GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Civil Engineering
Subject Code: BE05006061
Subject Name: Pavement Design and Construction

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	Transportation Engineering
Rationale:	The course is essential for developing the knowledge and skills required in planning, designing, constructing, and maintaining road infrastructure. It enables students to design appropriate pavements by providing fundamental principles and methods to ensure safety, durability, and economy based on traffic load, soil conditions, and environmental factors. The course also helps in understanding the construction procedures of roads through step-by-step practices, including material selection, use of equipment, and quality control measures for effective construction. Furthermore, it provides knowledge about the maintenance of roads by identifying different types of pavement failures and applying suitable maintenance and rehabilitation techniques to extend the service life of roads. In addition, the course introduces new and modern techniques in road construction, including innovative materials and advanced methods used in present-day engineering practices.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	To classify different types of pavements based on their structural and functional characteristics.	5
CO-2	To evaluate soil, aggregate, and bituminous materials for pavement applications as per IRC standards.	20
CO-3	To design flexible and rigid pavements using relevant IRC guidelines and standard design procedures.	30
CO-4	To apply and supervise the construction practices of flexible and rigid pavements in accordance with standard specifications (IRC/MoRTH)	25
CO-5	To assess pavement distresses and recommend appropriate maintenance and overlay strategies for flexible and rigid pavements as per relevant IRC guidelines.	20

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA (M)	PA (I)	TW/SL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Definition of pavement, types of pavements based on their structural and functional characteristics, comparison of flexible and rigid pavements, functions of the various layers of flexible and rigid pavements.	1
2	**Pavement Materials and Characterization:** **Soil:** Characterization for earthwork and subgrade, effective CBR, concept of resilient modulus of subgrade, classification of soils, problems related to soil. **Aggregate:** Granular sub-base and base layers; road aggregates used for WBM and WMM, aggregates used in bituminous layers and their characteristics, gradation (Fuller's equation), physical property requirements for rural roads and high-volume roads, concept of resilient modulus of sub-base and base courses as per IRC 37, use of locally available materials and quality control criteria. Use of alternative/waste materials – Fly ash, Blast Furnace Slag, and recycled aggregates. **Bituminous material:** Bitumen, emulsions, modified bitumen, bituminous mixes—volumetrics, concept of resilient modulus as per IRC 37, quality control and quality assurance plan for highways.	6
3	**Design of Highway Pavement:** **Flexible Pavement:** Factors affecting pavement design; ESWL, EWLF, and VDF, stress analysis—Boussinesq's theory and Burmister's two- and three-layer theories, flexible pavement design based on performance criteria, including subgrade rutting and fatigue cracking in bituminous layers, Pavement design using IITPAVE software for granular base and granular subbase, cementitious base, cementitious subbase. Overview of pavement design for low-volume roads using locally available materials as per IRC SP-72, drainage considerations in pavement design. **Rigid Pavement:** Design factors, Westergaard's stress analysis including load stress and temperature stress, design based on the fatigue behaviour of concrete, IRC 58 design method—fatigue concept (using IIT RIGID), design of joints, Friberg's analysis for dowel bar design, design of the tie bars, overview of pavement design for low-volume roads as per IRC SP-62.	20
4	**Construction of Pavement:** **Flexible pavement:** Soil stabilization, construction procedures for embankment, subgrade, sub-base (granular sub-base), drainage layer, and filter/separation layer, base courses—WBM, WMM, lime-stabilized, and cement-stabilized (granular layers),	10

	bituminous mixes—binder course and wearing course, including their selection, gradation, compaction, and density requirements, selection of different bituminous mix treatments based on functional and structural requirements, construction procedures as per MoRTH specifications. **Rigid pavement:** Earthwork, granular sub-base; drainage layer, dry lean concrete as per IRC 49, pavement quality concrete construction requirements as per IRC 15, IRC 58, and MoRTH, importance of joints and their provision, interlocking concrete block pavement (ICBP)—procedure for laying, requirements, block patterns, and strength requirements as per IRC SP 63.	
5	**Maintenance of pavement:** **Flexible pavement:** Failures of flexible and rigid pavements, IRC 82, need for maintenance—types, planning, and system approach, types of defects, including symptoms, location, causes, severity levels, and treatment, preventive and periodic renewals, including their warrants and treatments. **Rigid pavement:** Maintenance and its methodology as per IRC SP 83, types of overlays, design of overlays. **Introduction to New Technology:** Recycled aggregate pavement as per IRC:120 (RAP), Cold In-Place (CIP), Hot In-Place (HIP), Plant mix technology, Methodology of construction, Cold mix technology as per IRC SP:100, White topping – Conventional, Ultra-thin white topping as per IRC SP-76, Stone Matrix Asphalt as per IRC SP-79, Warm mix asphalt as per IRC SP 101, Micro surfacing, Slurry seal as per IRC SP-81.	**8**
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	**20%**	**20%**	**20%**	**20%**	**10%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The course contributes to the following SDGs:

SDG 9	Understanding pavement types supports sustainable infrastructure planning and development.

SDG 11	Promotes durable construction for safe, long-lasting roads, enhancing urban livability and sustainable communities.
SDG 12	Supports resource efficiency and responsible consumption through material evaluation and use of alternative and recycled materials.
SDG 13	Advances sustainable pavement design using alternative and recycled materials to reduce carbon footprint while maintaining infrastructure quality.

Reference Books:

1. Huang Y. H., Pavement Analysis and Design. Prentice Hall, Englewood Cliffs, New Jersey, USA, 1993, ISBN-0-13-655275-7
2. Yoder E. J. and Witczak M. W., Principles of Pavement Design, John Wiley and Sons, New York, 1975
3. Dr. Sharma S. K., Principles, Practice and Design of Highway Engineering (Including Airports), S. Chand & Company Ltd.
4. Chakraborty Partho, Das Animesh, Principles of Transportation Engineering, PHI
5. Khanna S.K., Justo C.E.G., Highway Engineering, Nem Chand & Bros., Roorkee.
6. Kadiyali L. R. and Lal, N. B., Principles & Practice of Highway Engineering, Khanna Publishers, Delhi.
7. Martin Rogers, Bernard Enright, Highway Engineering, Willey Blackwell
8. Paul H. Wright, Karen K. Dixon, Highway Engineering, John Wiley & Sons, 7th edition, 2004
9. Specifications for Road and Bridges, Ministry of Road Transport & Highways (MoRTH)
10. Rao G.V. Principles of Transportation and Highway Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, India, 1996.
11. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.

IRC Codes

1. IRC 82-2015 Code of practice for maintenance of bituminous surfaces of highways
2. IRC: SP:83 2015 - Maintenance & Rehabilitation of Cement Concrete Pavements
3. IRC: 37-2018 – Guidelines for the design of flexible pavement
4. IRC: 58-2015 - Guidelines for the design of plain jointed rigid pavement for highways
5. IRC :15 -2017: Standard specification and code of practice for construction of concrete roads
6. IRC SP 72-2015 - Guidelines for design and construction of flexible pavement for low volume road
7. IRC SP 63 Guidelines for the Use of Interlocking Concrete Block Pavement
8. IRC –SP-62-2014 – Guidelines for design and construction of cement concrete pavement for low volume road
9. IRC 120 Recycling of Bituminous Pavements
10. IRC SP-100 Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsion
11. IRC SP-81 Specifications for Slurry Seal and Micro surfacing
12. IRC SP-101 Guidelines for Warm Mix Asphalt
13. IRC SP-76 Guidelines for Conventional Thin White-Topping

14. IRC SP 49-2014 Guidelines of Use of Dry Lean Concrete as Sub-Base Course for Rigid Pavement

List of Experiments:

1. Bituminous mix design – Marshal Stability Test.
2. Determination of CBR value of subgrade.
3. Determination of overlay thickness.

Assignments:

1. Examples on stress analysis of flexible pavement for single layer, two layer and multi-layer
2. Problem on case study on design of Flexible pavement for NH/SH using IIT PAVE for granular sub base and base course
3. Problem on design of rural road
4. Problem on stress analysis of rigid pavement as per Westergaard's theory
5. Design of dowel bar as per Friberg's analysis and design of the tie bar
6. Design of Rigid pavement for fatigue damage as per IRC:58 using IITRIGID

Major Equipment:

1. Marshal Stability Test
2. California Bearing Ratio Test
3. Benkelman Beam Test
4. Bump Integrator/Falling weight deflectometer

List of Open-Source learning website:

1. http://www.nptel.iitm.ac.in/courses/

List of suggested activities for Term Work / Self Learning:

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Assignment/ Technical Writing/ Research Writing	Assignment writing. Numerical based assignment related to topics of the Pavement Design and Construction course	6 assignments of 2h each. Total = 12 h	Based on the assignment submitted.
2	Video Based Learning	Self-learning on-line courses related to Pavement Design and Construction course.	Minimum duration of the course should be 10 h.	Examination based assessment at the end of course. Based on the certificate produced.
		Videos on safety aspects of workers during construction and maintenance of pavement at the field	Duration of video = 5 h Report preparation = 2 h Total = 10 h	Based on quiz/report submitted
3	Micro project	Problem solving using standard	Field-based data	Based on the Pavement

		IRC Codes for the design of Pavement for a given traffic condition	collection and analysis Total = 5 h	Design submitted.
4	Industry / Research Laboratory Visit	Industry visit of any Pavement construction projects in terms of field laboratory and construction practices.	Visit = 5 h, Report preparation = 5 h Total = 10 h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
5	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving related to challenges infield during pavement construction.	Maximum 2 problems. Study of the problem and solution finding, Total = 10 h	Based on the depth of the solution submitted.
		Use of Professional software for analysis and design of pavement.	Duration = 10 h	Depending on the complexity of the Software
6	Poster/ Chart/ Power point presentation	Poster/chart/power point presentation on topics related to new technology of pavement construction	Duration = 6 h	Based on poster/chart preparation and presentation skills
7	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics related to advanced surveying techniques and tools	Duration = 2 h each	Based on performance in group discussion, technical depth, knowledge etc.
8	Case Study Analysis / Seminar	Workshop/seminar attended related to Pavement Design and Construction.	Duration = 4 hrs. per Workshop and 2 hrs. per seminar attended. Maximum 10 hrs.	Based on report submitted of summary and outcome of workshop/seminar attended
9	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluation critical parameters
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

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