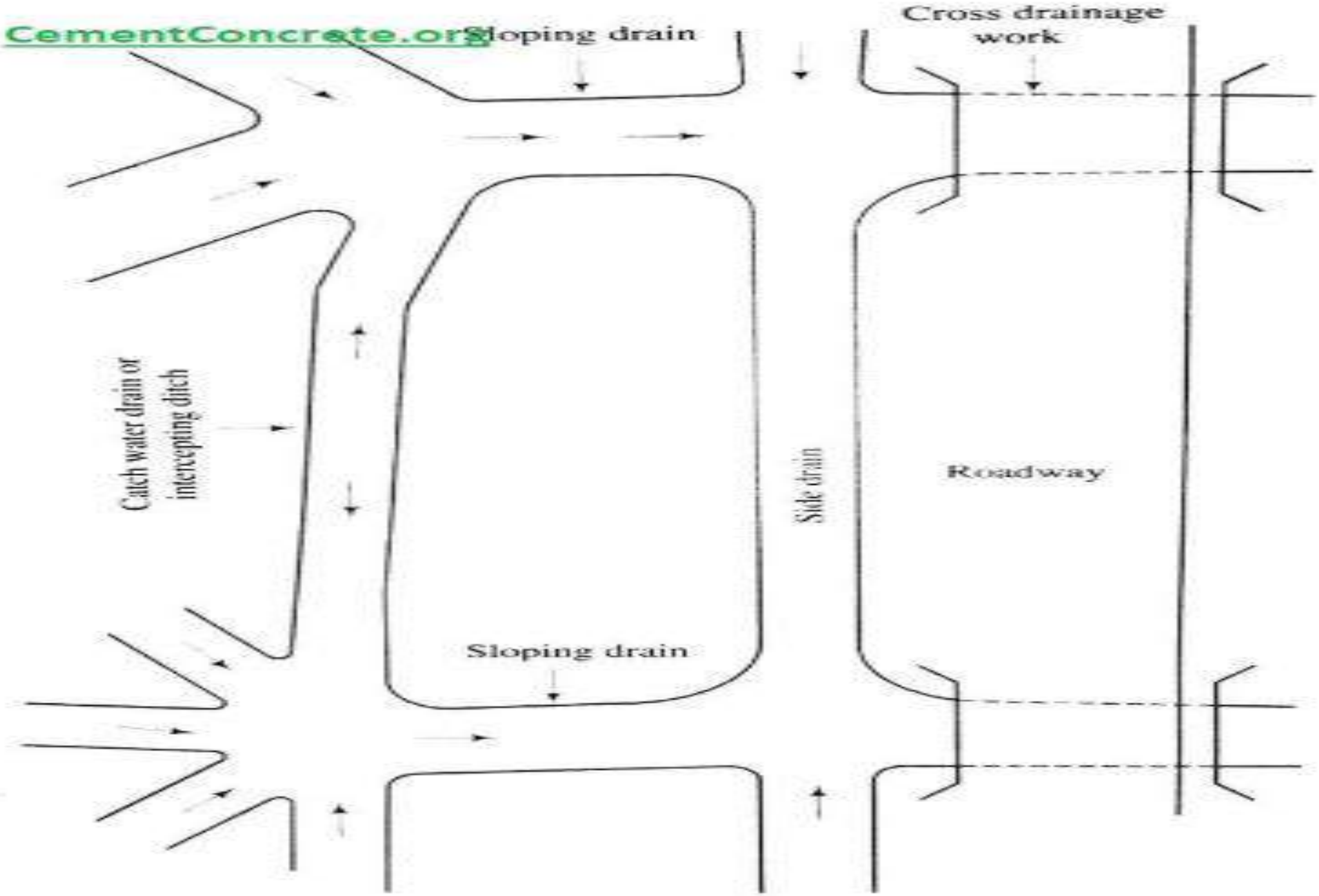


Fig.8. saucer side drain



Catch water drain and cross-drainage work

Fig.9. catch water drain and cross-drainage work for hill side road

Fig. 9 shows the layout plan of catch water drain, sloping drain and cross-drainage work. The water from the hill slope is intercepted and diverted through the catch water drains which are running parallel to the roadway. The catch water drains are usually provided with a gradient of 1 in 50 to 1 in 33 to avoid high water velocity and possible wash out. The water from the catch water drains is led to the cross-drainage works through the sloping drains.

The cross-drainage works are in the form of culverts, scuppers or causeways. They are constructed under the road and usually at right angle to it. For collecting the stones and debris and for preventing scour, the catch pits may be provided at the head of small cross drains. The floor level of catch pit may be kept about 300 mm below the sill of the culvert.

MAINTENANCE OF HILL ROADS

The hill roads because of their peculiar location require careful attention in their maintenance. For the purpose of convenience, the maintenance problems of the hill roads can be grouped into the following four categories:

(1) Control of avalanches

(2) Drainage structures

(3) Prevention of land slides

(4) Snow clearance.

Each of the above category will now be briefly described.

- **Control of avalanches:**

An avalanche indicates a large mass of loosened snow, earth, rocks, etc. which suddenly and swiftly slides down a hill. Where there are chances for an avalanche to occur, suitable remedial measures may be adopted so that minimum damage occurs to the road structures. One of such preventive measure which is commonly adopted is the construction of galleries above the road which permit the avalanche to slide over the gallery roof without inducing impact loads.

- ***Drainage structures:***

The drainage structures such as catch water drains, catch pits, side drains and culverts are to be periodically inspected and cleaned off all the debris and blockages which prevent the smooth flowing of water in such structures during rains.

As a precautionary measure, the upper slopes are planted with trees to reduce considerably scouring action of unstable ground due to rains.

- ***Prevention of land slides:***

The term land slide is used to indicate the downward and outward movement of slope-forming materials composed of natural rock soils, artificial fills or combinations thereof. The landslides move along the surface of separation by falling, sliding and flowing.

When the shear stresses exceed the shear strength of the soil, the movement in the form of land slide occurs. Hence, anything which contributes towards a decrease in shear strength of the soil or an increase in the shear stress can cause a land slide.

The decrease in shear strength of the soil takes place mainly due to the following causes:

- decrease in inter-granular pressure;
- formation of faults in bedding planes of strata:
- hair-cracking due to alternate swelling and shrinkage of the soil structure;
- increase in water content and consequent swelling and increase in pore water pressure;
- seepage pressure of percolating ground water; etc.

- ***Snow clearance:***

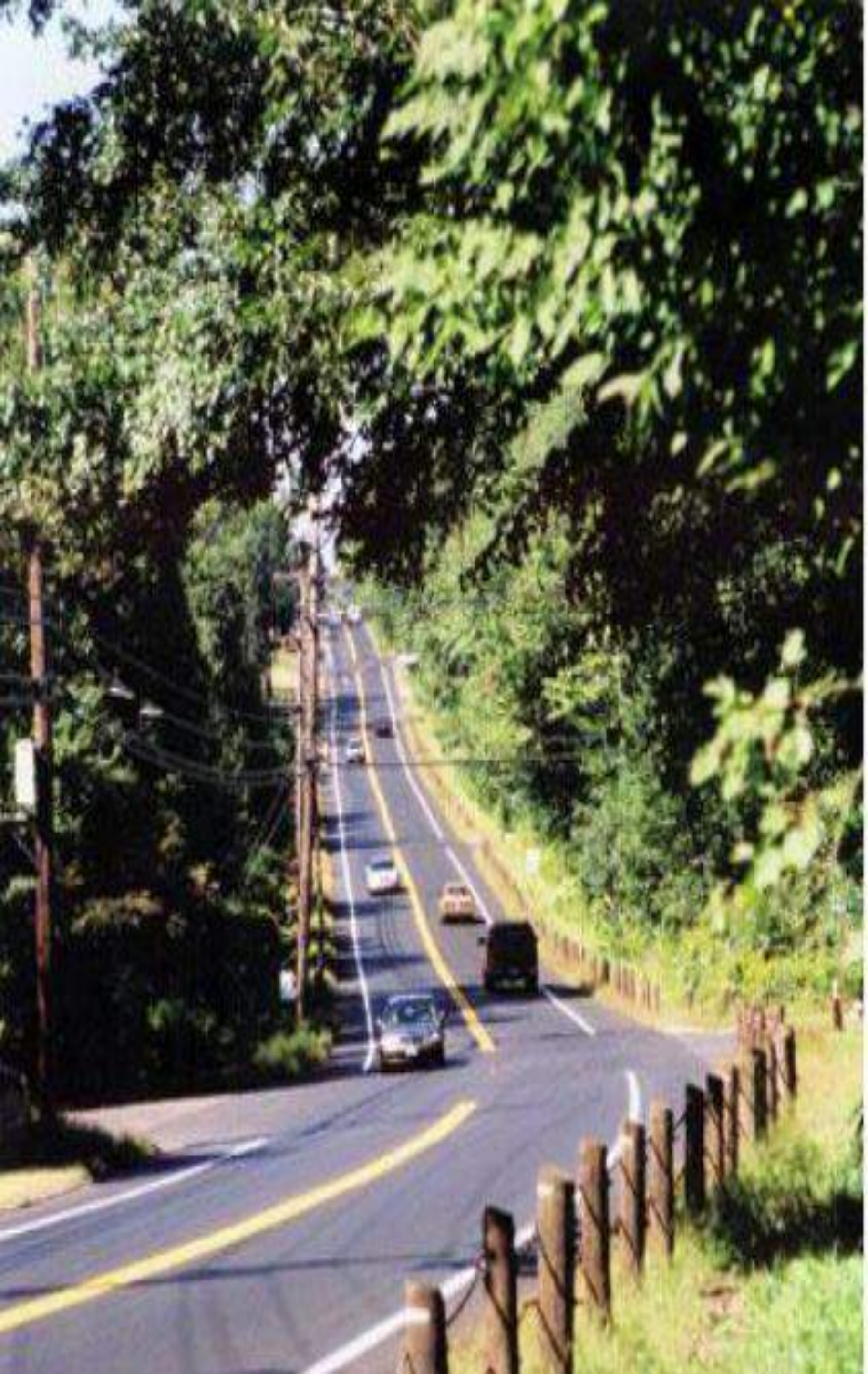
The depth of accumulated compacted snow on the road surface in winter poses a serious problem for its early removal to restore traffic. In the case of ***heavily snow bound areas***, it becomes difficult for the snow clearing party to locate the position of the road and other structures under the snow cover. For this purpose, the snow markers which are in the form of wooden posts with their height marked in meters are fixed before the winter starts along the road next to the parapet walls to mark the outer edge of the road.

The snow clearance is done with the help of machines and extreme care is taken to see that the top surface of the road is not damaged by the movement of such machines. The commonly used machines are motor graders, snow blasts, or wheel dozers. If the thickness of snow is more, the blasting by explosives may also be adopted. On the other hand, if the thickness of snow is less, the snow clearance can be carried out by manual labor only.

UNIT-V

PAVEMENT EVALUATION: Structural and functional evaluation of pavements, Introduction to IRI, Bump Integrator, Benkelman Beam and Falling weight deflectometer, Overlay design by Benkelman beam tests, Distress types in bituminous and concrete pavements, causes of distresses, Maintenance Problems and their remedial measures

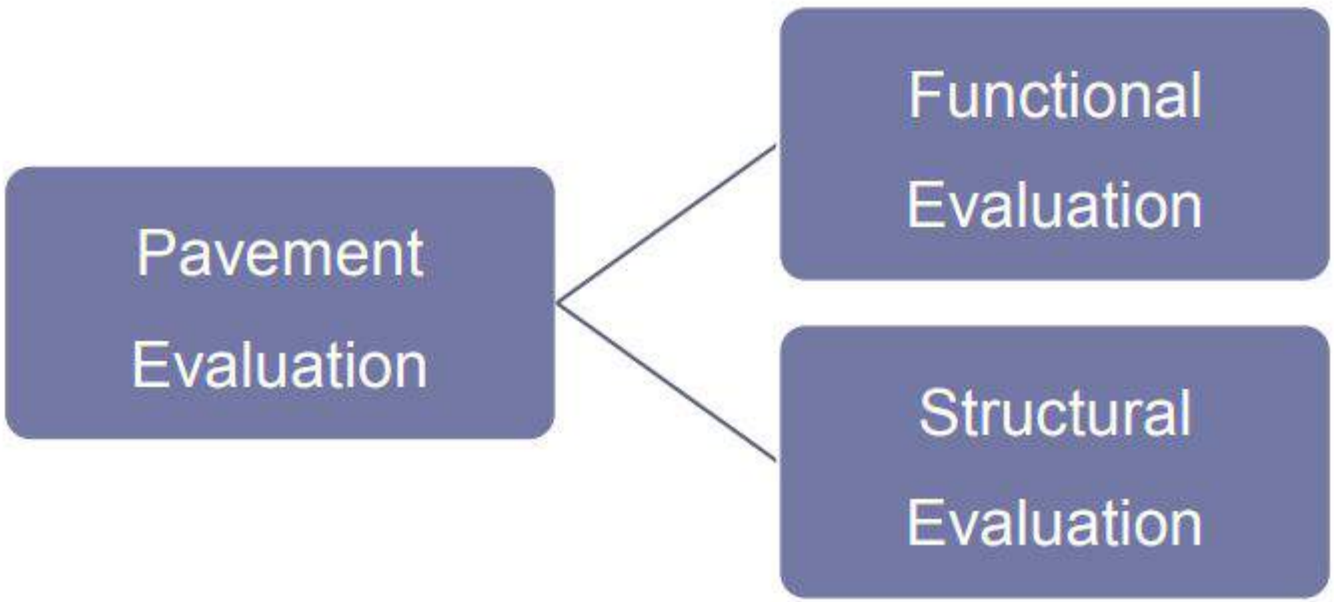
New Road



ecticut, Inc.

- Especially After rainy season
- Possible causes:
  - Faulty design or construction
  - Near by water bodies which may cause different pavement distresses etc

- Life of pavement reducing (15- 20 years to 5-10 years or less) and demands for *repairs/overlay* based on functional and structural evaluation!!!


Pavement Evaluation
Functional Evaluation
Structural Evaluation

Pavement Evaluation

- Functional Evaluation
  - Pavement Condition Survey - Visual
  - Pavement roughness
  - Skid resistance
- Structural Evaluation
  - Based on deflection measurement under standard axle load
  - Benkleman beam

Functional evaluation

- Pavement condition survey
  - A number of distresses may occur simultaneously, because many of the distresses are ***interrelated***, and the occurrence of one may as well initiate the other.
  - Individual assessment and quantification of the distresses may not therefore be very useful.
  - Rather, there is a need to assess the functional condition of the pavement as a ***whole***.

Pavement condition survey

- The survey on general pavement condition was primarily a visual exercise undertaken by means of ***slow drive-over survey***, and supplemented with measurements wherever necessary.
- Visual assessment was carried out from a vehicle, with speed not exceeding 15 km/hr and ***stopping at various locations*** at suitable intervals and wherever necessary, ***depending on variations*** in pavement conditions.

Pavement condition survey

- Aspects of pavement conditions assessed include surface defects, rut depth, cracking, potholes, patched areas, shoulder condition etc.
- An overall assessment of performance serviceability of the road was also done to qualitatively rate the existing pavement and shoulder condition.

Pavement condition survey

- The Survey was recorded under the following sub-heads:
- Shoulders:
  - Composition / Condition / material Loss
  - Riding Quality (Good / Fair / Poor / Very Poor)
- Pavement Condition (surface distress type & extent):
  - Cracking (%); Raveling (%); Potholes (%); Patching (%); Rut depth (mm)
  - Edge break (m); Pavement edge Drop (mm)
- Embankment Condition (Good / Fair / Poor)
- Road Side Drain (Non Existing / Partially Functional / Functional)
- Drainage condition

PAVEMENT CONDITION SURVEY

Sheet No.

Feasibility Study and DPR for 6 Laning of Gandhidham-Samyakhari Section (56.16Km) of NH-8A

ROAD NAME

ROAD NO. :

SECTION FROM : TO

DATE OF SURVEY :

DISTRICT FROM :

WEATHER :

CHAINAGE		Shoulder				Riding Quality		Pavement Condition												
FROM (KM)	TO (KM)	Composition (P/G/E)		Condition (Fair/Poor/Failed)		Speed (Km/Hr)	Quality (G/F/P/VP)	Cracking (%)		Ravelling (%)		Potholing (No. and % 100 m)**	Rut (None/Modereate/Severe)	Patching (No. and % 100 m)**	Pavement Edge Drop (cm)	Embankment Condition (Good/Fair/Poor)		Road Side Drain (NE/PF/F)****		Remarks
		L	R	L	R	Speed (Kmph)	G/F/P/VP	Length	Width	Length	Width	N0:		N0:		L	R	L NE/PF/F	R NE/PF/F	

Table : Yardstick of pavement condition

Sr. No.	Condition	Pot holes (%)	Cracking (%)	Patching (%)	Raveling (%)
1	Excellent	Nil	≤5	Nil	≤1.0
2	Good	≤5	> 5 ≤ 10	≤ 0.5	>1.0 ≤ 2.0
3	Fair	>5 ≤10	> 10 ≤ 20	> 0.5 ≤ 2.0	> 2.0 ≤ 5.0
4	Poor	>10	>20 ≤ 30	>2 ≤ 6.0	>5.0
		≤50			≤10.0
5	Very poor	>50	>30	>6.0	>10.0

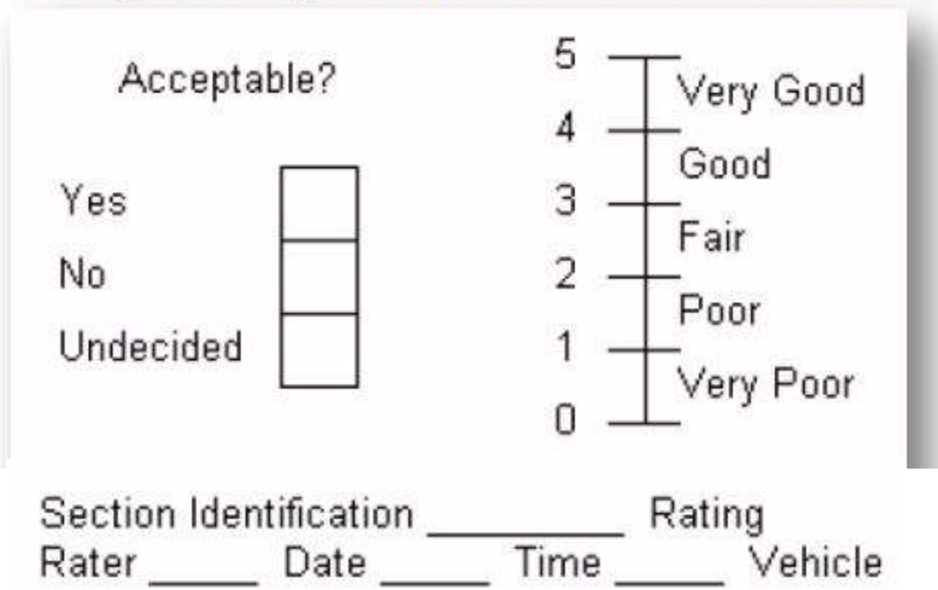
Summary	Length (km)	% of total length
Excellent	16	41.29
Good	9	23.22
Fair	5.25	13.54
Poor	2.75	7.09
Very Poor	5.75	14.83
Total	**38.75**	**100**

Pavement Roughness

- Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user).
- Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs.

Subjective measurement of Roughness

- Pavement Roughness can be measured subjectively or objectively.
- In subjective measurement, a set of road users can be asked to rate the riding quality on a 0-5 scale as shown below.



Subjective measurement of Roughness

- Present Serviceability Rating (as suggested by AASHTO on a scale of 0-5) can be worked out from these subjective ratings.

Objective Measurement of Roughness

- In the objective measurement, the roughness is indicated in terms of cumulative measure of vertical displacements as recorded by a *recording wheel* due to the unevenness in the longitudinal profile of the road.
- This *cumulative measure* of ups and downs in road profile is termed as *roughness index* or unevenness index and is normally represented in m/km or mm/km.

Roughness Measurement Equipment

Following are the methods/equipment that can be used for computing

Roughness index.

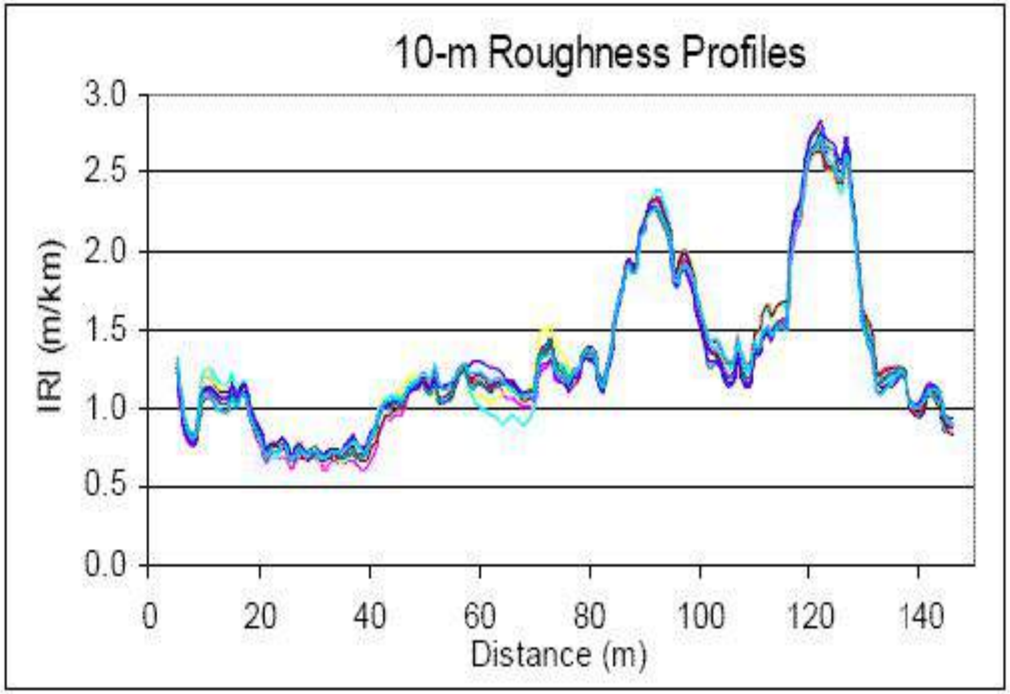
- **Rod and level survey:**
  - A survey can provide an accurate measurement of the pavement profile.
  - The use of surveys for large projects, however, is impractical and cost prohibitive.
- **Dipstick profiler:**

DIPSTICK

  - This instrument can record the pavement profile measurement very accurately.
  - The device records 10 to 15 readings per minute.
  - Software analysis provides a profile accurate to ± 0.127 mm. However,

    measurements by dipstic are time consuming and therefore, it is commonly used to measure a profile for calibration of more complex instruments.

Dipstick


10-m Roughness Profiles
IRI (m/km)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
120
140
Distance (m)

Roughness Measurement Equipment

- **Profilographs**
  - Profilographs have a sensing wheel, mounted to provide for free vertical movement at the center of the frame.
  - The deviation against a reference plane, established from the profilograph frame, is recorded on graph paper from the motion of the sensing wheel.
  - Profilographs can detect very slight surface deviations or undulations up to about 6 m in length. However, they are not practical for network condition surveys due to slow speed.

profilograph

Response type road roughness meters (RTRRMs)

- These instruments provide indirect measure of longitudinal road profile.
- The RTRRMs measure the relative movement between the body of the automobile and the centre of the rear axle.
- The RTRRM measurements are sensitive to the type of tyre, tyre pressure, load, vehicle suspension system, speed of vehicle, etc.
- Because of such sensitivity they need to be calibrated when any of the above factors change significantly.

RTRRMs

- The CRRI's fifth wheel bump integrator that is normally used in India also falls in this category.
- The advantage of these RTRRMs is that they can record the road roughness at speeds up to 80 km/hr.
- Since no to RTRRMs are exactly alike, it is necessary to convert the measures (unevenness index) to a standard common international scale.
- To provide a common quantitative basis on which the different measures of roughness can be compared, the **International**
  - To provide a common quantitative basis on which the different measures of roughness can be compared, the **International Roughness Index (IRI) was** developed by World Bank.

Bump Integrator

- The IRI summarises the longitudinal surface profile in the wheel path and is computed from surface elevation data collected by either topographic survey or a mechanical profilometer or a dipstick. IRI is reported in units of m/km.
- All the RTRRMs need to be calibrated by measuring the unevenness of a standard stretch for which IRI values are known.

Structural Evaluation

Deflection

- Pavement surface deflection measurements are the primary means of evaluating a flexible pavement structure.
- Although other measurements can be made that reflect (to some degree) a pavement's structural condition, surface deflection is an important pavement evaluation method because the magnitude and shape of pavement deflection is a function of traffic (type and volume), pavement structural section, temperature affecting the pavement structure and moisture affecting the pavement structure.

Deflection

- Deflection measurements can be used in backcalculation methods to determine pavement structural layer stiffness and the subgrade resilient modulus.
- Furthermore, pavement deflection measurements are non-destructive destructive in nature which adds on to the overall viability of usage.

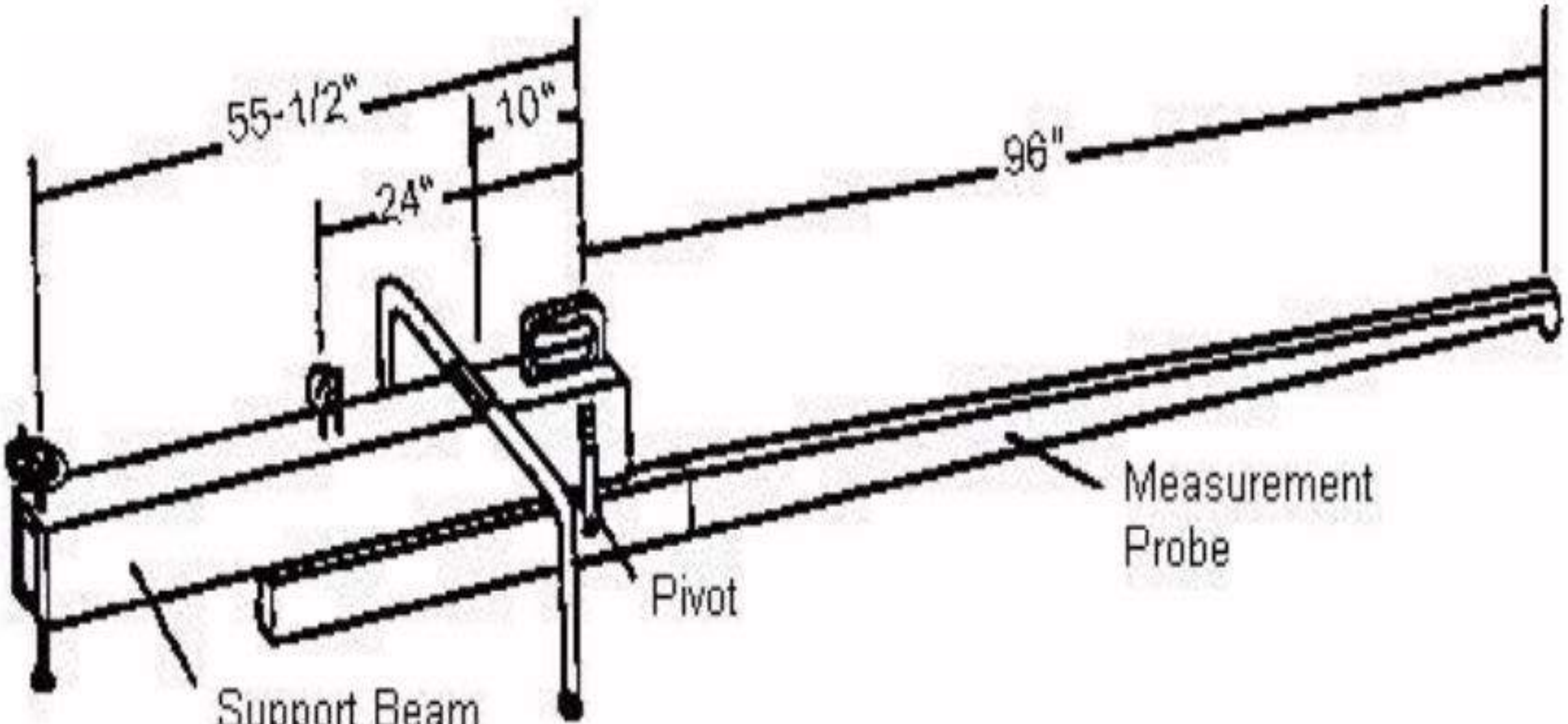
Measurement Technique

- The pavement surface deflections can be measured using either static deflection equipment or impact load deflection devices.
- Static deflection equipment measure pavement deflection in response to a static load.
- Benkelman Beam falls in this category.

Measurement Technique

- Impact load devices deliver a transient impulse load to the pavement surface.
- The subsequent pavement response (deflection basin) is measured by a series of sensors.
- The most common type of equipment is the falling weight deflectometer (FWD).

Benkleman Beam Deflectometer (Structural Evaluation)

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Benkelman Beam

- Benkelman Beam is a simple device that operates on the lever arm principle.
- The Benkelman Beam is used with a loaded truck - typically 80 kN on a single axle with dual tires inflated to 480 to 550 kPa.
- Measurement is made by placing the tip of the beam between the dual tires and measuring the pavement surface rebound as the truck is moved away.
- The Benkelman Beam is low cost but is also slow, labor intensive and does not provide a deflection basin.

Benkelman Beam

- The procedure of measuring rebound deflection and finding the characteristic deflection using Benkelman Beam is documented in the following standard.
  - IRC:81-1997 Guidelines for strengthening of flexible road pavements using Benkelman Beam deflection technique.
- Using the above standard one can design the overlays after arriving at the pavement characteristic rebound deflection.

Falling Weight Deflectometer (FWD)

- Falling Weight Deflectometer (FWD) is an impact load device that delivers a transient impulse load to the pavement surface and the resulting pavement response (deflection basin) is measured by a series of sensors (geophones).
- Vertical deflection of the pavement in multiple locations is recorded by the geophones, which provides a more complete characterization of pavement deflection.
- The area of pavement deflection under and near the load application is collectively known as the "deflection basin".

Falling Weight Deflectometer (FWD)

- One of the advantages of FWD is that multiple tests can be performed on the same location using different weight drop heights.
- The advantage of FWD over BB is that it is quicker, the impact load can be easily varied and it more accurately simulates the standard loading of trucks, both with respect to time of application of the load as well as the magnitude of the load.
- Therefore, using FWD deflection data one can characterize the existing pavement layers in terms of their layer modulii using backcalculation procedures with the help of mechanistic structural models.

Falling Weight Deflectometer (FWD)

- Once the pavement layers are characterised in terms of their present resilient modulii, overlays can be designed using mechanistic procedures.
- The characteristics of important equipment for the pavement performance evaluation is documented in "Guidelines for Maintenance Management of Primary, Secondary and Urban Roads," IRC, 2004.
- The same is provided in Table 12-A.1.

Table 12-A.1 Important Characteristics of Recommended Equipment for Data collection

Name of Equipment	Principal of Operation	Output	Operating Speed	Multiple Measurement	Merits	Limitations	Recommendations
Benkelman Beam	Elastic deflection under static load	Rebound deflection at single point under load	Crawling	NA	Simple, quick, cheap	Single point deflection	Can be used for routine overlay requirements for all categories of roads
Falling Weight Deflectometer	Elastic deflection under impulse load	Deflection basin	200-300 stations per day	NA	Easy to operate relatively fast, complete deflection profile is measured	Expensive	Recommended for use on primary / secondary road network
Loadman	Elastic deflection under impulse load	Single point deflection	80-100 stations per day	NA	Simple, portable	Single point deflection	Recommended on thin pavements with smooth surfaces subject to good correlations with already established methods
Automatic Road Analyser (ARAN)	Continued images one forward and two straight down	Video tapes	30-100 kmph	Distress (Crack rut depth) profile, roughness, gradients, curveture, etc	Covers about 600 km a day with good accuracy	Expensive, dry surface measurements, processing is manual	Recommended for use on primary / secondary road network with dry surface
Laser Road Surface Tester (LRST)	Measures slope profile in the time domain	Distress unevenness IRI long, profile	Upto 90 kmph	Distress rut depth, profile, macro texture	Suitable for all weather condition	Calibration needed daily for laser and accelerometer	Recommended for all categories of roads