PAVEMENT DESIGN

Subject code: **CE852PE**
Regulations: R16-JNTUH
Class: IV Year B. Tech CE II Sem

DEPARTMENT OF CIVIL ENGINEERING
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY
Ibrahimpatnam - 501 510, Hyderabad

PAVEMENT DESIGN (CE852PE)
COURSE PLANNER

I. COURSE OVERVIEW:

The aim of this course is to make the students understand the intricacies of the principles of pavement analysis and design. A pavement is a man-made structure built by laying different layers using different quality materials and gradations. Pavement is different from the other civil engineering structures generally constructed as it doesn't fail catastrophically. Also the pavement designed and constructed has to sustain for the design life irrespective of the environmental conditions it has to face during the period. The course introduces the necessity of performance criteria both for functional and structural performance. The primary topics include types of pavements constructed all over the world, the factors influencing the flexible and rigid pavements, characterization of materials used in each of the layers, design of flexible and rigid pavements using IRC and AASHTO methods, introducing the design concepts of prestressed and continuously reinforced concrete pavements, design of low volume roads, design and suitability of overlays for the existing pavements. By the end of this course the students will be in a position to design any type of pavement for a new construction and also for strengthening of the existing paverments.

II. PREREQUISITE(S):

Level	Credits	Periods	Prerequisite
UG	3	3	Transportation Engineering

III. COURSE OBJECTIVES:

The objectives of the course are to enable the student:

1. To understand thoroughly about the study factors affecting pavement design
2. To understand about the materials used for the pavement construction and their characterization techniques
3. To learn how to design flexible pavements (generally mentioned as black top – BT roads) for high volume roads
4. To learn the procedure to design rigid pavements – concrete pavements for high volume roads along with the introduction to prestressed concrete pavements and continuously reinforced concrete pavements (CRCP)
5. To learn how to design low volume roads having a traffic lower than 2 msa – both for rigid and flexible pavements

6. To learn how to design overlays as well as the evaluation techniques to receive inputs for the overlay design methods

IV. COURSE OUTCOMES:

At the end of this course, a student will be able to:

S.No	Course Outcome	Blooms Taxonomy Level
1	Characterize the response characteristics of soil, aggregate, asphalt, and asphalt mixes	**L2: Understanding**
2	Analyse flexible pavements	**L2: Understanding**
3	Analyse rigid pavements	**L2: Understanding**
4	Design a flexible pavement using IRC, Asphalt Institute, and AASHTO methods	**L3: Apply**
5	Design a rigid pavement using IRC, and AASHTO methods	**L3: Apply**
6	Design low volume roads both flexible and rigid pavements	**L3: Apply**
7	Design overlay for an existing pavement	**L3: Apply**

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Level	Proficiency assessed by
PO1	**Engineering knowledge**: To Apply the knowledge of mathematics, science, engineeringfundamentals/principals, and civil engineering to the solution of complex engineering problems encountered in modern engineering practice.	3	Assignments
PO2	**Problem analysis**: Ability to Identify, formulate, review research literature, and analyze complexengineering problems related to Civil Engineering andreaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.5	Exercise, Exams
PO3	**Design/development of solutions**: Design solutions for complex engineering problems related to Civil Engineering anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Exercise
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2.85	Discussion,Seminars

PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	Discussion, Seminars
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Civil Engineering professional engineering practice.	3	Discussions
PO7	**Environment and sustainability**: Understand the impact of the Civil Engineeringprofessional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	------
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.		------
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.	2.71	------
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.		------
PO11	**Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2.71	-----
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.	2.71	Prototype,Discussions

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program outcomes		**Level**	**Proficiency assessed by**
PSO 1	**ENGINEERING KNOWLEDGE:**Graduates will be able to apply technical knowledge in drawing, analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good basics in mathematics, basic sciences and technical communication.	3	Lectures and Assignments
PSO 2	**BROADNESS AND DIVERSITY:**Graduates will be able to summarize and can demonstrate about societal,	2.43	Tutorials

	economical, environmental, health and safety factors involved in infrastructural development, and shall work within multidisciplinary teams with competence in modern tool usage.		
PSO 3	**SELF-LEARNING AND SERVICE:**Graduates will be able to pursue lifelong learning and professional development to face the challenging and emerging needs of our society, ethically and responsibly.	1.86	Seminars and Projects

N - None **S - Supportive** **H – Highly Related**

VII. SYLLABUS:

UNIT – I

Factors Affecting Pavement Design: Variables Considered in Pavement Design, Types of Pavements, Functions of Individual Layers, Classification of Axle Types of Rigid Chassis and Articulated Commercial Vehicles, Legal Axle and Gross Weights on Single and Multiple Units, Tire Pressure, Contact Pressure, EAL and ESWL Concepts, Traffic Analysis: ADT, AADT, Truck Factor, Growth Factor, Lane, Directional Distributions & Vehicle Damage Factors, Effect of Transient & Moving Loads.

UNIT – II

Stresses In Pavements: Vehicle-Pavement Interaction: Transient, Random & Damping Vibrations, Steady State of Vibration, Experiments on Vibration, Stress Inducing Factors in Flexible and Rigid pavements.

Stresses in Flexible Pavements: Visco-Elastic Theory and Assumptions, Layered Systems Concepts, Stress Solutions for One, Two and Three Layered Systems, Fundamental Design Concepts.

Stresses in Rigid Pavements: Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, Stresses in Dowel Bars & Tie Bars

UNIT – III

Material Characteristics: CBR and Modulus of Subgrade Reaction of Soil, Mineral aggregates – Blending of aggregates, binders, polymer and rubber modified bitumen, Resilient, Diametral Resilient and Complex (Dynamic) Moduli of Bituminous Mixes, Permanent Deformation Parameters and other Properties, Effects and Methods of Stabilization and Use of Geo Synthetics.

UNIT - IV

Design of Flexible Pavements: Flexible Pavement Design Concepts, Asphalt Institute's Methods with HMA and other Base Combinations, AASHTO, IRC Methods **Design Of Rigid Pavements**: Calibrated Mechanistic Design Process, PCA, AASHTO & IRC Specifications, and Introduction to Prestressed and Continuously Reinforced Cement Concrete Pavement Design

UNIT – V

Design of Pavement for Low Volume Roads: Pavement design for low volume roads, rural road designs – code of practice. **Design of Overlays**: Types of Overlays, Suitability, Design of overlays.

SUGGESTED BOOKS:

TEXT BOOKS:

1. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers
2. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc

REFERENCES:

1. Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications
2. Principles of Pavement Design, Yoder.J. &Witzorac Mathew, W. John Wiley & Sons Inc
3. Pavement and Surfacings for Highway & Airports, MichealSargious, Applied Science Publishers Limited.
4. IRC Codes for Flexible and Rigid Pavements design

MOOC'S- SWAYAM/ NPTEL:

https://nptel.ac.in/courses/105101087/

https://nptel.ac.in/content/storage2/courses/105101087/downloads/Lec-19.pdf

GATE SYLLABUS:

Highway Pavements: Highway materials - desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement using IRC: 37-2012; Design of rigid pavements using IRC: 58-2011; Distresses in concrete pavements

IES SYLLABUS:

Highways - Principles of flexible and rigid pavement design

VIII. COURSE PLAN:

Lecture No.	Week	Unit	Topics to be covered	Learning Objective	Teaching Methodology	References
1.	1	1 1 1	**UNIT-I:** Historic development of pavements and introduction to pavement design	To **understand** thoroughly about the study factors affecting	Chalk and Talk	T2,R2

				pavement design		
2.	2	1 1 1 1	Variables Considered in Pavement Design, Types of Pavements	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1,R2
3.	3	1 1 1	Functions of Individual Layers, Classification of Axle Types of Rigid Chassis and Articulated Commercial Vehicles	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1
4.		1 1	PreLegal Axle and Gross Weights on Single and Multiple Units, Tire Pressure, Contact Pressure	To **understand** how pre-stressing force is imparted to structural elements by different methods and devices.	Chalk and Talk	T2,R1,R2
5.	4	1 1 1	EAL and ESWL Concepts, Traffic Analysis: ADT, AADT, Truck Factor, Growth Factor, Lane, Directional Distributions & Vehicle Damage Factors, Effect of Transient & Moving Loads	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1
6.	5	2 2 2	**UNIT-II:**Stresses In Pavements: Vehicle-Pavement Interaction: Transient, Random & Damping Vibrations, Steady State of Vibration, Experiments on Vibration,	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1
7.	6	2 2 2	Stress Inducing Factors in Flexible and Rigid pavements. Stresses In Flexible Pavements: Visco-Elastic Theory and Assumptions, Layered Systems Concepts,	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1,R2
8.		2	Stress Solutions for One,		Chalk and	T2,R1,R2

		2	Two and Three Layered Systems, Fundamental Design Concepts.	To **understand** how pre-stressing force is imparted to structural elements by different methods and devices.	Talk	
9.	7	2 2	Stresses In Rigid Pavements: Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, Stresses in Dowel Bars & Tie Bars	To **understand** thoroughly about the study factors affecting pavement design	Chalk and Talk	T2,R1
10.		3 3	**UNIT – III** Material Characteristics: CBR and Modulus of Subgrade Reaction of Soil, Mineral aggregates – Blending of aggregates	To **understand** about the materials used for the pavement construction and their characterization techniques	Chalk and Talk	T2,R1
11.		3	Binders, polymer and rubber modified bitumen	To **understand** about the materials used for the pavement construction and their characterization techniques	Chalk and Talk	T2,R1,R2
12.	8	3 3	Resilient, Diametral Resilient and Complex (Dynamic) Moduli of Bituminous Mixes	To **understand** about the materials used for the pavement construction and their characterization techniques	Chalk and Talk	T2,R1,R2
13.		3 3	Permanent Deformation Parameters and other Properties	To **understand** about the materials used for the pavement construction and	Chalk and Talk	T2,R1

				their characterization techniques		
14.	9	3	Effects and Methods of Stabilization and Use of Geo Synthetics.	To **understand** about the materials used for the pavement construction and their characterization techniques	Chalk and Talk	T2,R1,R2
15.	9	4	**UNIT - IV** Design Of Flexible Pavements: Flexible Pavement Design Concepts,	To **learn** how to design flexible pavements (generally mentioned as black top – BT roads) for high volume roads	Chalk and Talk	T2,R1
16.		4	Asphalt Institute's Methods with HMA and other Base Combinations, AASHTO	To **learn** how to design flexible pavements (generally mentioned as black top – BT roads) for high volume roads	Chalk and Talk	T2,R1
17.		4	IRC Methods for flexible pavement design	To **learn** how to design flexible pavements (generally mentioned as black top – BT roads) for high volume roads	Chalk and Talk	T2,R1,R2
	10	4				
18.	10	4	Design Of Rigid Pavements: Calibrated Mechanistic Design Process, PCA, AASHTO & IRC Specifications	To **learn** the procedure to design rigid pavements – concrete pavements for high volume roads along with	Chalk and Talk	T2,R1
	10	4				

				the introduction to prestressed concrete pavements and continuously reinforced concrete pavements (CRCP)		
19.	10 11 11	4 4 4	Introduction to Prestressed and Continuously Reinforced Cement Concrete Pavement Design.	To **learn** the procedure to design rigid pavements – concrete pavements for high volume roads along with the introduction to prestressed concrete pavements and continuously reinforced concrete pavements (CRCP)	Chalk and Talk	T2,R1,R2
20.	11 11 12	5 5 5	**UNIT – V** Design of Pavement for Low Volume Roads	To **learn** how to design low volume roads having a traffic lower than 2 msa – both for rigid and flexible pavements	Chalk and Talk	T2,R1,R2
21.	12 12 12	5 5 5	Pavement design for low volume roads	To **learn** how to design low volume roads having a traffic lower than 2 msa – both for rigid and flexible pavements	Chalk and Talk	T2,R1
22.	13 13 13 13	5 5 5 5	Rural road designs – code of practice.	To **learn** how to design low volume roads having a traffic	Chalk and Talk	T2,R1

				lower than 2 msa – both for rigid and flexible pavements		
23.	14 14 14	5 5 5	Design of Overlays: Types of Overlays	To **learn** how to design overlays as well as the evaluation techniques to receive inputs for the overlay design methods	Chalk and Talk	T2,R1
24.	14 15 15	5 5 5	Suitability of overlays for different pavements	To **learn** how to design overlays as well as the evaluation techniques to receive inputs for the overlay design methods	Chalk and Talk	T2,R1,R2
25.	15 15	5 5	Design of overlays	To **learn** how to design overlays as well as the evaluation techniques to receive inputs for the overlay design methods	Chalk and Talk	T2,R1,R2
26.	16 16	5 5	REVISION			
27.	16	5	REVISION			
28.	16	5	REVISION			
	Extra topics beyond syllabus					
1			Calculation of stresses in flexible pavement using Odemark's method			
2			Functional evaluation of pavements			
3			Structural evaluation of pavements			
4			General construction practices of the pavements			

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Objectives						**Program Outcomes**					**Program Specific Outcomes**				
CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**

I	**3**	**-**	**3**	**2**	**3**	**3**	**3**	**-**	**3**	**-**	**3**	**3**	**3**	**2**	**2**
II	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**2**	**-**	**3**	**3**	**3**	**2**	**1**
III	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**3**	**-**	**3**	**2**	**3**	**2**	**2**
IV	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**3**	**-**	**2**	**2**	**3**	**2**	**1**
V	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**3**		**2**	**3**	**3**	**3**	**2**
VI	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**3**		**3**	**3**	**3**	**3**	**3**
VII	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**2**		**3**	**3**	**3**	**3**	**2**
AVG	**3**	**2.5**	**3**	**2.85**	**3**	**3**	**3**	**-**	**2.71**	**-**	**2.71**	**2.71**	**3**	**2.43**	**1.86**

Small(S)-1 **Medium(M)-2** **High(H)-3**

X. QUESTION BANK:

DESCRIPTIVE QUESTIONS: (WITH BLOOMS PHRASES)

UNIT-I

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Name different kinds of pavements constructed all over the world.	Remember	1
2.	Define vehicle damage factor	Remember	1
3.	Define lane distribution factor	Remember	1
4.	What is meant by a commercial vehicle? Explain	Understand	1
5.	What is the difference between vehicle with rigid chasis and articulated commercial vehicle?	Remember	1
6.	What are the legal axle loads for different axle types?	Remember	1
7.	Define tire pressure	Remember	1
8.	Define contact pressure	Remember	1
9.	Define ADT	Remember	1
10.	Define AADT	Understand	1
11.	What is meant by growth factor? Why is it used in the calculation of design traffic?	Remember	1
12.	What is the effect of transient and moving loads on the pavement?	Remember	1
13.	What are the different shapes of contact areas of a tyre used in the pavement design?	Remember	1

LONG ANSWER QUESTIONS-

S.No	Question	Blooms	Program

		Taxonomy Level	meOut come
1.	Explain different factors affecting pavement design?	Understand	1
2.	Draw neat sketches of different types of pavements?	Understand	1
3.	Explain the calculation procedure for vehicle damage factor?	Remember	1
4.	Write about the classification of vehicles with rigid chasis and articulated commercial vehicles.	Remember	2
5.	Brief about the function of each of the layers used in rigid as well as flexible pavements.	Remember	2
6.	Write down the formulae to calculate design traffic for a pavement. Explain each of the terms used in the formulae and their calculations.	Remember	5
7.	What are the lane distribution factors used for pavements having single carriage way and dual carriageway (single lane, two lane, three lane and four lane roads)	Understand	5
8.	Calculate the vehicle damage factor for a given axle load spectrum.	Understand	5

UNIT-2

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	What is meant by curling stress?	Remember	2
2.	What are the critical locations for wheel load stresses?	Remember	2
3.	Define elastic layered theory.	Remember	2
4.	Define frictional stresses.	Remember	2
5.	What is meant by visco-elastic nature of a material	Understand	4
6.	What are the assumptions of Westergaard's theory?	Remember	2
7.	What are the assumptions of visco-elastic theory?	Understand	2
8.	What are the assumptions of linear elastic layered theory?	Understand	2
9.	What are the different factors that induce stresses in flexible pavement?	Understand	2
10.	What are the different factors that induce stresses in rigid pavement?	Understand	2
11.	What is meant by vibrational loading?	Remember	2
12.	What is meant by transient loading?	Understand	2
13.	What are the different stresses induced in dowel bars?	Remember	2
14.	What are the different stresses induced in tie bars?	Understand	2
15.	What is the purpose of dowel bars in the concrete pavement?	Understand	2

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms	Programme

		Taxonomy Level	Out come
1.	What are different factors influencing flexible pavement?	Understand	8
2.	What are different factors influencing rigid pavement?	Understand	8
3.	Calculate the stresses and strains at a depth of 100 mm and radius of 0 mm for a single layered pavement. Poisson's ratio of the material is 0.5, take p and a as standard values. Modulus of the layer is 100 MPa	Remember	8
4.	Calculate the stresses and strains at a depth of 0 mm and radius of 0 mm for a single layered pavement. Poisson's ratio of the material is 0.35, take p and a as standard values. Modulus of the layer is 70 MPa	Understand	8
5.	Calculate the stresses and strains at a depth of 100 mm and radius of 0 mm for a two layered pavement structure. Thickness of the first layer is 100 mm. Poisson's ratio of the material is 0.5, take p and a as standard values. Modulus of the first layer is 450 MPa and modulus of the second layer is 100 MPa	Understand	8
6.	Calculate the stresses and strains at a depth of 0 mm and radius of 0 mm for a single layered pavement. Poisson's ratio of the material is 0.5, take p and a as standard values. Modulus of the first layer is 350 MPa and modulus of the second layer is 70 MPa	Understand	8
7.	Calculate the stresses and strains at a depth of 100 mm and radius of 0 mm for a three layered pavement structure. Thickness of the first layer is 100 mm and second layer is 350 mm. Poisson's ratio of the materials is 0.5, take p and a as standard values. Modulus of the first layer is 3000 MPa, modulus of the second layer is 250 MPa and modulus of the third layer is 50 MPa	Understand	8
8.	Calculate the stresses and strains at a depth of 0 mm and radius of 0 mm for a three layered pavement structure. Thickness of the first layer is 120 mm and second layer is 370 mm. Poisson's ratio of the materials is 0.5, take p and a as standard values. Modulus of the first layer is 2500 MPa, modulus of the second layer is 200 MPa and modulus of the third layer is 100 MPa	Understand	8
9.	What are the assumptions of Westergard's theory? Detail about the stresses in the rigid pavement according to Westergaard's theory.	Remember	8
10.	What is the purpose of dowel and tie bars? Brief about the stresses induced in dowel bars and tie bars.	Understand	5
11.	Calculate the stresses by Westergaard's theory at the edge and center of the slab. Wheel load = 4400 kg, Modulus of Elasticity of concrete = $2x10^5 kg/cm^2$. PQC thickness = 25 cm, Poisson's ratio = 0.15, modulus of	Understand	8

	subgrade reaction = 5 kg/cm^2, radius of contact area = 20 cm		
12.	Calculate the stresses by Westergaard's theory at the edge and corner of the slab. Wheel load = 4800 kg, Modulus of Elasticity of concrete = 3x10^5 kg/cm^2. PQC thickness = 22 cm, Poisson's ratio = 0.15, modulus of subgrade reaction = 8 kg/cm^2, radius of contact area = 20 cm	Remember	8

UNIT-3

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	What is meant by CBR of a soil?	Remember	5
2.	What is the property used to grade polymer modified binders as per IS 15462?	Understand	5
3.	What is the property used to grade crumb rubber modified binders as per IS 15462?	Remember	5
4.	What are the different grades of VG grade binders used for flexible pavement construction?	Remember	5
5.	What is meant by modulus of subgrade reaction?	Remember	5
6.	What are the types of gradations used for road construction?	Understand	5
7.	What is the purpose of blending of aggregates in preparing aggregate gradation?	Remember	5
8.	Define resilient modulus of bituminous mixture?	Understand	5
9.	Define dynamic modulus of bituminous mixtures?	Understand	5
10.	What are the different distresses in a flexible pavement?	Remember	6
11.	What are the different methods of stabilization adopted to stabilize granular layers?	Remember	7
12.	What is the purpose of geosynthetics in pavement applications?	Remember	5
13.	What are the different tests used to evaluate permanent deformation resistance?	Remember	5
14.	What is meant by moisture damage of a bituminous mixture?	Understand	5

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Outcome
1.	Explain the procedure of CBR tests in detail.	Remember	5
2.	Explain the procedure for the determination of modulus of subgrade reaction of soil.	Understand	6
3.	What are the different gradations used for pavement	Understand	6

	construction? Explain the characteristics of each of these gradations with neat sketches.		
4.	Explain the process of blending of aggregates when a sample gradation is given. Arrive at the proportion of each of the bins.	Understand	6
5.	What are the required properties of aggregates for the usage of surface course mixes? Explain the significance of each of those properties.	Understand	6
6.	What is meant by rutting of a bituminous pavement? Explain the procedure of wheel tracking test and significance of it.	Understand	6
7.	What is meant by fatigue cracking of a bituminous pavement? Explain the procedure of beam fatigue test to evaluate the fatigue resistance of the mixes and significance of it.	Understand	6
8.	What is meant by moisture damage of a bituminous pavement? Explain the procedure of tensile strength ratio to evaluate the moisture resistance of the mixes and significance of it.	Understand	6
9.	Explain the lime stabilization and flyash stabilization. Explain the process which is responsible to increase the strength of the soil material.	Understand	9

UNIT-4

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	What is meant by effective CBR?	Understand	6
2.	What is meant by modulus of subgrade reaction?	Understand	5
3.	Major difference between IRC and AASHTO methods of flexible pavement design?	Remember	7
4.	What are the salient features of IRC 37-2012?	Understand	7
5.	What are the different base combinations that can be used for flexible pavements?	Understand	7
6.	What are parameters used in AASHTO flexible pavement design for functional performance of the pavement?	Understand	8
7.	For what all reliability levels a pavement can be designed using AASHTO method?	Understand	7
8.	For what all reliability levels a pavement can be designed using IRC method for flexible pavements?	Understand	8
9.	What is the analysis method used in IRC 58-2011?	Understand	7
10.	What is the critical combination of stresses/ strains for bottom up cracking in a rigid pavement?	Understand	7

11.	What is the critical combination of stresses/ strains for top down cracking in a rigid pavement?	Remember	9
12.	What are the different performance criteria available in IRC 37?	Remember	9
13.	What is the recommendation given in IRC-37 for rut resistance of bituminous mixes?	Understand	9
14.	What is the recommendation given in IRC-37 for top down cracking resistance of bituminous mixes?	Remember	9

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	What are different types of pavement compositions that are allowed according to IRC 37-2012? Draw neat sketches of these different pavement compositions	Understand	8
2.	What are different stresses that are caused in a rigid pavement? Describe each of these stresses in terms of the reasons behind these stresses along with neat sketches	Understand	8
3.	What are the different performance criteria used in IRC 37-2012 for design of flexible pavement? What are two levels of reliability used for these performance criteria?	Understand	8
4.	Design a flexible pavement as per IRC 37-2012 for a CBR of subgrade 5 % and design traffic of 20 msa. Assume poisson's ratio of materials to be 0.35	Understand	7
5.	Design a flexible pavement as per IRC 37-2012 for a CBR of subgrade 10 % and design traffic of 50 msa. The pavement composition chosen should consist of subgrade, CTSB, GSB and bituminous layers.	Understand	8
6.	Design a flexible pavement as per AASHTO 1993 for a CBR of subgrade 5 % and design traffic of 20 msa. Assume poisson's ratio of materials to be 0.35	Understand	9
7.	Explain the procedure to design a rigid pavement (unbonded – plastic sheet is placed between DLC and PQC) using IRC 58-2011.	Understand	9
8.	Explain the procedure to design a rigid pavement (bonded – plastic there is no plastic sheet used between DLC and PQC) using IRC 58-2011.	Understand	9
9.	Design a rigid pavement as per AASHTO 1993 for a k value of subgrade 100 pci and design traffic of 40 msa. Assume values for any of the inputs not mentioned in the question.	Understand	9
10.	Explain the procedure for design of prestressed concrete pavement.	Understand	8
11.	Explain the procedure for design of continuously reinforced concrete pavement.	Understand	9

UNIT-5

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	ProgrammeOut come
1.	What are the different kind of overlay combinations available for an existing rigid pavement?	Remember	10
2.	What are the different kind of overlay combinations available for an existing flexible pavement?	Remember	10
3.	For what level of design traffic a pavement will be considered as low volume road?	Remember	10
4.	Draw the shape of the tyre imprint used along with dimensions for design of rigid pavements for low volume roads?	Understand	10
5.	What is the pavement combination recommended for low volume rigid pavement with a commercial vehicle count upto 50 per day?	Remember	10
6.	Into how many number of zones the temperature differentials in India are divided?	Understand	10
7.	How is subgrade strength assessed for a low volume flexible pavement?	Remember	10
8.	What are the different corrections done for the deflections measured using BBD?	Remember	10
9.	What is the major difference between FWD and BBD measured deflections?	Remember	10

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Describe the overview of overlay design using IRC 81 – 1997 for a flexible pavement	Understand	10
2.	Explain the procedure to design a low volume flexible pavement for 1 msa design traffic and 5 % subgrade CBR	Understand	10
3.	Explain the procedure to design a low volume rigid pavement for 1 msa design traffic and 5 % subgrade CBR	Remember	10
4.	Explain the overlay design process for a flexible pavement using IRC 115-2014	Understand	9
5.	Explain the overlay design process for a rigid pavement using IRC 117-2015	Understand	9
6.	Explain the process to arrive characteristics deflection from the measured deflections using BBD.	Understand	10

OBJECTIVE QUESTIONS:

UNIT-1

1. _____ and _____ are the factors affecting rigid pavements
2. _____ and _____ are the major factors affecting flexible pavements

3. _____ is the standard axle load considered in the pavement design for single axle dual wheel
4. _____ is the vehicle damage factor considered in IRC 37-2012
5. _____ is the standard tire pressure used for flexible pavement design in India
6. _____ is the standard tire pressure used for rigid pavement design in India
7. _____ is the function of granular sub base in a pavement
8. _____ is the function of granular base in a pavement
9. _____ is the function of wearing course in a pavement
10. EAL stands for_____

UNIT-2

1. The stresses in dowel bars are induced due to _____
2. The stresses in tie bars are induced due to _____
3. _____ is the critical location for wheel load stresses in a rigid pavement
4. _____ is the critical location for stresses induced due to daily temperature variations in a rigid pavement
5. _____ is the critical location for frictional stresses in rigid pavement
6. Top down cracking in the rigid pavement is caused due to application of wheel load on the slab during _____ time (day /night)
7. Bottom up cracking in the rigid pavement is caused due to application of wheel load on the slab during _____ time (day /night)
8. _____ has given the solutions for analysis of stresses caused in a flexible pavement
9. _____ has given the solutions for analysis of stresses caused in a rigid pavement

UNIT-3

1. Full form of CBR is _____
2. Modulus of subgrade reaction is obtained from _____ test
3. VG 30 binder is used for a design traffic less than _____ msa
4. _____ is the parameter used to grade PMB binders
5. _____ is the parameter used to grade CRMB binders
6. _____ is the parameter used to grade VG unmodified binders
7. Resilient modulus is the ratio of stress applied to _____ strain
8. Dynamic modulus is the ratio of stress applied to _____ strain
9. _____ test is used to determine permanent deformation resistance of bituminous mixes
10. _____ test is used to determine moisture resistance of bituminous mixes

UNIT -4

1. The surface dressing over an existing worn out flexible pavement is known as

   a) Prime Coat b) seal coat c) tack coat d) overlay
2. Present serviceability index is rated in a scale of

   a) 0 to 5 b) 5 to 10 c) 0 to 10 d) 0 to 100
3. Cause for functional failure and structural failure

   a) Overload b) Climatic condition c) Disintegration of pavement material d) All of these
4. The essential differences between the two types of pavements - flexible and rigid
   a)Rigidity b)Flexibility c)Load carrying Capacity d)The manner of distribution of load over the sub-grade

5. Deformation in the sub-grade is transferred to the upper layers in

   a) Flexible pavement b) Rigid pavement c) Both of these d) None of these
6. Sub-grade deformation is not transferred to the upper layer in

   a) Flexible pavement b) Rigid pavement c) Both of these d) None of these
7. Compared to flexible pavements, rigid pavements have

   a) More life span b) Less life span c) Equal life span d) Double life span
8. Load is transferred by grain to grain to contact in
   a) Flexible pavement b) Rigid pavement c) Both of these d) None of these
9. Surfacing can be directly laid on the sub-grade in case of which pavement
   a) Flexible pavement b) Rigid pavement c) Both of these d) None of these
10. Which of the pavement have high flexural strength

    a) Flexible pavement b) Rigid pavement c) Both of these d) None of these
11. Curling stresses in a rigid pavement are caused due to [ ]
    a. Temperature b. cement content c. moisture d. all
12. _____ location is critical for the wheel load stresses applied on a rigid pavement.

UNIT -5

1. What are the corrections that have to be applied for the deflection determined using BBD [ ]
   a. Moisture correction b. temperature correction c. both a and b d. none
2. Which is not a layer of flexible pavement [ ]
   a. Bituminous layers b. pavement quality concrete c. granular base d. granular sub base
3. What is the purpose of pavement design [ ]
   a. To establish layer thickness of each of the layers b. traffic management c. to provide parking facility d. to provide traffic signals
4. _____ layer is the top most layer of a flexible pavement
5. _____ is measured using BBD for an overlay design
6. _____ is the standard temperature at which deflections have to be measured in order to design an overlay using IRC 81-1997
7. Low volume roads are the pavements designed for a design traffic volume less than _____ msa

XI. GATE QUESTIONS:

1. Which layer of pavement should withstand stress?
   a) Surfaceb) Sub gradec) Sub based) Base
2. The surface of bitumen should be
   a) Smoothb) Roughc) Sufficient enough to resist frictiond) Very smooth
3. The DBM mix is used in
   a) Local streetsb) Rural roadsc) Highwayd) Concrete bridges

4. The filler material should pass from
   a) 0.075mmb) 0.75mmc) 7.5mmd) 75mm
5. The cement on touching should give
   a) Cool feelingb) Hot feelingc) neutrald) Very cool feeling
6. Cement specific gravity is measured by
   a) Waterb) Kerosenec) Oild) Petrol
7. The waste material mostly used in pavement is
   a) Fly ashb) GGBSc) Rice huskd) Soil
8. The specific gravity of cement is
   a) 2.5b) 1.44c) 3.15d) 30
9. Bleeding may be avoided by
   a) Water voidsb) Air voidsc) Porosityd) Water content
10. Maximum size of aggregate in surface course is
    a) 18.5mmb) 19.5mmc) 20.5mmd) 21.5mm

IES QUESTIONS:

1. The specific gravity of bitumen lies between
   a) 0.8& 0.9b) 0.95& 0.97c) 0.97&1.02d) 1.02&1.05
2. The specified method for bitumen mix in India is
   a) Hveemb) Marshalls methodc) Hubbard methodd) Super paver mix method
3. The temperature in Marshall's method is
   a) 25b) 30c) 35d) 60
4. The number of blows in Marshalls test specimen is
   a) 25b) 30c) 55d) 75
5. Marshall stability determines
   a) Ductilityb) Flexibilityc) Utilityd) Grade of bitumen
6. Rutting may be avoided by
   a) Good compactionb) Good aggregatec) Good fillerd) Good workmanship
7. One meter cube of cement consists of how many bags of cement?
   a) 30b) 50c) 15d) 10
8. The initial setting time of cement is not less than
   a) 30 secondsb) 300 secondsc) 30 minutesd) 300 minutes
9. Bitumen is obtained from
   a) Woodb) Petroleumc) Coald) Kerosene
10. Tar is not used now because of
    a) Costb) Efficiencyc) Harmful effectsd) Not satisfactory

XII. WEBSITES:

a) https://www.slideshare.net/husna004/pavement-design-42831939
b) https://en.wikipedia.org/wiki/Pavement_engineering

XIII.EXPERT DETAILS:

1. Prof. Kusam Sudhakar Reddy
   Department of Civil Engineering
   Indian Institute of TechnologyKharagpur
   Kharagpur - 721302
2. Prof. Muppireddy Amaranatha Reddy

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XIV. JOURNALS:(NATIONAL & INTERNATIONAL)

1. Road Materials and Pavement Design
2. International Journal of Pavement Engineering
3. Journal of Materials in Civil Engineering
4. Construction and Building Materials
5. Materials and Structures
6. International Journal of Pavement Research Technology

XV. LIST OF TOPICS FOR STUDENT SEMINARS:

1. AASHO road test and the outcomes of the AASHO road test
2. WASHO road test and the outcomes of the WASHO road test
3. Development of falling weight deflectometer
4. Recent advances in bitumen characterization
5. Recent advances to characterize permanent deformation resistance of bituminous mixes
6. Recent advances to characterize bituminous mixes for fatigue cracking resistance
7. Recent advances to characterize bituminous mixes for moisture damage resistance

XVI. CASE STUDIES / SMALL PROJECTS:

1. Case study on flexible pavement design -problems during the design stage and the solutions adopted
2. Case study on rigid pavement design – problems during the design stage and the solutions adopted
3. Case study on continuously reinforced concrete pavements
4. Case study on overlay designs done for concrete pavements in India