**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**

**KAKINADA – 533 003, Andhra Pradesh, India**

**R25 M.Tech CIVIL ENGINEERING**

**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

## DEPARTMENT OF CIVIL ENGINEERING

# COURSE STRUCTURE & SYLLABUS

# M. Tech HIGHWAY ENGINEERING Program

*(Applicable for batches admitted from 2025-2026)*

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITYKAKINADA**

# JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

**KAKINADA – 533 003, Andhra Pradesh, India**

## R25 M.Tech CIVIL ENGINEERING

## HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS

### VISION AND MISSION OF THE UNIVERSITY

#### VISION

The University is primarily promoting quality of education in the areas of Science, Technology, Engineering and Mathematics (STEM) as four academic pillars of education, to excel in teaching, learning, research, consultancy and placements through innovative practices with global perspective.

#### MISSION

Design an Industry relevant curriculum from time to time with a Global perspective Promoting quality education by embracing ICT delivery mechanism with continuous pedagogy through e-learning mechanism Spread across for industry collaborations with a focus to pre-training and placements for technology transfer to society Establishing centers of excellence to promote research and innovations in multidisciplinary areas to bring in patent culture and consultancy practices International Collaborations for student outreach Facilitating international students to study in JNTUK to infuse cross culture learning practices.

Vision and Mission of the Institute

Vision and Mission of the Department

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**KAKINADA – 533 003, Andhra Pradesh, India**

## R25 M.Tech CIVIL ENGINEERING

## HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS

## I - Semester

| S. No | Category | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | Program Core 1 | Pavement Materials and Characterization | 3 | 1 | 0 | 4 |
| 2 | Program Core 2 | Traffic Engineering and Management | 3 | 1 | 0 | 4 |
| 3 | Program Core 3 | Urban Transportation Systems Planning | 3 | 1 | 0 | 4 |
| 4 | Program Elective I | a) Bridge Engineering | 3 | 0 | 0 | 3 |
| | | b) Project Management | | | | |
| | | c) Ground Improvement Technique | | | | |
| | | d) Airport planning and Design | | | | |
| | | | | | | |
| 5 | Program Elective II | a) GIS for Transportation | 3 | 0 | 0 | 3 |
| | | b) Pavement Management Systems | | | | |
| | | b) Transportation Modeling and Simulation | | | | |
| | | d) Optimization Techniques | | | | |
| | | | | | | |
| 6 | Laboratory 1 | Pavement materials laboratory | 0 | 1 | 2 | 2 |
| 7 | Laboratory 2 | Traffic Engineering laboratory | 0 | 1 | 2 | 2 |
| 8 | | Seminar I | 0 | 0 | 2 | 1 |
| | | **Total Credits** | **15** | **5** | **16** | **23** |

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## II - Semester

| S.No | Category | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | Program Core 4 | Analysis and Design of Pavement | 3 | 1 | 0 | 4 |
| | Program Core 5 | Probability and Statistics for Transportation Engineering | 3 | 1 | 0 | 4 |
| 2 | Program Core 6 | Road Safety Engineering and Management | 3 | 1 | 0 | 4 |
| 3 | Program Elective III | | 3 | 0 | 0 | 3 |
| | | a) Pavement Construction Practices | | | | |
| | | b) Environmental Impact Assessment for Transportation Infrastructure | | | | |
| | | c) Traffic Flow Analysis | | | | |
| | | d) Fundamentals of Machine Learning | | | | |
| 4 | Program Elective IV | | 3 | 0 | 0 | 3 |
| | | Geosynthetics and Reinforced Earth Structures | | | | |
| | | Geometric Design of Highways | | | | |
| | | Intelligent Transportation Systems | | | | |
| | | Pavement Evaluation and Maintenance | | | | |
| 5 | Laboratory 3 | Pavement Evaluation laboratory | 0 | 1 | 2 | 2 |
| 6 | Laboratory 4 | Transportation Studio laboratory | 0 | 1 | 2 | 2 |
| 7 | | Seminar II | 0 | 0 | 2 | 1 |
| | | **Total Credits** | 15 | 5 | 6 | **23** |

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## III- semester

| S. No | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Research Methodology and IPR/ Swayam 12 week MOOC course-RM & IPR | 3 | 0 | 0 | 3 |
| 2 | Summer Internship/ Industrial Training (8 -10 weeks)* | - | - | - | 3 |
| 3 | Comprehensive Viva# | - | - | - | 2 |
| 4 | Dissertation Part –A $ | | | 20 | 10 |
| | **Total Credits** | | | 20 | **18** |

* Student attended during summer / year break and assessment will be done in 3rd Sem.

# Comprehensive viva can be conducted courses completed upto second sem.

$ Dissertation – Part A, internal assessment

## IV- semester

| S. No | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Dissertation Part –B & | - | - | 32 | 16 |
| | **Total Credits** | - | - | 32 | **16** |

& External Assessment

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| I Semester | PAVEMENT MATERIALS AND CHARACTERIZATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**UNIT I: Introduction to Pavement Systems and Materials**: Overview of pavement types: Flexible, Rigid, Composite, Functional requirements of pavement materials, Material components: aggregates, bitumen, cement, additives. Influence of climate, traffic loading, and subgrade on material selection. Historical evolution and current trends in pavement design.

**UNIT II: Characterization of Aggregates:** Aggregate classification and properties (gradation, shape, angularity). Physical tests: Specific gravity, water absorption, impact and crushing value. Durability and soundness assessments as per IS, ASTM standards, Specifications of aggregates and gradations as per MoRTH specifications for different types of pavement layers Superpave tests on aggregates, Influence of aggregate characteristics on pavement performance.

**UNIT III: Bituminous Material Properties and Testing:** Types of bituminous binders, modified binders: polymer-modified, crumb rubber modified, Bituminous emulsions and types, Tests on binders- penetration, ductility, viscosity, softening point tests as per IS and ASTM, Specifications of binders as per BIS code, Rheological properties of binder: Dynamic Shear Rheometer (DSR), Bending Beam Rheometer (BBR). Bitumen behaviour under temperature and loading variations.

**UNIT IV: Characterization of Cement and Concrete for Rigid Pavements:** Cement types and hydration chemistry. Concrete mix design for pavements (MORTH and IRC guidelines). Properties: compressive strength, flexural strength, workability. Durability aspects: shrinkage, scaling, alkali-silica reaction. NDT techniques: rebound hammer, ultrasonic pulse velocity.

**UNIT V: Pavement Materials Evaluation and Performance-Based Characterization:** Lab-based performance evaluation of mixes: Marshall Stability, Superpave. Field performance indicators: rutting, cracking, skid resistance. Surface characterization using sensors and remote sensing (thermal/microwave). Use of FWD (Falling Weight Deflectometer), GPR (Ground Penetrating Radar). Material selection for sustainability and climate resilience.

**Textbooks:**

1. A.T. Papagiannakis & E.A. Masad ,2008, Pavement Design and Materials, John Wiley & Sons Inc; 1st edition.
2. Nick Tom, 2008. Principles of Pavement Engineering, Thomas Telford Ltd Publications, 1st edition
Relevant IS and ASTM codes, Superpave specifications.
3. Specifications for Road works and Bridges, 2013, MoRTH 5th edition, New Delhi

**References:**

1. Dar-Hao Chen & Cindy Estakhri, 2009, Material, Design, Construction, Maintenance, and Testing of Pavement, ASCE Publisher, 2nd edition.
2. S.K. Khanna & C.E.G. Justo, 2013, Highway Engineering, Nemchand Bros , 10th edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| I Semester | TRAFFIC ENGINEERING AND MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**UNIT I: TRAFFIC PLANNING AND CHARACTERISTICS**: Road Characteristics – Road user characteristics – PIEV theory – Vehicle – Performance characteristics – Fundamentals of Traffic Flow – Urban Traffic problems in India – Integrated planning of town, country, regional and all urban infrastructure – Towards Sustainable approach. – land use & transport and modal integration.

**UNIT II: TRAFFIC SURVEYS:** Traffic Surveys – Speed, journey time and delay surveys – Vehicles Volume Survey including nonmotorized transports – Methods and interpretation – Origin Destination Survey – Methods and presentation – Parking Survey – Accident analyses - Methods, interpretation and presentation – Statistical applications in traffic studies and traffic forecasting – Level of service – Concept, applications and significance.

**UNIT III: TRAFFIC DESIGN AND VISUAL AIDS**: Intersection Design – channelization, Rotary intersection design – Signal design – Coordination of signals — Grade separation – Traffic signs including VMS and road markings – Significant roles of traffic control personnel – Networking pedestrian facilities & cycle tracks.

**UNIT IV: TRAFFIC SAFETY AND ENVIRONMENT:** Road accidents – Causes, effect, prevention, and cost – Street lighting – Traffic and environment hazards – Air and Noise Pollution, causes, abatement measures – Promotion and integration of public transportation – Promotion of non-motorized transport.

**UNIT V: TRAFFIC MANAGEMENT:** Area Traffic Management System – Traffic System Management (TSM) with IRC standards – Traffic Regulatory Measures-Travel Demand Management (TDM) – Direct and indirect methods – Congestion and parking pricing – All segregation methods- Coordination among different agencies – Intelligent Transport System for traffic management, enforcement and education.

**Textbooks:**

1. Kadiyali. L.R, 2013, Traffic Engineering and Transport Planning, Khanna Publishers, Delhi.
2. Garber and Hoel, 2010, Principles of Traffic and Highway Engineering, CENGAGE Learning, New Delhi
3. Salter. R.I and Hounsell N.B, 1996, Highway Traffic Analysis and design, Macmillan Press Ltd.

**References:**

1. Fred L. Mannering, Scott S. Washburn and Walter P. Kilareski, 2011, Principles of Highway Engineering and Traffic Analysis, Wiley India Pvt. Ltd., New Delhi
2. Indian Roads Congress (IRC) 75-2015 Guidelines for Traffic Management in Urban Areas
3. Taylor MAP and Young W, 1998, Traffic Analysis – New Technology and New Solutions, Hargreen Publishing Company.

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| I Semester | URBAN TRANSPORTATION SYSTEMS PLANNING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**UNIT I: URBANIZATION:** Urbanization, urban class groups, transportation problems and identification, impacts of transportation, urban transport system planning process, modeling techniques in planning.

**UNIT II: URBAN MASS TRANSPORTATION SYSTEMS:** Urban transit problems, travel demand, types of transit systems, public, private, para-transit transport, mass and rapid transit systems, BRTS and Metro rails, capacity, merits and comparison of systems, coordination, types of coordination.

**UNIT III: LAND USE PLANNING METHODS:** Land use and transportation interaction. The transportation study area definition; division into traffic zones; network identification and coding; types of trips, characteristics of various surveys; home interview; roadside survey; goods, mass transit and intermediate public transport surveys; sampling and expansion factors; accuracy checks, screen line checks, consistency checks.

**UNIT IV: TRAVEL DEMAND MODELING:** Trip generation-zonal regression and category analysis, Trip distribution-growth factor models, gravity model, opportunity models, Desire line diagram. Modal split analysis-trip end models, trip interchange models, logit models, Trip assignment techniques-route choice, diversion curves, shortest path algorithms, all- or-nothing assignment, capacity restraint models and Direct demand models.

**UNIT V: MASS TRANSIT SYSTEMS**: Introduction to routing and scheduling, transit system's performance parameters. Corridor identification and corridor screen line analysis. Urban forms and structures: point, linear, radial, poly-nuclear developments and suitable transit systems, Urban goods movement. Preparation of comprehensive plan and transportation system management planning.

**Textbooks:**

1. CS Papacostas, 2015. Transportation Engineering and Planning, Pearson Publishers, 3rd edition
2. Michael D Meyer and Eric J Miller, 2001. Urban Transportation Planning, Mc Graw Hill, 2nd edition

**References:**

1. Konstadinos G. Goulias, 2002, "Transportation Systems Planning: Methods and Applications", CRC Press, Boca Raton

2. Edward K.Morlok, 1978, "Introduction to Transportation Engineering and Planning" McGraw-Hill College

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| I Semester | BRIDGE ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: MASONRY ARCH BRIDGE DESIGN DETAILS**- Rise, radius, and thickness of arch- Arch ring- Dimensioning of sub structures- Abutments pier and end connections. (Ref: IRC- SP-13)

**UNIT II: SUPER STRUCTURE:** Slab bridge- Wheel load on slab- effective width method- slabs supported on two edges- cantilever slabs- dispersion length- Design of interior panel of slab- Pigeaud's method- design of longitudinal girders- Guyon-Messonet method- Hendry Jaegar method-Courbon's theory. (Ref: IRC-21), voided slabs, T-Beam bridges.

**UNIT III: PLATE GIRDER BRIDGES**- Elements of plate girder and their design-web-flange- intermediate stiffener- vertical stiffeners- bearing stiffener-design problem

**UNIT IV: COMPOSITE BRIDGES**- Composite action- shear connectors- composite or transformed section- design problem. (Ref: IRC:Section-VI)

**UNIT V: SUB STRUCTURE**- Abutments- Stability analysis of abutments- piers- loads on piers – Analysis of piers- Design problem (Ref: IRC-13, IRC-21, IRC-78)- Pipe culvert- Flow pattern in pipe culvers- culvert alignment- culvert entrance structure- Hydraulic design and structural design of pipe culverts- reinforcements in pipes .(Ref: IRC: SP-13

**Textbooks:**

1. Weiwei Lin, Teruhiko Yoda, 2017, Bridge Engineering, Butterworth-Heineman,1st edition.
2. V.N. Vazirani and M.M. Ratwani M.G. Aswani, 1995, Design of Concrete Bridges, Khanna Publishers, 1st edition

**References:**

1. D. Victor Johnson, Vikctor, 2017, Essentials of Bridge Engineering, CBS Publishers & Distributors, 3rd edition

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| I Semester | PROJECT MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: INTRODUCTION TO PROJECT MANAGEMENT**: A systems Approach, Systems Theory and Concepts, Organization, Management Functions, Overview of Management Objectives, Tools and Techniques, Project Management – Processes and Organizational Structures – Team Management – Project Manager as a Team Leader – Leadership Qualities, PMIS.

**UNIT II: CONSTRUCTION COST AND VALUE ENGINEERING**: Types of Estimates, Implementation of Cost Controls, Project Cost Forecasting, Cost Optimization and Resources Planning - Value Engineering, Techniques for Project Selection, Break-Even Analysis, Cost Modelling, Energy Modelling, Life Cycle Cost Approach.

**UNIT III: CONTRACT MANAGEMENT SAFETY IN CONSTRUCTION INDUSTRY**: Tendering and Contracting, Laws of Contracts, subcontracts, Potential Problems, Post Contract Problems, Documents, Conditions, Arbitration, Special Features of International Contracts. Quality Management and Safety in Construction Industry - Quality control by statistical methods, sampling plan, control charts, ISO 14000, Safety Measures, Safety Programmes, Safety Awareness and Implementation of Safety Plan – Compensation.

**UNIT IV: PROJECT SCHEDULING AND ANALYSIS METHODS** : CPM, PERT, Linear programming, queuing concept, simulation, bidding models, game theory.

**UNIT V**: **HUMAN RESOURCE MANAGEMENT AND CONSTRUCTION MANAGEMENT PRACTICES** : Man Power Planning – Training – Motivation – Industrial Relations – Welfare Measures – MIS – Components and Structure – Personal Management. Resource Management and Inventory - Basic concepts, labour requirements & productivity, non-productive activities, site productivity, equipment and material management, inventory control. Construction Management Practices - Implementation of Procedures and Practices – International Experiences– Case Studies – Examples.

**Textbooks:**

1. Herold Kerzner, 2009, Project Management: A systems approach to Planning, Scheduling and Controlling. Wiley John Wiley & Sons, 10th edition
2. Kwaku A. Tenah,, Jose M. Guevara, 1985, Fundamentals of Construction Management and Organization, Reston Pub Co, 1st edition

**References:**

1. Choudhary Sadhan, 1988, Project Management, Tata McGraw Hill Publishing Co., Ltd., 1st edition

2.

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| I Semester | GROUND IMPROVEMENT TECHNIQUE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: INTRODUCTION** – Need for Engineering Ground – Classifications of Ground Modification Techniques – Suitability, Feasibility and Desirability. Densification of cohesionless soils – deep Compaction – Vibroflobation – Vibro Composer method Blasting – Densification at Ground. - Vibrocompaction - Heavy Tamping, Stability of foundation trenches and surrounding structures through soil Nailing.

**UNIT II: STABILIZATION-** Mechanical Stabilization, Lime Stabilization, Cement Stabilization, Bitumen Stabilization, Thermal Stabilization and Chemical Stabilization.

**UNIT III: DEWATERING AND GROUTING**: - Dewatering methods – open sumps and ditches – gravity flow wells – Vacuum dewatering – Electro – kinetic dewatering – electroosmosis - Overview of grouting - Suspension grouts – Solution grouts – Methods of grouting – Grouting applications– Dams, Tunnels, Shafts and drifts, excavations.

**UNIT IV: IMPROVEMENT OF COHESIVE SOILS** – Preloading Soil Replacement – Radial Consolidation – Vertical and Radial Consolidation - Vertical Drains – Sand Drains – Effect of Smear – Sand wicks – Band drains – Dynamic Compaction.

**UNIT V: STONE COLUMNS** – Methods of installation of Stone Columns – Load shared by stone columns and the stabilized ground – uses of stone columns Lime columns and granular trenches – Installation – Improvements expected on Soil behavior. In situ ground reinforcement– ground anchors – types – Components and applications – uplift capability.

**Textbooks:**

1. Robert M. Koerner, 1988, Construction and Geotechnical Methods in Foundation Engineering, McGraw Hill Book Co, 2nd edition.

2. P. Purushothama Raj, 2005, Ground Improvement Techniques, Laxmi Publications (P) Ltd., New Delhi.

**References:**

1. Joseph E. Bowles, 2001, Foundation Analysis and Design, McGraw-Hill, 5th edition

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| I Semester | AIRPORT PLANNING AND DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: INTRODUCTION TO AIRPORT PLANNING-** Overview of Airport Systems, Types of airports (commercial, general aviation, military), Airport roles in transportation networks. History and Evolution of Airports- Development of aviation and airport infrastructure, Key milestones in airport design. Regulatory Framework-International Civil Aviation Organization (ICAO) guidelines, National regulations and standards (DGCA, FAA)

**UNIT II: AIRPORT SITE SELECTION**-Site Selection Criteria, Geographical considerations (topography, climate), Environmental impact assessments. Accessibility and Connectivity-Transportation links (road, rail, public transport), Proximity to urban centers and population density. Land Use and Zoning - Land acquisition and property rights, Compatibility with surrounding land uses.

**UNIT III: AIRPORT LAYOUT AND DESIGN**- Runway and Taxiway Design, Runway orientation and length considerations, Taxiway systems and clear zones. Terminal Design-Passenger flow and terminal layout, Facilities for security, customs, and baggage handling. Support Facilities-Hangars, maintenance, and cargo facilities, Ground transportation and parking design.

**UNIT IV: CAPACITY AND DEMAND FORECASTING**- Traffic Forecasting Techniques, Historical data analysis and trend forecasting, Use of statistical models and simulation. Capacity Analysis -Determining airport capacity (runway, terminal, parking), Level of Service (LOS) concepts and metrics. Demand Management Strategies- Slot allocation and scheduling, Pricing strategies and incentives for demand management.

**UNIT 5: ENVIRONMENTAL AND ECONOMIC CONSIDERATIONS**- Environmental Impact Assessment (EIA), Noise pollution and mitigation strategies, Air quality and ecological impacts. Economic Feasibility Studies- Cost-benefit analysis of airport projects, Funding sources and financial models. Sustainability in Airport- Design, Green building practices and energy efficiency, Innovations in sustainable aviation technologies

**Text books:**

1. Norman J. Ashford, Saleh Mumayiz , Paul H. Wright, 2011, Airport Engineering, Wiley Publishers, 4th edition

2. E. J. Yoder, M. W. Witczak, 1991, Principles of Pavement Design, Wiley &-Sons, 2nd edition

**References:**

1. M. Sargious, 1975, Pavements and Surfacings for Highways and Airports, John Wiley & Sons, 1st edition.

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| I Semester | GIS FOR TRANSPORTATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I**: **INTRODUCTION TO GIS AND TRANSPORTATION SYSTEMS**, GIS over view, use of GIS in decision making, Data processing, Components of GIS, The GIS and the organization.

**UNIT II: GIS DATA INPUT AND OUTPUT**: Data input - Key board entry, Remotely and sensed data, existing digital data, census related data sets, Data output - Hard copy and soft, copy devices.

**UNIT III: DATA QUALITY AND DATA MANAGEMENT:** Components of data quality - Micro level, Macro level components, Sources of error, A note about data accuracy. The data base approach, 3 classic data models, Nature of geographic data, Spatial data models, Databases for GIS.

**UNIT IV**: **GIS ANALYSIS, FUNCTIONS AND IMPLEMENTATION:** Organizing geographic data for analysis, Maintenance and analysis of the spatial data and non-spatial attribute data and its integration output formatting. Awareness, Developing system requirements, Evaluation of alternative systems, System justification and Development of an implementation plan, System acquisition and start up, Operation of the system.

**UNIT V**: **APPLICATION OF GIS IN TRANSPORTATION ENGINEERING** : Intelligent information system for road accessibility study, GIS data base design for physical facility planning, Decision support systems for land use planning. GIS applications in environment impact assessment, GIS based Highway alignment, GIS based road network planning, GIS based traffic congestion analysis and accident investigation.

**Textbooks:**

1. Harvey J. Miller (Author), Shih-Lung Shaw ,2001, Geographic Information Systems for Transportation: Principles and Applications, Oxford University, 3rd edition
2. Paul A. Longley, 2015, Geographic Information Science and Systems, Wiley Publications, 4th edition

**References:**

1. John Stillwell, Graham Clarke, 2019, Applied GIS and Spatial Analysis, Wiley Publications, 1st edition

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| I Semester | PAVEMENT MANAGEMENT SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: INTRODUCTION**: Definition -Components of Pavement Management Systems, Essential features. Pavement Management Levels and functions: Ideal PMS- Network and Project levels of PMS, Influence Levels- PMS Functions- Function of Pavement evaluation

**UNIT II: PAVEMENT PERFORMANCE**: Serviceability Concepts- roughness-Roughness Components, Equipment-IRI - modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models.

**UNIT III: PAVEMENT EVALUATION:** Functional Evaluation: Functional and Structural deterioration models, unevenness prediction models and other models, comparison. Case studies. Equipment's Structural Evaluation:- Basics- NDT and Analysis—Condition Surveys-Distress-Destructive Structural Analysis- Application in Network and Project Levels

**UNIT IV: DESIGN ALTERNATIVES-**Rehabilitation and Maintenance: Design objectives and constraints, basic structural response models, physical design inputs, alternate pavement design strategies and economic evaluation, life cycle costing, analysis of alternate pavement strategies based on distress and performance, case studies. Equipment's. Identification of Alternatives-Deterioration Modeling- Priority Programming Methods.

**UNIT V: EXPERT SYSTEMS IN PAVEMENT MANAGEMENT**: Role of computers in pavement management, applications of expert systems for managing pavements, expert system for pavement evaluation and rehabilitation, knowledge-based expert systems, case studies

**Textbooks:**

1. Ralph Haas and Ronald W. Hudson, 1982, Pavement Management System, McGraw Hill Book Co. 2nd edition.

2. Ralph Haas, Ronald Hudson Zanieswki, 1994, Modern Pavement Management, Kreiger Publications, 2nd edition

**References:**

1. R Srinivasa Kumar, 2020, Pavement Evaluation and Maintenance Management System, Orient Black Swan, 2nd edition

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| I Semester | TRANSPORTATION MODELING AND SIMULATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: INTRODUCTION OF MODELING**: Fundamentals of systemic approach. System modeling, Model structure, Variables, controllable variables, uncontrollable variables, parameters, coefficients and other statistical methods for testing of models and data.

**UNIT II CLASSIFICATION OF MODELS**; Classification of models - Linear models, Non-linear models, Time, invariant models, Time-variant models, State-space models, Distributed. parameter models. System Synthesis- - Direct and Inverse Problems, Role of optimization and Examples from transportation engineering.

**UNIT III PRELIMINARY DATA PROCESSING**: data collection, Regression Analysis-Linear multiple regression analysis; Analysis of residues, Tests of goodness of fit. Spatial Distribution- Polynomial surfaces, Spline functions, Cluster. analysis and Numerical production of contour maps. Time Series Analysis-Auto-cross. correlation analysis, Identification of trend, spectral analysis, Identification of dominant cycles, smoothening techniques, Filters and forecasting.

**UNIT IV: MODEL BUILDING**: Choice of Model Structure- A priori considerations, Selection based upon preliminary data analysis, Comparing model structures. Model Calibration- Role of historical data, Direct and Indirect methods of solving inverse problem.-Model Validation.

**UNIT V: SIMULATION;** Random variables, Basic concepts. Probability density and distribution functions, Expectation and standard deviation of discrete and continuous random variables and their functions, Covariance and correlation, commonly used theoretical Probability distributions: Uniform, Normal, Binomial, Poisson, Negative exponential. Fitting distributions to raw data: Chi-square and Kolmogrov-Smirnov's tests of the goodness of fit. Central limit theorem, various algorithms for generation of Random numbers. Queuing theories, Applications of Monte, Carlo simulation.

**Textbooks:**

1. Bratley, P., Fox B. L., Schrage, L. E. B., 2012, A Guide to Simulation, Springer, New York, 2nd edition
2. Leigh, J. R., 2009, Modeling and Simulation, Peter Peregrinus, London, 2nd edition

**References:**

1. Bernard, Z., 2011,Theory of Modeling and Simulation, John- Wiley, New York, 1st edition
2. Ortuzar, J. and Willumsen, 2024, L.G, Modeling Transport, Wiley, Chinchestor, 5th edition

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| I Semester | OPTIMIZATION TECHNIQUES | L | T | P | C |
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**UNIT I: INTRODUCTION TO OPTIMIZATION**- basic concepts and importance of optimization, Classification: Linear vs. Nonlinear, Static vs. Dynamic, Deterministic vs. Stochastic, Formulation of optimization problems, Applications in engineering, transportation, and economics, Optimality conditions and feasible region concepts.

**UNIT II: LINEAR PROGRAMMING**, Formulation of linear programming problems, Graphical method for two-variable problems, Simplex method and its applications, Duality in linear programming. - Graphical method for two-variable problems, Simplex method: theory and algorithm, Big-M and Two-phase methods. Duality theory and sensitivity analysis, Transportation and assignment problems.

**UNIT III: NONLINEAR OPTIMIZATION**- Unconstrained optimization: Gradient descent, Newton's method- Constrained optimization: Lagrange multipliers, KKT conditions, Convexity and its role in optimization, - Penalty and barrier methods.

**UNIT IV: METAHEURISTIC AND EVOLUTIONARY ALGORITHMS**- Introduction to heuristics and metaheuristics, Genetic Algorithms (GA): encoding, selection, crossover, mutation, Particle Swarm Optimization (PSO), Simulated Annealing and Tabu Search, Applications in complex and multi-modal problems

**UNIT V: MULTI-OBJECTIVE AND DYNAMIC OPTIMIZATION**, Multi-objective optimization: Pareto optimality, weighted sum method, Goal programming, Dynamic programming: principle of optimality, recursive formulation, Case studies: transport planning, scheduling, energy systems

**Textbooks:**

1. Edwin K. P. Chong, Stanislaw H. Żak, 2013, An Introduction to Optimization, Wiley Publication, 2nd edition

2. Michel Bierlaire, 2021, Optimization: Principles and Algorithms, EPFL Press , 2nd edition

**References:**

1. David G. Luenberger (Author), Yinyu Ye, 2021, Linear and Nonlinear Programming, Springer, 5th edition



| I Semester | PAVEMENT MATERIALS LAB | L | T | P | C |
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| | | 0 | 1 | 2 | 2 |

**Experiments:**

1. Aggregate: Gradation Analysis, Specific Gravity, Absorption of Aggregates, Los Angeles Abrasion Test, Sand Equivalent Test on fine aggregates
2. Tests on Bitumen binders: Penetration Test, Ductility test, Softening Point Test, Viscosity Test of Bitumen, Flash and Fire point test,
3. Tests on modified binders: Elastic Recovery, Separation Test, Ductility Test
4. Test on soils: Compaction Test (Proctor and Modified), California Bearing Ratio (CBR) Test,
5. Test on subgrade and GSB pavement materials (lab and field test): Dynamic Cone Penetrometer (DCP) test
6. Development of Correlation between CBR of soil and DCP value of soil

**References:**

1. Rao, G.V. Ramachandra Rao, K, Pahari, K. and Bhavanna Rao, D.V. 2019 Highway Material Testing and Quality Control, Dreamtech Press. 2nd edition
2. Khanna, S.K., Justo, CEG, Veeraragavan, 2013 A. Highway Materials and Pavement Testing, Nem Chand Bros. 5th edition
3. IS:73(2013) Specifications for PAVING BITUMEN, Fourth Revision, New Delhi
4. IS:15462, 2004, Specifications for Polymer and Rubber Modified Bitumen, New Delhi
5. Specifications for Road works and Bridges, 2013, MoRTH 5th edition, New Delhi

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| I Semester | TRAFFIC ENGINEERING LAB | L | T | P | C |
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**Experiments:**

1. Roadway Geometric Design Evaluation
2. Traffic Volume Count- Vehicle classification, Peak hour factors
3. Speed Measurement- Speed limit adherence, spot speed
4. Intersection Capacity Analysis- Lane utilization , Capacity
5. Develop traffic signal times for intersection – Using IRC and Webster method
6. Pedestrian Crossing Behavior Study- Volume and safety
7. Traffic Flow Characteristics – traffic flow, including density, speed, and flow rate
8. Level of Service (LOS) Analysis
9. Traffic Control Device Effectiveness
10. Public Transport Usage Study
11. Traffic queue study
12. Delay studies

**References:**

1. Murthy, A.N. and Mohle, H.R., 2001. Transportation Engineering Basics (2nd edition). American Society of Civil Engineers.

2. Jamar Technologies Manuals, 2022, Traffic Engineering II, 3rd edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

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|---|---|---|---|---|---|
| **II Semester** | **ANALYSIS AND DESIGN OF PAVEMENT** | **L** | **T** | **P** | **C** |
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**UNIT I: PAVEMENT TYPES**- Introduction, Wheel Loads and Design Factors Definition of Pavement Types, Comparison of Highway pavements, Wheel Loads, Tyre pressure, Contact pressure, Design Factors: Traffic and Loading, Environment, Materials, Failure criteria, Reliability.

**UNIT II: STRESSES IN PAVEMENTS,** Layered System Concepts: One Layer System: Boussinesq Theory. Two Layer Theory: Burmister's Theory. Three Layer System. Stresses in Rigid Pavements. Relative Stiffness of Slabs, Modulus of Subgrade Reaction, Stresses due to Warping, Stresses due to Friction, Stresses due to Load, IRC Recommendations.

**UNIT III: PAVEMENT DESIGN** IRC Method of Flexible Pavement Design (IRC:37-2018), AASHTO Method of Flexible Pavement Design, IRC Method for Rigid Pavements(IRC:58-2015), use of Geosynthetics in pavements.

**UNIT IV: PAVEMENT INVENTORIES**: Serviceability Concepts, Visual Rating, Pavement Serviceability Index, Roughness, Measurements, Measurement of Distress Modes Cracking, Rutting, Rebound Deflection, using Benkleman Beam Deflection Method, Load Man Concept, Skid Resistance Measurement.

**UNIT V: PAVEMENT EVALUATION**- Functional Pavement Performance Evaluation: AASHTO Method, Psycho Physical and Psycho Metric Scaling Techniques, Deduct Value Method.Beam Deflection Method, Pavement Distress Rating Technique. Design of Overlays by Benkelmen Beam Deflection Methods as per IRC – 81 - 1997 – pavements on problematic soils

**TextBooks:**

1. Yang, H. Huang, 2001 "Pavement Analysis and Design", Prentice Hall Publication, Englewood Cliffs, New Jersy. 2nd edition
2. Yoder and Witzorack, 1978, "Principles of Pavement Design", John Willey and Sons.

**References**:

1. IRC:37-2018, IRC:58-2015, IRC:81-1997 guidelines, Indian Roads Congress (IRC), New Delhi

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

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|---|---|---|---|---|---|
| **II Semester** | **PROBABILITY AND STATISTICS FOR TRANSPORTATION ENGINEERING** | **L** | **T** | **P** | **C** |
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**UNIT 1: INTRODUCTION TO PROBABILITY: F**undamental concepts of probability and its applications in transportation. Basic definitions and concepts (sample space, events, probability). Rules of probability (addition and multiplication rules). Conditional probability and Bayes' theorem Applications of probability in transportation scenarios (e.g., traffic flow, accident analysis) Activities

**UNIT 2: RANDOM VARIABLES AND PROBABILITY DISTRIBUTIONS-** Definition of random variables (discrete and continuous). Common probability distributions (Binomial, Poisson, Normal, Exponential). Properties of distributions (mean, variance, standard deviation). Applications of probability distributions in transportation (e.g., vehicle arrivals, travel times).

**UNIT 3: STATISTICAL INFERENCE-** Concepts of population, sample, and sampling distributions Point estimation and interval estimation Hypothesis testing (null and alternative hypotheses, Type I and Type II errors) Applications of statistical inference in transportation data analysis (e.g., traffic counts, survey data).

**UNIT 4: REGRESSION ANALYSIS AND MODELING-** Simple linear regression and multiple regression analysis Assumptions of regression models and diagnostics Model selection and validation techniques Applications of regression analysis in transportation (e.g., predicting traffic volumes, travel demand forecasting)

**UNIT 5: QUEUING THEORY AND SIMULATION-** Introduction to queuing theory concepts (arrival rates, service rates, queue discipline) Common queuing models (M/M/1, M/M/c, M/G/1) Simulation techniques for analyzing transportation systems Applications of queuing theory in traffic flow, public transport, and service facilities.

**Textbooks:**

1. Douglas C. Montgomery and George C. Runger, 2021, Applied Statistics and Probability for Engineers Wiley Publication, 2nd edition
2. Anthony J. Hayter, 2012, Probability and Statistics for Engineers and Scientists, Duxbury Press, 3rd edition

**References:**

1. David A. Hensher and Kenneth J. Button, 2000, Handbook of Transport Modeling, Pergamon, 3rd edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | ROAD SAFETY ENGINEERING AND MANAGEMENT | L | T | P | C |
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**UNIT I: INTRODUCTION TO SAFETY**: Road accidents, Trends, causes, Collision diagrams; Highway safety; Human factors and road user limitations; Speed and its effect on road safety; Vehicle factors; Highway safety in India. Multi-causal dynamic systems approach to safety; Crash Vs Accident; Road safety improvement strategies; Elements of a road safety plan, Safety data Needs; Safe vehicle design.

**UNIT II: STATISTICAL INTERPRETATION AND ANALYSIS OF CRASH** -Before-after methods in crash analysis, Recording of crash data; Accident Investigation and Analysis; Statistical testing and the role of chance; Black Spot Identification and Investigations, Case Studies.

**UNIT III: ROAD SAFETY AUDITS**: Key elements of a road safety audit, Road Safety Audits & Investigations, Work zone safety audit; Crash investigation and analysis, Methods for identifying hazardous road locations, Case Studies.

**UNIT IV: CRASH RECONSTRUCTION:** Describe the basic information that can be obtained from the roadway surface, Understand basic physics related to crash reconstruction, speed for various skid, friction, drag, and acceleration scenarios, variables involved in jump and flip crashes, variables involved in pedestrian crashes, Case Studies. Mitigation measures, Road safety law.

**UNIT V: ROAD SAFETY MANAGEMENT AND POLICY:** Road safety management systems (RSMS) Development and implementation of road safety policies Role of enforcement in road safety (traffic laws, penalties) Public awareness campaigns and education programs. Intelligent Transportation Systems (ITS) and their applications. Role of data analytics and machine learning in predicting road safety issues. Autonomous vehicles and their impact on road safety. Future trends in road safety engineering and management

**Textbooks:**

1. Athelstan Popkess, 1997 (Digitized 2008).Traffic Control and Road Accident Prevention, Chapman and Hall,
2. Ezra Hauer, 1997 (reprinted 2002).Observational Before-After Studies in Road Safety, Pergamon Press.

**References:**

1. IRC: SP- 88 ,2010, Manual on Road Safety Audit, Indian Roads Congress (IRC), New Delhi.

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | PAVEMENT CONSTRUCTION PRACTICES | L | T | P | C |
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**UNIT I: PAVEMENT CONSTRUCTION:** Introduction; Construction of Embankment and Subgrade; Soil stabilization MoRTH specifications, Quality control.

**UNIT II: CONSTRUCTION OF GRANULAR BASE**: Introduction, Gradation of different granular base layers as per MoRTH specifications, Construction of Granular Sub-base, Wet Mix Macadam, Water Bound Macadam; Construction of Cementitious bases and sub-bases.

**UNIT III: CONSTRUCTION OF BITUMINOUS LAYERS:** Introduction, Types of bituminous layers of high-volume roads and low volume roads (LVR), Hot Mix Asphalt (HMA) production; HMA Storage and Transport; HMA Placement and Joint construction; HMA Compaction; MoRTH Specifications, quality control.

**UNIT IV: MILLING AND RECYCLING OF EXISTING BITUMINOUS PAVEMENTS**: Introduction, Types of milling and recycling; Hot Recycling (in-situ and in-plant); Cold Recycling (in-situ and inplant); full depth reclamation (FDR) of High Volume and Low Volume Roads.

**UNIT V: CONSTRUCTION OF CONCRETE PAVEMENT:** Introduction, Typical layers of concrete pavement, Construction of Dry lean Concrete (DLC) layer, Concrete Slip form paving, Concrete Fixed form paving; Construction of Paving quality Concrete (PQC) layer, Surface finishing and Joints; Quality Control and Quality Assurance , MoRTH specifications.

**TEXTBOOKS**

1. Kandhal, Prithvi Singh, Veeraragavan, Amirthalingam, Choudhary, Rajan, 2023. Bituminous Road Construction in India, 2nd edition, PHI publishers.
2. Ray Brown, Dah-Yinn Lee, Thomas W. Kennedy, 2010, National Asphalt Pavement Association, Maryland, USA, 2nd edition

**References:**

1. Specifications for Road works and Bridges, 2013, MoRTH, New Delhi, 5 th edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

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|---|---|---|---|---|---|
| **II Semester** | **ENVIRONMENTAL IMPACT ASSESSMENT FOR TRANSPORTATION INFRASTRUCTURE** | **L** | **T** | **P** | **C** |
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**UNIT 1: INTRODUCTION:** Environment and its interaction with human activities – Environmental imbalances ¬Attributes, Impacts, 'Indicators and Measurements - Concept of Environmental Impact Assessment (EIA), Environmental Impact Statement, Objectives of EIA, Advantages and Limitation. Importance of EIA in transportation planning and decision-making.

**UNIT II: ENVIRONMENTAL INDICATORS** - Indicators for climate - Indicators for terrestrial subsystems Indicators for aquatic subsystems - Selection of indicators - Socia-economic indicators – Basic information - Indicators for economy - Social indicators - Indicators for health and nutrition - Cultural indicators - Selection of indicators.

**UNIT III: ENVIRONMENTAL IMPACTS IN TRANSPORTATION**- Potential environmental impacts associated with transportation infrastructure projects. Assessment of impacts on air quality, noise, and vibration. Effects on water resources and aquatic ecosystems. Impacts on terrestrial cosystems and biodiversity. Socio-economic impacts and community considerations

**UNIT IV: MITIGATION MEASURES AND ENVIRONMENTAL MANAGEMENT PLANS-**

Identification of mitigation measures for various environmental impacts. Development of Environmental Management Plans (EMPs). Monitoring and evaluation of environmental impacts post-implementation. Role of adaptive management in transportation projects

**UNIT V: EMERGING TRENDS AND CHALLENGES IN EIA FOR TRANSPORTATION-**

Integration of sustainability principles in EIA Climate change considerations in transportation projects. Technological advancements in EIA (e.g., remote sensing, big data). Challenges in EIA implementation and compliance

**Textbooks:**

1. Peter Wathern, 2013, Environmental Impact Assessment: Theory and Practice, Routledge Press, 5th edition

2. Charles H. Eccleston, 2013, Environmental Impact Assessment: A Guide to Best Professional Practices, CRC Press, 3rd edition

**References:**

1. Jain, R.K., Urban, L.V., Stracy, G.S., 1991, Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 5th edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | TRAFFIC FLOW ANALYSIS | L | T | P | C |
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**UNIT 1: TRAFFIC FLOW DESCRIPTION:** Traffic Stream Characteristics and Description Using Distributions: Measurement, Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests.

**UNIT II: TRAFFIC STREAM MODELS**: Fundamental Equation of Traffic Flow, Speed-Flow-Concentration Relationships, Normalized Relationship, Fluid Flow Analogy Approach, Shock Wave Theory - Flow-Density diagram use in Shockwave analysis; Use of Time-space diagram for shockwave description; Bottleneck situations and shockwaves; traffic signal and shockwave theory; numerical Examples for application of shockwave theory;, Platoon Diffusion and Boltzman Like Behavior of Traffic Flow, Car-Following Theory, Linear and Non- Linear CarFollowing Models, Acceleration Noise, Fuel consumption models.

**UNIT III: QUEUING ANALYSIS**: Fundamentals of Queuing Theory, Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels, Analysis of M/M/1 system; Assumptions and Derivation of System State Equations; Application of M/M/1 analysis for parking Garages and Toll Plazas- numerical Examples; Analysis of D/D/1 system for delay characteristics; Traffic Signal analysis as D/D/1 system; Computation of delays and queue dissipation Time – Numerical Examples.

**UNIT IV: PEDESTRIAN DELAYS AND GAPS**: Pedestrian Gap acceptance and delays; Concept of Blocks, Antiblocks, Gaps and Non-Gaps; Underwood's analysis for Pedestrian Delays; Warrants for Pedestrian Crossing Facilities – Minimum Vehicular Volume Warrant, Minimum Pedestrian Volume Warrant, Maximum Pedestrian Volume Warrant.

**UNIT V: SIMULATION MODELS:** Philosophy of Simulation Modelling, Formulation of Simulation Model, Methodology of System Simulation, Simulation Languages, Generation of Random Numbers, Generation of Inputs – Vehicle Arrivals, Vehicle Characteristics, Road Geometrics, Design of Computer Simulation Experiments, Analysis of Simulation Data, Formulation of Simulation Problems in Traffic Engineering and Validation.; Basic concepts of simulation modelling application for Signalized Intersections, Pedestrian Crossings and Transit scheduling

**Textbooks:**

1. C.S.Papacostas, 2000, Fundamentals of Transportation Engineering, Prentice Hall India Publication Traffic, 5th edition.
2. F. L. Mannering &W. P. Kilareski, 2019, Principles of Highway Engineering and Traffic Analysis, Wiley Press, 7th edition

**References:**

1. Flow Theory: A Monograph , 2005, TRB Special Report 165



| II Semester | FUNDAMENTALS OF MACHINE LEARNING | L | T | P | C |
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**UNIT I: INTRODUCTION TO MACHINE LEARNING-** Concepts and types of machine learning. Importance of machine learning in transportation. Types of machine learning: supervised, unsupervised, and reinforcement learning. Overview of the machine learning process (data collection, preprocessing, model training, evaluation).

**UNIT II: DATA PREPARATION AND PREPROCESSING-**Preparing and preprocessing data for machine learning. Data collection methods in transportation (sensors, surveys, historical data) Data cleaning and handling missing values Feature selection and engineering. Data normalization and scaling techniques

**UNIT III: SUPERVISED LEARNING TECHNIQUES**-Overview of supervised learning algorithms (linear regression, decision trees, support vector machines, neural networks) Model training and evaluation metrics (accuracy, precision, recall, F1 score) Applications of supervised learning in transportation (traffic prediction, demand forecasting, accident analysis)

**UNIT IV: UNSUPERVISED LEARNING AND CLUSTERING** -Overview of unsupervised learning algorithms (k-means clustering, hierarchical clustering, principal component analysis) Applications of clustering in transportation (traffic pattern analysis, route optimization, anomaly detection) Dimensionality reduction techniques and their importance in data visualization

**UNIT V: FUTURE TRENDS IN MACHINE LEARNING FOR TRANSPORTATION-** Introduction to deep learning and its applications in transportation (e.g., image recognition for traffic signs) Reinforcement learning and its potential in traffic signal control Ethical considerations and challenges in implementing machine learning in transportation Future trends in machine learning technologies and their impact on transportation systems.

**Textbooks:**

1. Christopher M. Bishop, 2006, Pattern Recognition and Machine Learning, Springer, 2nd edition
2. John D. Kelleher, 2020, Fundamentals of Machine Learning for Predictive Data Analytics, second edition: Algorithms, The MIT Press, 2nd edition.

**References:**

1. Tingting Yuan et el, 2021, Machine learning for next-generation intelligent transportation systems: A survey, Wiley Press, 1st edition.

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**R25 M.Tech CIVIL ENGINEERING**

**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | GEOSYNTHETICS AND REINFORCED EARTH STRUCTURES | L | T | P | C |
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**UNIT I: INTRODUCTION TO GEOSYNTHETICS**-Concepts and types of geosynthetics. Classification of geosynthetics (geotextiles, geomembranes, geogrids, geonets). Properties and functions of geosynthetics in civil engineering. Historical development and applications of geosynthetics. Overview of standards and specifications for geosynthetics.

**UNIT II: MATERIAL PROPERTIES AND TESTING OF GEOSYNTHETICS**-Mechanical properties of geosynthetics (tensile strength, elongation, permeability) Durability and environmental resistance of geosynthetics Standard testing methods for geosynthetics (ASTM, ISO). Interpretation of test results and their implications for design

**UNIT III: PRINCIPLES FOR REINFORCED EARTH STRUCTURES**-Fundamentals of soil reinforcement and mechanics Design methodologies for reinforced earth structures (retaining walls, slopes, embankments). Factors influencing the design of reinforced earth structures (loading conditions, soil properties). Use of geosynthetics in reinforcement applications.

**UNIT IV: APPLICATIONS OF GEOSYNTHETICS IN CIVIL ENGINEERING**-Use of geosynthetics in road construction and pavement design. Applications in erosion control and slope stabilization. Role of geosynthetics in landfill design and waste containment. Case studies of geosynthetic applications in real-world projects

**UNIT V: FUTURE TRENDS AND CHALLENGES IN GEOSYNTHETICS**-Advances in geosynthetic materials and technologies. Sustainability considerations in the use of geosynthetics. Challenges in the design and implementation of geosynthetic solutions. Future research directions and innovations in geosynthetics.

**Textbooks:**

1. R W Sarsby, W, 2007, Geosynthetics in Civil Engineering, Woodhead Publishing, 1st edition.
2. Ernst & Sohn, 2012, Recommendations for Design and Analysis of Earth Structures using Geosynthetic Reinforcements. 1st edition

**References:**

1. G. L. Sivakumar Babu and M. R. Madhav, 2016, Ground Improvement with Geosynthetics, 1st edition

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | GEOMETRIC DESIGN OF HIGHWAYS | L | T | P | C |
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**UNIT I: GEOMETRIC DESIGN OF HIGHWAYS**: Functional classification of Highway system; Design controls - Topography, Driver characteristics, Vehicle characteristics. Traffic, Capacity and Level of Service, Design speed. Objectives of Geometric Design. Road Margins – design specifications; Pavement surface characteristics - Skid Resistance, measurement of skid resistance; Road roughness, measurement of Road roughness; Camber design and standards.

**UNIT II: Horizontal and Vertical Alignment:** Sight Distance - SSD, OSD and ISD. Horizontal curves, Super elevation; computing of super elevation; attainment of super elevation; Extra widening on curves; Transition curves - Objectives and Design. Gradients - Types of Gradients, Design Standards; Summit Curves, Valley curves and Design criteria. Combination of Vertical and Horizontal curves - Grade Compensation. Importance of Sight Distances for Horizontal and Vertical curves.

**UNIT III: Design of Intersections**: Types of Intersections; Design Principles for Intersections; Design At grade Intersections – Channelization, Objectives; Traffic Islands and Design standards Rotary Intersection - Concept, Advantages and Disadvantages; Grade separated Interchanges - Types, warrants and Design standards as per IRC.

**UNIT IV: Traffic Signs and Road Markings**: Types of Road Signs; Guidelines for the provision of Road Signs; Caution Signs, Regulatory signs. Information signs - Design standards. Road markings - Objectives of Road markings; Types of Road Marking, Role of Road markings in Road Safety and Traffic Regulation; Specification for Road Marking Highway Appurtenances Delineators, Traffic Impact Attenuators, Safety Barriers.

**UNIT V: Pedestrians :** Requirements of Pedestrians; Pedestrian facilities on Urban Roads; Cycle Tracks - Guidelines and Design standards; Bus bays-Types and Guide lines-Design of On street and Off street parking facilities - Guidelines for lay out Design. Design of Subways and foot over bridges.

**Textbooks:**

1. L.R. Kadiyali and N. B. Lal, 2013, Principles and Practice of Highway Engineering, Khanna Publications. 7th edition

2. R. Srinivasa Kumar, 2020, A Text Book of Highway Engineering, Universities Press, 3rd edition.

**References:**

1. IRC Codes for signs, Markings and Mixed Traffic Control in Urban Areas

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

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| **II Semester** | **INTELLIGENT TRANSPORTATION SYSTEMS (ITS)** | **L** | **T** | **P** | **C** |
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**UNIT I: FUNDAMENTALS OF ITS**: Definition of ITS s, The historical context of ITS from both public policy and market economic perspectives, Types of ITS; Historical Background, Benefits of ITS.

**UNIT -II: SENSOR TECHNOLOGIES AND DATA REQUIREMENTS OF ITS**: Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems. Concepts; ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), GIS, video data collection

**UNIT III: ITS FUNCTIONAL AREAS** – Advanced Traffic Management systems (ATMS), Advanced Traveler Information systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control systems (AVCS), Advanced Public Transportation systems (APTS), Advanced Rural Transportation systems (ARTS). ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

**UNIT-IV: ITS ARCHITECTURE** – Regional and Project ITS architecture; Concept of operations; ITS Models and Evaluation Methods; Planning and human factor issues for ITS, Case studies on deployment planning and system design and operation; ITS and safety, ITS and security, ITS as a technology deployment program, research, development and business models, ITS planning

**UNIT V: ITS APPLICATIONS:** Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing.; Transportation network operations; commercial vehicle operations and intermodal freight; public transportation applications; ITS and regional strategic transportation planning, including regional architectures: ITS and changing transportation institutions Automated Highway Systems-Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries

**Textbooks**:

1. Mashrur A. Chowdhury, Adel WadidSadek, 2003, Fundamentals of intelligent transportation systems planning. Artech House 4th edition.
2. Lawrence A. Klein , 2001, Sensor technologies and Data requirements of ITS, Artech House, 1st edition.

**References:**

1. Kan Paul Chen, John Miles , 2000, ITS Hand Book: Recommendations for World Road Association (PIARC), Artech House, 1st edition.

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**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

| II Semester | PAVEMENT EVALUATION AND MAINTENANCE | L | T | P | C |
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**UNIT I: INTRODUCTION:** Definition -Components of Pavement Management Systems, Essential features. Pavement Management Levels and functions: Ideal PMS- Network and Project levels of PMS Influence Levels- PMS Functions- Function of Pavement evaluation.

**UNIT II: PAVEMENT PERFORMANCE**: Serviceability Concepts- roughness-Roughness Components Equipment-IRI - modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models.

**UNIT III: PAVEMENT EVALUATION**: Functional Evaluation: Functional and Structural deterioration models, unevenness prediction models and other models, comparison. Case studies. Equipment's Structural Evaluation:- Basics- NDT and Analysis—Condition Surveys-Distress-Destructive Structural Analysis- Application in Network and Project Levels

**UNIT IV: DESIGN ALTERNATIVES**, Rehabilitation and Maintenance: Design objectives and constraints, basic structural response models, physical design inputs, alternate pavement design strategies and economic evaluation, life cycle costing, analysis of alternate pavement strategies based on distress and performance, case studies. Equipment Identification of Alternatives-Deterioration Modeling- Priority Programming Methods.

**UNIT V: EXPERT SYSTEMS AND PAVEMENT MANAGEMENT:** Role of computers in pavement management, applications of expert systems for managing pavements, expert system for pavement evaluation and rehabilitation, knowledge-based expert systems, case studies.

**Textbooks**:

1. Ralph Haas and Ronald W. Hudson, 1982, Pavement Management System, McGraw Hill Book Co. 2nd edition.
2. Ralph Haas, Ronald Hudson Zanieswki. 1994, Modern Pavement Management, Kreiger Publications 2nd edition

**References:**

1. Proceedings of North American Conference on Managing Pavement, 1985, AASHTO proceedings

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**KAKINADA – 533 003, Andhra Pradesh, India**

**R25 M.Tech CIVIL ENGINEERING**

**HIGHWAY ENGINEERING COURSE STRUCTURE & SYLLABUS**

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| **II Semester** | **PAVEMENT EVALUATION LAB** | **L** | **T** | **P** | **C** |
| | | **0** | **1** | **2** | **2** |

**EXPERIMENTS LIST:**

1. Bituminous Mix Design by Marshall Method for finding out optimum binder content
2. Tensile strength Ratio (TSR) and Indirect Tensile Strength (ITS) Test on bituminous mixes
3. Road Roughness by MERLIN device
4. Core collection of bituminous mixes from pavement (field) and extraction of bitumen and aggregate gradation from field cores
5. Studies on wheel wandering (lateral placement) of vehicles
6. Benkelman Beam Deflection studies for measurement of rebound deflection of existing pavements and calculation of overlay thickness of existing pavement

**References:**

1. MS-2 Asphalt Mix Design Methods, 2017, Asphalt Institute Publisher, USA, 7th edition
2. ASTM D6927-15 Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures
3. Khanna, S.K., Justo, CEG, Veeraragavan, 2013 A. Highway Materials and Pavement Testing, 2013, Nem Chand Bros. 10th edition

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|---|---|---|---|---|---|
| **II Semester** | **TRANSPORTATION STUDIO LAB** | **L** | **T** | **P** | **C** |
| | | **0** | **1** | **2** | **2** |

**Experiment List:**

1. Traffic Volume and Flow Analysis
2. Speed Measurement and Analysis
3. Intersection Design and Analysis
4. Traffic Signal Timing Optimization
5. Pedestrian Behaviour Study
6. Public Transport Accessibility Assessment
7. Road Safety Audit
8. Travel Demand Forecasting
9. GIS for Transportation planning ( network allocation, Optimized route)
10. Queue analysis for a busy Intersection.
11. Simulation of Traffic
12. Environmental Impact Assessment of Transportation Projects
13. Smart City using transportation
14. Accident analysis and IoT applications for safety

**References:**

1. National Highway Authority of India Publications (MORTH)
2. Transportation Research Board (TRB) Publications & Reports
3. American Association of State Highway and Transportation Officials (AASHTO) Resources

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| III Semester | RESEARCH METHODOLOGY AND IPR / SWAYAM 12 WEEK MOOC COURSE-RM & IPR | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**UNIT I: RESEARCH METHODOLOGY:** Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods verses methodology - Research and scientific method - Importance of research methodology - Research process - Criteria of good research - Problems encountered by researchers in India - Benefits to the society in general. Defining the research problem: Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.

**UNIT II LITERATURE SURVEY:** Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Literature review: Need of review - Guidelines for review - Record of research review.

**UNIT III: RESEARCH DESIGN**: Meaning of research design - Need of research design - Feature of a good design - Important concepts related to research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes.

**UNIT IV: DATA COLLECTION:** Collection of primary data - Secondary data - Data organization - Methods of data grouping - Diagrammatic representation of data - Graphic representation of data - Sample design - Need for sampling - Some important sampling definitions - Estimation of population - Role of statistics for data analysis - Parametric vs. non parametric methods - Descriptive statistics - Measures of central tendency and dispersion - Hypothesis testing - Use of statistical softwares. Data Analysis: Deterministic and random data - Uncertainty analysis - Tests for significance - Chi-square - Student's t-test - Regression modeling - Direct and interaction effects – ANOVA - F-test - Time series analysis - Autocorrelation and autoregressive modeling.

**UNIT V: RESEARCH REPORT WRITING**: Format of the research report – Synopsis – Dissertation - Thesis - Its differentiation References – Bibliography – Webliography - Technical paper writing - Journal report writing - Making presentation - Use of visual aids. Research proposal preparation: Writing a research proposal and research report - Writing research grant proposal.

**Textbooks:**

1. C.R Kothari, 2004, "Research Methodology, Methods & Technique", New Age International Publishers, New Delhi, 1st edition
2. R. Ganesan, 2011, "Research Methodology for Engineers", MJP Publishers, Chennai, 2nd edition.
3. Ratan Khananabis and Suvasis Saha, 2015, "Research Methodology", Universities Press, Hyderabad, 1st edition

**References:**

1. Y.P. Agarwal, 2004,"Statistical Methods: Concepts, Application and Computation", Sterling Publishing Pvt. Ltd., New Delhi, 1st edition.
2. Vijay Upagade and AravindShende, 2019, Research Methodology, S. Chand & Company Ltd., New Delhi, 1st edition