# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering**
**Subject Code: 3174019**
**Semester – VII**
**Subject Name: Pavement Analysis and Design**

**Type of course:** Professional Elective Course

**Prerequisite:** Highway and Traffic Engineering

**Rationale:**

The Indian Government has set ambitious plans for upgrading of the National Highways in a phased manner. It is required to upgrade the knowledge of current practices in design of pavement structures. The objective of the course is to introduce the basic concepts of stress analysis and design of flexible and rigid pavement structure as per IRC standards and MORTH specifications. It includes the study of various types of failures of pavement and its remedial measures. It is necessary to reduce the cost of repairs and maintenance. Various evaluation techniques and overlay design are also covered in the course.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | |
| L | T | P | C | ESE (E) | PA (M) | ESE (V) | PA (I) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 30 | 20 | 150 |

**Content:**

| Sr. No. | Content | Total Hrs |
|---|---|---|
| 1 | **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 Distributions & Vehicle Damage Factors, Effect of Transient & Moving Loads. | 6 |
| 2 | **Stresses In flexible Pavement:** Vehicle-Pavement Interaction: Transient, Random & Damping Vibrations, Steady State of Vibration, Experiments on Vibration, Stress Inducing Factors in Flexible and Rigid pavements; Stress In Flexible Pavements: Visco-Elastic Theory and Assumptions, Layered Systems Concepts, Stress Solutions for One, Two and Three Layered Systems, Fundamental Design Concepts. | 6 |
| 3 | **Stresses in Rigid Pavements:** Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, and Stresses in Dowel Bars & Tie Bars. | 6 |
| 4 | **Design of Flexible Pavements:** Factors affecting Design. Deflection studies in Flexible Pavements. Present Serviceability Index. IRC guidelines and MORTH specifications for Flexible Pavements. Pavement Performance and methods- AASHTO and Asphalt Institute | 8 |

| | | |
|---|---|---|
| | Method. | |
| **5** | **Design of Rigid Pavements:** Factors affecting Design - Wheel load & its repetition, subgrade strength & proportion, strength of concrete - modulus of elasticity. Reinforcement in slab. Design of joints. Design of Dowel bars. Design of Tie bars. IRC and AASHTO methods of Rigid Pavement design. | **8** |
| **6** | **Pavement evaluation and strengthening:** Failures in flexible and rigid pavements, pavement evaluation, deflection survey, serviceability rating techniques, strengthening techniques, maintenance, Need for Overlays, Overlays design methods for Flexible and Rigid pavements, replacements. Surface and sub-surface drainage design. | **8** |
| | **Total** | **42** |

**Suggested Specification table with Marks (Theory):**

| **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.

**Reference Books:**

1. Yoder, E.J., and Witczak, `Principles of Pavement Design', 2nd ed. John Wiley and Sons, 1975.
2. Yang, `Design of Functional Pavements', McGraw Hill Book Co.
3. Khanna S. K. and Justo C. E. G., 'Test Book of Highway Engineering 'Nemchand brothers, Roorke- 2004.
4. Y. H. Huang, Pavement Analysis and Design. Prentice Hall, Englewood Cliffs, New Jersey, USA, 1993, ISBN-0-13-655275-7
5. AF Stock, Concrete Pavements, Elsevier, Applied Science Publishers.
6. Micheal Sargious, Pavement and Surfacing for Highway & Airports, Applied Science Publishers Limited.
7. Haas and Hudson `Pavement Management System', McGraw Hill Book Co., New York.
8. HRB/TRB/IRC/International Conference on Structural Design of Asphalt Pavements.
9. IRC– 37, 2001, 2012, IRC – 58-2002, 2011, Relevant IRC and MORTH Publications
10. CMA Hand Book
11. Sharma & Shrama, Principles and Practice of Highway Engg.
12. H. N. Atkins, Highway Construction and Maintenance, Soils, and Concretes, Reston Publishing Company, Reston VA, 1983.

13. J.P.Watson, Highway Construction and Maintenance, Longman Scientific and Technical, New York, 1989.
14. Relevant BIS, AASHTO and PCA Specifications and Guidelines.
15. Kadiyali L.R.and Lal, N. B., Principles & Practice of Highway Engineering, Khanna Publishers, Delhi.
16. Partho Chakraborty and Animesh Das, Principles of Transportation Engineering, PHI
17. F. L. Mannering, W. P. Kilareski and S. S. Washburn, Principles of Highway Engineering and Traffic Analysis. Wiley India Pvt. Ltd., New Delhi.

**Course Outcomes:** After studying this subject, students will be able to

| Sr. No. | CO statement | Marks % weightage |
|---|---|---|
| CO-1 | Understand various factors affecting pavement design | 15 |
| CO-2 | Carry out stress analysis in flexible and rigid pavements | 30 |
| CO-3 | Design flexible and rigid pavements as per IRC and MORTH guidelines | 40 |
| CO-4 | Evaluate the flexible and rigid pavement condition and design overlays for them. | 15 |

**List of Experiments:**

1. Plate Bearing Test.
2. Lab and Field CBR Test.
3. Pavement Evaluation by Benkelman Beam/Falling weight deflectometer Method.
4. Road Unevenness Measurement by Bump-Integrator.
5. Evaluation of Pavement Roughness by Roughometer / Profilometer.
6. Marshall Stability Test

**Major Equipment:**

1. CBR (Lab and Field) testing machine
2. Benkelman Beam / Falling weight deflectometer
3. Bump integrator
4. Marshall stability testing machine

**List of Open Source Software/learning website:**
1. IITPAVE – IIT Khargpur
2. www.nptel.iitm.ac.in/courses/