

**ACADEMIC REGULATIONS  
COURSE STRUCTURE  
AND  
DETAILED SYLLABUS**

**M.Tech.  
Highway Engineering**

(Effective for the students admitted from the Academic Year 2007-08)



**Jawaharlal Nehru Technological University  
Hyderabad – 500 085**

## COURSE STRUCTURE AND SYLLABUS

## I SEMESTER

Subject	T	P
Highway Infrastructure Design	4	-
Highway Project Formulation and Economics	4	-
Traffic Engineering	4	-
Pavement Materials Characterization	4	-
Elective - I	4	-
Elective - II	4	-
Highway Engineering Lab. - I	-	3

## II SEMESTER

Subject	T	P
Pavement Analysis and Design	4	-
Urban Transportation Planning	4	-
Highway Construction and Quality Control	4	-
Pavement Evaluation Maintenance and Management	4	-
Elective - III	4	-
Elective - IV	4	-
Highway Engineering Lab. - II	-	3

## Elective - I :

1. Applied Statistics
2. Project Management
3. Rural Roads

## Elective - II :

1. Road safety & Traffic Management
2. Remote Sensing and GPS
3. Ground Improvement Methods

## Elective - III :

1. Transportation Systems and Management
2. Principles of Bridge Engineering
3. Environmental Impact Assessment for Transportation Projects

## Elective - IV :

1. Advanced Modeling Techniques in Highway Engineering
2. Airport Planning and Design
3. GIS Applications in Transportation Engineering

## III &amp; IV SEMESTERS

## SEMINAR

## PROJECT



I SEMESTER

Highway Infrastructure Design

1. **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
2. **Highway Cross Section Elements :** Carriageway, Shoulders, Formation, Right of way, Kerbs, foot paths, Medians - design specifications; Pavement surface characteristics - Skid Resistance, factors affecting skid resistance, measurement of skid resistance; Road roughness, measurement of Road roughness; Camber, Objectives of Camber, design standards.
3. **Horizontal Alignment :** Objective of horizontal curves, elevation - Need for Super elevation; Method of computing super elevation; Minimum Radius of Curve; Methods attainment pf super elevation; Extra widening on curves; Transition curves - Objectives and Design.
4. **Vertical Alignment and Sight Distances :** Gradients - Types of Gradients, Design Standards; Vertical Curves - Summit Curves, Valley curves and Design criteria for Vertical curves; Combination of Vertical and Horizontal curves - Grade Compensation; Sight Distance - Stopping Sight Distance, Overtaking Sight Distance and Intermediate Sight Distance - Importance of Sight Distances for Horizontal and Vertical curves.
5. **Intersection Design :** Types of Intersections; Design Principles for Intersections; Design At-grade Intersections - Channelisation, Objectives; Traffic Islands and Design standards Rotary Intersection - Concept, Advantages and Disadvantages; Grade separated Interchanges - Types, warrants and Design standards;
6. **Traffic Signs :** Types of Road Signs; Guidelines for the provision of Road Signs; Caution Signs, Regulatory signs. Information signs - Design standards.
7. **Road Markings :** 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.
8. **Miscellaneous Elements :** 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.

**References :**

1. Principles and Practice of Highway Engineering, L.R.Kadiyali and N.B.Lal, Khanna Publications
2. Traffic Engineering and Transportation Planning, L.R.Kadiyai, Khanna Publications
3. Highway Engineering, C.E.G.Justo and S.K.Khanna, Nem Chand and Brothers
4. IRC Codes for signs, Markings and Mixed Traffic Control in Urban Areas.



I SEMESTER

**Highway Project Formulation and Economics**

1. Project Formulation: Requirements in project formulation, Criteria fixation, Components of project, Non-monetary and monetary Criteria in formulation of project, Decision making Criteria input in Project formulation. Preparation of DPR - Guidelines
2. Transport Projects and development : preparation of Project, Highway Planning, Traffic infrastructure, Project formulation, Road Network project development.
3. Economic evaluation of Transportation plans, Need for Economic Evaluation; Principles of economic evaluation; Welfare economics; Social costs, Vest change, Rate of return.
4. Value of Travel time Savings; Economic concept of evaluation of travel time savings, Issues connected with evaluation of travel time savings. Vehicle operating costs; Components of VOC, Road user Cost study in India; Accident costs; Methodologies for economic evaluation of an accident; Factors involved.
5. Basic methods of economic analysis; cash flow diagrams, Time value of money, Inflation, Interest, Depreciation, Cost and benefit components, Discounting criteria.
6. Equivalent Uniform Annual cost Method; Present worth of cost method; Equivalent uniform annual net return method; Net present value method; Benefit cost ratio method; Rate of Return Method; Application of these methods to numerical examples.
7. Analysis of variable costs; Types of Capital Financing; valuation; Project appraisal by shadow pricing with case studies.
8. Environmental impact assessment: Basic concepts, Objectives, Transportation related Environmental Impacts - Vehicular Impacts - Safety and Capacity Impacts - Roadway Impacts - Construction Impacts, Environmental Impact Assessment - Environmental Impact Statement, Environment Audit, Typical case studies.

**References :**

1. Transportation Engineering Economics - Heggie. I.G., McGraw Hill Publishers.
2. Economic Analysis for Highways - Winfrey. R; International Text Book Company.
3. Traffic Engineering and Transport Planning - L. R. Kadiyali, Khanna Publishers.
4. Road User Cost Study, CRRI,
5. Road Project Appraisal for Developing Countries, J. W. Dickey, John Wiley & Sons.
6. Construction Management & Planning, B.Sengupta, H.Guha, Tata McGraw Hill, New Delhi



**I SEMESTER**

**Traffic Engineering**

1. **Traffic Characteristics:** Basic traffic characteristics – Speed, Volume and Concentration. Relationship between Flow Speed and Concentration.
2. **Traffic Measurement and Analysis :** Volume Studies – Objectives, Methods; Speed studies, Definition of spot speed time mean speed and space mean speed; Methods of conducting speed studies; Presentation of speed study data; Head ways and Gaps; Critical Gap; Gap acceptance studies.
3. **Highway Capacity and Level of Service :** Basic definitions related to capacity; Level of service concept; Factors affecting capacity and level of service; Computation of capacity and level of service for two lane highways, Multilane highways and free ways.
4. **Parking Studies and Analysis :** Types of parking facilities – on-street parking and off-street parking facilities; Parking studies and analysis – Parking Inventory Study, Parking usage study by Patrolling, Questionnaire Survey, Cordon Surveys; Evaluation of parking parameters; Parking accumulation, Parking Load, Parking Turnover, Parking Index Parking Volume.
5. **Traffic Safety :** Accident studies and analysis; Causes of accidents – The road, the vehicle, the road user and the Environment Engineering, Enforcement and Education measures for the prevention of accidents.
6. **Traffic Control and Regulation:** Traffic signals – Types of signals; Principles of phasing; Timing diagram; Design of Isolated Traffic signal by Webster method, Warrants for signalization.
7. **Signal Coordination:** Signal Coordination methods, Simultaneous, Alternate, Simple progression and Flexible progression Systems.
8. **Traffic and Environment:** Detrimental effects of Traffic on Environment, Air pollution; Noise pollution; Measures to curtail environmental degradation due to traffic.

**References :**

1. Traffic Engineering and Transportation Planning - L.R. Kadiyali and Khanna Publishers.
2. Traffic Engineering – Theory & Practice \_ Louis J. Pignataro, Prentice Hall Publication.
3. Principles of Highways Engineering and Traffic Analysis – Fred Mannering & Walter Kilareski, John Willey & Sons Publication.
4. Transportation Engineering – An Introduction – C.Jotin Khisty, Prentice Hall Publication
5. Fundamentals of Transportation Engineering – C. S. Papacostas, PrenticeHall India.
6. I.T.E. Traffic Engineering Hand Book.



I SEMESTER

Pavement Materials Characterization

1. **Soil:** Soil Classification methods, Tests: CBR, Consistency, Engineering Properties and Modulus of subgrade reaction of soil, selection of suitable filter for soils, Triaxial method.
2. **Aggregates:** Origin, Classification, requirements, properties and tests on road aggregates for flexible and rigid pavements, Blending of aggregates, Importance of aggregate shape factor in mix design.
3. **Methods of Test for Stabilized Soils:** Method of sampling and Preparation of Stabilised Soils for Testing, Relation for Moisture content and Dry Density of Stabilised mixes, wetting. Drying, Thawing & freezing tests for compacted soil cement mix, UCS of Stabilized soil, test for: soil bituminous, soil lime and soil fly ash mixes.
4. **Bitumen and Tar:** Origin, preparation, properties and tests, constitution of bituminous road binders, requirements, criteria for selection of different binders, Temperature susceptibility, Bitumen test data chart, Stiffness modulus, Vander Poel Nomograph. Bituminous emulsion and Cutbacks, fillers, extenders, polymers, Crum rubber, rubber modified bitumen and anti-stripping agents on pavement performance.
5. **Bituminous mix design, binder content, gradation, Engineering properties :** Dynamic conditions, Quasi static conditions, Fracture and Fatigue; Marshal stability, Haveem stability test, example problem, static creep test, repeated load test, Resilient & dynamic modulus test, empirical test, simulation test, flexural test, diametral repeated load test, splitting tension test, permanent deformation Parameters and other properties, Effects use of Geo Synthetics.
6. **Introduction to super pave technology :** Methods of selection of suitable ingredients for super pave method, Gyratory compaction, rolling thin film oven, pressure aging vessel, rotational viscometer, dynamic shear rheometer, bending beam rheometer, direct tension test. Use of super pave perform and grade binder specifications, Comparison between Marshal mix method and Super pave method
7. **Cement concrete Mixes:** Requirements of paving concrete, mix design, Admixtures, Tests on cement Concrete.

8. Recycling bituminous material, fundamental of recycling bituminous material, hot and cold recycling of bituminous material, methods of recycling, equipment use, sites specific material specifications, Design of mixes for recycling of bituminous and concrete pavement surface.

**References:**

1. Highway Engineering, Paul H. Wright, Karen K. Dixon, John Wiley & Sons, 7<sup>th</sup> edition, 2004.
2. Principles and Practices of Highway Engineering, Sharma & Sharma.
3. SRC, DSIR, Bituminous Materials in Road Construction, HMSO publication.
4. Principles of Pavement Design, Yoder E.J. and Witczak M. W. John Wiley & Sons, 1975.
5. ISI and IRC publications on related topic.



I SEMESTER

Applied Statistics

ELECTIVE - I

1. **Introduction & Sampling Techniques :** Frequency distribution; Mean; Standard error, Skewness; Kurtosis; Definitions and Applications; Simple random sampling ; Stratified sampling; Systematic sampling; Sample size determination; Applications in Highway and Traffic Engineering
2. **Statistical Distribution :** Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions; Mean and variance ; Chi-square test of goodness-of-fit; Applications in Highway and Traffic Engineering.
3. **Probability :** Laws of Probability; Conditional Probability and Independent events; Laws of expectation.
4. **Regression and Correlation :** Linear regression and correlation; Multiple correlation; Multiple correlation coefficient; Standard error of estimate ; Analysis of variance; Curvilinear regression; Applications in Transportation Engineering.
5. **Multi Variate Data Distributions :** Types of data; Basic vectors and matrices; Simple estimate of centroid, Standard deviation, Dispersion, Variance and covariance ; Correlation matrices ; Principal component analysis; Time series analysis.
6. **Exact Sampling Distributions :** Chi-square distribution; students T-distribution; Snedectors F-distribution.
7. **Tests of Significance & Confidence Interval-I :** Large sample and small sample tests ; Tests for single mean, Means of two samples, Proportions, two variances, two observed correlation coefficients, paired T-tests, Applications.
8. **Tests of Significance & Confidence Interval-II :** Intervals for mean, variance and regression coefficients ; Applications in Highway and Traffic Engineering Problems.

References :

1. Basic Statistics - Simpson and Kafks; Oxford and IBH Calcutta, 1969.
2. Fundamentals of Mathematical Statistics - Gupta, S.C. and Kapoor, K. V. Sultanchand
3. Multivariate Data Analysis - Cootey W.W & Cochens P.R; John Wiley & Sons.



I SEMESTER

**Project Management  
ELECTIVE - I**

1. **Introduction to project Management :** A systems approach, Systems Theory and concepts, Organisation, Management functions, Overview of Management objectives Tools and Techniques, Project Management - Processes and Organisational structures - Team Management - Project Manager as a Team Leader - Leadership qualities, PMIS
2. **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.
3. **Contract Management:** Tendering and Contracting, Laws of Contracts, subcontracts, Potential problems, Post contract problems, Documents, conditions, Arbitration, special features of International Contracts.
4. **Quality Management and safety in Construction Industry :** Quality control by statistical methods, sampling plan, control charts, ISO 14000, Safety programmes, Safety Awareness and Implementation of Safety Plan - Compensation
5. **Project Scheduling and Analysis Methods :** CPM, PERT, Linear programming, queuing concept relation, bidding models, game theory.
6. **Human Resource Management :** Man power planning - Training - Motivation- Industrial Relations - Welfare Measures - MIS - Components and Structure - Personal Management.
7. **Resource Management and Inventory :** Basic concepts, labor requirements & productivity, non-productive activities, site productivity equipment and material management, inventory control
8. **Construction Management Practices :** Implementation of procedures and practices - International experiences - Case studies - Examples.

**References :**

1. Herold Kerzner - Project Management - A systems approach to planning, Scheduling and controlling, CS Publishers and Distributors
2. K.Waker A Teraih and Jose M.Grevan; Fundamentals of Construction Management and Organisations
3. Anghel Patterson - Construction Cost Engineering Handbook - Marcel Dekken Inc.
4. Dell Isola- Value Engineering in Construction Industry, Van Nostrand Reinhold Co.
5. Choudary, S.Project Management, Tata Mcgraw Hill Publishing Co.,
6. Raina UK, construction management practices, Tata McGraw Hill publishing company Ltd. Sengupta B and Guha H, Construction Management and Planning, Tata McGraw Hill Publishing Company Limited, New Delhi.



**I SEMESTER**

**Rural Roads  
ELECTIVE - I**

1. **Planning and Alignment :** Planning of Rural roads, concept of network planning, rural road plan, road alignment and surveys, Governing factors in route selection, factors considered for alignment.
2. **Road Materials :** Introduction, Soil material surveys, embankment and subgrade materials, stabilized soils, road aggregates, aggregate for base courses, new materials as stabilizers, materials for desert areas, materials for bituminous constructions and surfacings; Materials for rigid pavements, special pavement, climatic suitability of concrete material.
3. **Pavement Design :** Introduction, Design procedure, pavement components, design of flexible and rigid pavements, Special pavements design.
4. **Road Drainage :** Types of drainage, General criteria for road drainage, system of drainage, surface and subsurface systems.
5. **Construction and Specifications :** Introduction, Selection of materials and Methodology, Embankment and subgrade, subbase (granular), base (granular), shoulder, Bituminous concrete, Semi-rigid pavements construction, Concrete pavements, Construction of special pavements, Equipment required for different procedures.
6. **Use of Waste Materials :** Introduction, Fly ash for road construction, Design & Construction of Fly ash embankments, Lime fly ash stabilized soil, Lime fly ash bound Macadam, Lime fly ash concrete, rolled compacted fly ash pavements, Control of compaction, concrete stabilized fly ash with admixtures.
7. **Quality Control in Construction :** Introduction, Pre requirements, organizational setup, specification and code of practice, Laboratory equipment, Earth and Granular layers, Bituminous courses, Semi rigid and rigid pavements, special requirements, Recovered of quality control data.
8. **Maintenance :** Introduction, Distresses/Defects in rigid and flexible pavements, Maintenance and Evaluation, Inventory of roads and inspections, Types of maintenance activities, Maintenance.

**Reference :**

1. IRC manual for Rural roads, S.P.20.
2. HMSO, Soil Mechanics for Road Engineers, London.



I SEMESTER

**Road Safety & Traffic Management  
ELECTIVE - II**

1. Road accidents: causes, scientific investigations and data collection, Analysis of individual accidents to arrive at real causes, statistical methods of analysis of accident data, Basic concepts of Road accident statistics, Safety performance function : The empirical Bayes method Identification of Hazards road location. Application of computer analysis of accident data.
2. Safety in Road Design, Operating the road network for safety, highway operation and counter measures, road safety audit, principles-procedures and practice, code of good practice and checklists, vehicle design factors & Driver characteristics influencing road safety.
3. Road Signs: Classification, Location of Signs, measures of sign effectiveness, Types of visual perception, sign regulations, sign visibility, sign variables, Text versus symbols. Road Marking: Role of Road markings, Classification, visibility.
4. Traffic Signals: Need, Signal face, Illumination and location of Signals, Factors affecting signal design, pedestrians safety, fixed and vehicle actuated signals, Design of signals, Area Traffic control.
5. Highway Appurtenances: Delineators, Traffic Impact Attenuators, Road side rest areas, Safety Barriers, Traffic Aid Posts.
6. Traffic Management techniques. Integrated safety improvement and Traffic Calming Schemes, Speed and load limit, Traffic lights, Safety cameras, Tests on driver and vehicles, pedestrian safety issues, Parking, Parking enforcement and its influence on Accidents.
7. Traffic management: Introduction, Travel Demand Management; Methods of Traffic management measures: Restriction of Turning Movements, Oneway streets, Tidal Flow Operation Methods, Exclusive Bus Lanes and Closing Side-streets; Latest tools and techniques used for Road safety and traffic management. Road safety issues and various measures for road safety; Legislation, Enforcement, Education and Propaganda, Air quality, Noise and Energy Impacts; Cost of Road Accidents.



8. Incident Management : Introduction, Characteristics of Traffic Incidents, Types of Incidents, Impacts, Incident management process, Incident traffic management; Applications of ITS : Motorist information, Equipment used; Planning effective Incident management program, Best practice in Incident management programs.

References :

1. Guidelines on Design and Installation of Road Traffic Signals, IRC:93.
2. Specification for Road Traffic Signals, IS: 7537-1974.
3. Principles and Practice of Highway Engineering by L.R. Kadiyali and N. B. Lal.
4. Hand book of T.E. Myer Kutz, Editor McGraw Hill, 2004.



I SEMESTER

**Remote Sensing and GPS  
ELECTIVE - II**

1. **Remote Sensing:** Basic Principles - Introduction, Electromagnetic and its properties, interaction with earth surface materials, recent developments in remote sensing, social and legal implications of Remote Sensing, status of Remote Sensing.
2. **Remote Sensing Platforms & Sensors :** Introduction characteristics of imaging remote sensing instruments, satellite remote sensing system - a brief over view, other remote sensing satellites
3. **Pre-Processing of Remotely Sensed Data :** Introduction, cosmetic operation; Geometric connection and registration, atmospheric correction.
4. **Enhancement Technique :** Introduction, human visual system, contrast enhancement; Pseudo color enhancement.
5. **Image Transforms :** Introduction, arithmetic operations, empirically based image transforms, Principal component analysis, Multiple discriminant analysis etc.
6. **Filtering Technique Classification :** Low-pass (smoothing filters) High pass (sharpening) filters, edge detection, frequency domain filters, geometrical basis, classification, Unsupervised and supervised classification, classification accuracy.
7. **G.P.S. :** Introduction, Elements of satellite surveying, e global positioning system, GPS satellites, Adjustment computations, GPS observables, Application of GPS technology in Highway alignment, Network planning.

**References :**

1. GPS Satellite Surveys, Alfred Leick, Willey & sons
2. Principles of Remote Sensing, Paul Juman, ELBS, 1985
3. Computer Processing of Remotely sensed Images An Introduction - Paul M.Mather, John Wiley & Sons 1989.



I SEMESTER

**Ground Improvement Methods**  
**ELECTIVE - II**

1. **Introduction to Ground Modification** : Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – suitability and feasibility, Emerging Trends in ground improvement.
2. **Mechanical Modification** : Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro floatation, Blasting, Dynamic consolidation, pre-compression and compaction piles, Field compaction control.
3. **Hydraulic Modification** : Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains.
4. **Physical and Chemical modification** : Stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen, Grouting: categories of grouting, Art of grouting, Grout materials, Grouting techniques and control.
5. **Reinforced Earth Technology** : Concept of soil reinforcement, Reinforcing materials, Backfill criteria, Art of reinforced earth technology, Design and construction of reinforced earth structures.
6. **Soil Confinement Systems** : Concept of confinement, Gabion walls, CRB walls, Sand bags, Evergreen systems and fabric formwork
7. **Miscellaneous Techniques** : Design, Construction and applications of stone columns lime columns and cofferdams, Applications of Geo-textiles in Highway construction.

**References :**

1. Manfred R.Hansmann - Engineering principles of ground modification - Mc Graw-Hill pub. Co., New York
2. Robert M.Koerner - Construction and Geotechnical methods in Foundation Engineering - Mc.Graw-Hill Pub. Co., New York
3. Winterkorn and Fang - Foundation Engineering Hand book - Van Nostrand Reinhold Co., New York.
4. Aris C.Stamatopoulos & Panaghiotis C.Kotzios - Soil Improvement by Preloading - John Wiley & Sons Inc. Canada
5. P.Purushothama Rao - Ground Improvement Techniques - Laxmi Publications (P) Limited.



I SEMESTER

**HIGHWAY ENGINEERING LAB - I**

**I. Tests on Soil**

1. Soil Consistency tests, Sieve Analysis, Fineness modulus and Soil gradation.
2. CBR Test
3. Plate load Test
4. Compaction of soil
5. Standard Proctor Test
6. Modified Proctor Test
7. Triaxial Shear Test

**II. Tests on Aggregate :**

1. Flakiness & Elongation tests
2. Aggregate Impact and Crushing tests
3. Los Angeles Abrasion test
4. Aggregate Polishing test
5. Soundness test

**III. Tests in Bitumen :**

1. Viscosity of bitumen using Brookfield viscometer and Pensky martens Viscometer
2. Bitumen Penetration and Softening point tests
3. Ductility test
4. Flash, Fire point test and Loss of heating tests
5. Thin Film Oven Test
6. Rolling thin film Oven (RTFOT) Test
7. Bitumen Extraction Test

**IV. Traffic Surveys :**

1. Traffic Volume Study
2. Spot speed study
3. Moving observer method
4. Parking survey



II SEMESTER

**Pavement Analysis and Design**

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 multi units, Tire Pressure, Contact pressure, EAL and ESWL concepts, Equivalent Axle Load Factor, Traffic Analysis: ADT, AADT, Truck factor, Growth factor, Lane, Directional distributions & Vehicle Damage factors, Effect of Transient & Moving loads.
2. **Stresses in Pavements :** Vehicle-Pavement Interaction: Transient, random & Damping vibrations, Steady state of vibration, Experiments on vibration, Stress inducing factors flexible and Rigid pavements
3. **Stress in Flexible Pavements :** Visco-Elastic Theory and Assumptions. Layered system concepts, Stress solutions for one, two and three layered systems, Fundamental Design concepts.
4. **Stresses in Rigid Pavements :** Westergaard's theory and Assumptions, Stresses due to loading & curling, Stresses and Deflections due to loading, Frictional Stresses in Dowel Bars & Tie Bars
5. **Mechanistic Design procedures for Flexible and Rigid Pavements:** General Methodology; Flexible Pavements: Climatic Models, Structural models, Distress models: fatigue cracking, rutting and thermal cracking models; Rigid Pavements: Structural models, fatigue cracking: load and curling stress, Pumping and Erosion Models, Faulting Models, Joint Deterioration and Punchout models; Need and verification of Flexible and Rigid pavement Mechanistic design procedures.
6. **Design of Flexible Pavements:** Flexible Pavement Design Concepts, Asphalt Institute Methods with HMA and other Base Combinations, AASHTO, IRC Methods.
7. **Design of Rigid Pavements :** Calibrated Mechanistic Design Process, PCA, AASHTO, IRC specifications, Introduction to pre-stressed and continuously Reinforced cement Concrete Pavement Design, Rigid Pavement, Design for Low volume Rural Roads
8. **Design of overlays:** Types & Design of overlays: Asphalt Institute's Principal Component Analysis, IRC Methods of Overlay Design, Importance of Profile Correction Course.

**References :**

1. Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications
2. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers
3. Principles of Pavement Design, Yoder J. & Witzac Mathew W., John Wiley & Sons.
4. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc.
5. Pavement and surfacings for Highway & Airports, Micheal Sargious, Applied science Publishers Limited.
6. IRC Codes for Flexible and Rigid Pavements design



II SEMESTER

URBAN TRANSPORTATION PLANNING

1. **Urban Transportation Problem :** Urban Issues, Travel Characteristics, Evolution of planning process, supply and demand - system approach
2. **Travel Demand :** Trends, Overall Planning Process, Long term Vs Short term planning, demand function, independent variables, travel attributes, assumptions in Demand estimation, sequential and simultaneous approaches, aggregates and disaggregate techniques.
3. **Data Collection and Inventories :** Collection of data - Organization of surveys and analysis. Study Area, Zoning, Types and sources of Data, Road side Interviews, Home Interview surveys, Commercial vehicle surveys, sampling techniques, expansion factors, Accuracy, checks, use of secondary sources, Economics data - Income - Population - Employment - Vehicle owner ship.
4. **Four Stage Demand Forecasting :** UTPS Approach, Trip Generation Analysis, Zonal models, Category analysis, Household Models, Trip Attraction models, commercial trip rates.
5. **Trip Distribution :** Growth factor methods, Gravity models, Opportunity models, Time action iteration models.
6. **Mode Choice Analysis :** Mode Choice Behaviour, Competing Modes, Mode split curves, models and Probabilistic approaches.
7. **Traffic Assignment :** Basic Elements of Transport Networks, Coding, Route properties, Path coding criteria, skimming tree, All-or-nothing Assignment, capacity restraint techniques, allocation of assigned volumes, equilibrium assignment, diversion curves.
8. **Plan Preparation and Evaluation :** Travel Forecasts to evaluate alternative improvements, facts of new development on transportation facilities. Master plans, Selection of corridor, corridor identification, Corridor deficiency analysis.

References :

1. Introduction to Transportation Planning - M.J.Bruton; Hutchinson of London Ltd.
2. Introduction to Urban System Planning - B.G.Hutchinson; McGraw Hill
3. Traffic Engineering and Transport Planning - Kadiyali L.R.Khanna Publishers
4. Lecture notes on UTP - Prof. S.Raghavachari, R.E.C.Warangal.



## II SEMESTER

### Highway Construction and Quality Control

1. Equipment in Highway Construction: various types of equipment for excavation, grading and compaction - their working principle, advantages and limitations; cement concrete and Bituminous concrete plants.
2. Construction Planning and Management: Need and significance of Highway construction planning, Role of labour and machinery in construction; Time, cost and resource management of projects for planning, scheduling, Control and forecast using networks with Bar chart, Critical Path Method (CPM), PERT; Personal, material and finance management, Safety Engineering.
3. Construction of Base, Sub base & Drainage layer, General construction, Earth work, Roadway and Drain excavation, Excavation and blasting, Embankment construction, Selection and proportioning of soil elements, Construction of : Earth & Roads, Gravel base, Cement stabilized sub bases, WBM, WMM, Unbound cement bases, Shoulders, Drainage surface, Turfing sand, Drains, Sand wicks, Rope drains, Geo-textile drainage, Pre loading techniques, Field Control checks.
4. Bituminous Pavement Construction : Preparation and laying of Tack coats, Seal coats, Slurry seal coats, Classification of hot mix paving, Bituminous Macadam, Penetration macadam, Built-up spray grout, Semi dense Asphalt concrete, Interface treatment and overlay construction, IRC specifications, Determination of job mix formula, Types of Mix plants, Introduction to Mechanical Mixers, Pavers, spreaders and Finishes.
5. Cement Concrete Construction : Construction of Cement roads, Manual and Mechanical methods, Use of distributed steel reinforcement, interlocking block pavements, construction : interlocking block pavements, joints in concrete and reinforced concrete pavements and overlay construction, Drainage, Maintenance of roads, Construction of: Hill Roads, Desert Roads and Roads in swampy & Water-logged Areas and Black cotton Soils, Bridge construction and Inspection Equipment.- related equipment.
6. Quality Control : Introduction, Requirements of a Highway Project, Pre requisite, Specifications and Code of Practice, Quality assurance, Quality Control - ISO 9000, Elements of Quality Assurance System, Distinguish Quality Assurance & Quality Control, Sampling techniques, Tolerance & Controls related to profile and compaction, methods in quality control.



**References :**

1. Pavement and surfacings for Highway & Airports, Micheal Sargious, Applied science Publishers Limited.
2. IRC Codes for Flexible and Rigid Pavements design
3. Highway Engineering, Paul H.Wright, Karen K.Dixon, John Wiley & Sons, 7<sup>th</sup> edition, 2004.
4. Construction planning, Equipment and methods, Pourifoy R.C. and C.J.Shexnaydr, McGraw Hill, 2002
5. The Asphalt Handbook, MS-4, Asphalt Institute, Maryland, 1989
6. IRC: Special Publication 11, Handbook on Quality Control for Construction of Roads and Ruwaways, IRC, 1988
7. Specifications for Hotmix plant, IS:5890-1970 and IS:3066-1965, New delhi



II SEMESTER

**Pavement Evaluation, Maintenance and Management**

1. Pavement Inventories and Evaluation : Purposes of Pavement Evaluation, Functional Evaluation: Serviceability concepts, Distress types: Bituminous and Concrete pavements; Visual Rating; Pavement serviceability Index ; Methods for Measuring Roughness: Response type & Profile type; IRI: Quarter Car Model, Riding Number ; Pavement Safety Evaluation: Skid Resistance, Factors affecting, measurement of skid, methods measurement of skid resistance, Change of Skid resistance with time, traffic and climate; Control of Skid Resistance; Distress Modes - Cracking, Rutting etc;
2. Structural Evaluation: Pavement Deflection - Different Methods of NDT (Working Principles): Benkelman Beam, LaCroix Deflectometer, Dynaflect, Road Ratar, Rolling Dynamic Deflectometer, Loadman, Different Types of Falling Weight Deflectometers (FWD) for evaluation of rigid and flexible pavements; Factors influencing deflections, Back-calculation of Pavement Layer Moduli and detection of loss of bonding of cement concrete pavements using FWD data; Destructive Structural Evaluation; Pavement Performance Prediction Models for Flexible and Rigid Pavements.
3. Pavement Management System (PMS): Components of PMS and their activities; Major steps in implementing PMS; Inputs; Design construction and maintenance; Rehabilitation and Feedback systems; Examples of HDM and RTIM packages; Evaluating alternate strategies and Decision criteria based on Structural section, Material type, Construction policy, maintenance policy, Overlay and seal coat; Pavement performance prediction models; Techniques and Tools, Expert Systems and Pavement Management.
4. Pavement Maintenance Management: Components of maintenance management and related activities - Network and project level analysis - Budgeting; Prioritization Techniques and Formulation of Maintenance Strategies, Pavement Preservation.
5. Pavement Life Cycle Cost Analysis (LCCA): Cost Components, Methods of LCCA -Components involved, Brief Description - Items considered - Case studies.
6. Maintenance: Need of Highway maintenance, methods of maintenance of flexible and rigid pavement layers; WBM, Bituminous and Cement Concrete pavements.



**References :**

1. Haas and Hudson W.R. Pavement management systems - McGraw Hill publications
2. Sargious, M.A. - Pavements and surfacing for highways and airports - Applied Science Publishers Ltd.
3. Bridge and Pavement maintenance - Transportation Research Record No.800, TRB
4. Shahin M.Y.1994 - Pavement Management for airports, roads and parking lots
5. Bent Thagesan, 1996 - Highway and Traffic engineering for developing countries
6. Principles of Pavement Design, Yoder J. & Witzac Mathew W., John Wiley & Sons.
7. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc.
8. Hand Book of Highway Engineering, Rober F. Baker, Editor, L. G. Byrd D. Grant Mikle, Associate Edotor, Van Nostrand Reinhold Comp, 1975.
9. Relevant IRC Code books
10. AASHTO Guide for Design of Pavement Structures, published by American Association of State Highway and Transportation Officials, 1993.



II SEMESTER

**Transportation Systems and Management**

**ELECTIVE - III**

1. **TSM Philosophy:** Systems approach to Transportation Planning; Long Term Strategies and short term Measures; TSM actions - Objectives and Philosophy; Relevance of TSM actions to Indian Urban Context Broad spectrum of TSM action.
2. **Traffic Management Measures :** Measures for Improving Vehicular Flow - One way streets, Signal Improvements, Transit Stop relocation, Parking management, Reversible lanes; Reducing Peak Period Traffic - Staggering of working hours, Congestion pricing, differential Toll Policies
3. **Measures to Promote Transit :** Preferential Treatment to High Occupancy Vehicles; Car pooling; Transit service Improvement Measures; Transit management Improvement measures; Transit and Para Transit Integration; Para-transit Role in Urban Areas; Multi modal coordination
4. **Bus Route Network Planning and Management :** Types of Bus Route Networks suitability for a given Urban Area; Types of Routes - Corridor Routes, Activity Routes and Residential Routes; Issues in Route Network Evaluation - Number of Routes, Length of Routes; Route Alignment Methods; Service Coverage and Accessibility Index.
5. **Promotion of Non-Auto Modes :** Measures to Promote Non-Auto modes; Pedestrianisation; Bicycle Transportation - Advantages; planning Bicycle facilities - Class I, Class II and Class III Bikeways; Junction Treatments for Cycle Tracks; LOS criteria for pedestrian and Bicycle facilities.
6. **Advanced Transit Technologies :** Conventional and Unconventional Systems; Rapid Transportation Systems; New Technologies - LRT, Monorail, Automated Highways Hovercraft; System characteristics and suitability.

**References :**

1. Transportation System Management Notes, S.Ragvachari, REC, Warangal.
2. Metropolitan Transportation Planning, John W Dickey, Tata McGraw Hill
3. The Bicycle Planning, Mike Hudson, Open Rocks UK



II SEMESTER

Principles of Bridge Engineering  
ELECTIVE - III

1. **Concrete Bridges :** Introduction -Types of Bridges -Economic span length Types of loading-Dead load-live load-Impact Effect -Centrifugal force-wind loads-Lateral loads-Longitudinal forces-Seismic loads-Frictional resistance of expansion bearings-Secondary Stresses-Temperature Effect-Erection. Forces and effects-Width of roadway and footway-General Design Requirements.
2. **Solid slab Bridges :** Introduction-Method of Design: Solid Slabs Spanning in One-Direction, Cantilever; Dispersion of Loads Along the Span. Design Principles of Solid Slab Bridge with numerical examples.
3. **Girder Bridges:** Introduction, Method of Design: Pigeaud's Theory and Courbon's Theory with numerical examples as per IRC class AA tracked vehicle, Class AA wheeled vehicle, Class A loading.
4. **Continuous Bridges :** Introduction-Span lengths -Analysis of continuous bridges-Decking of girders with constant Moment of Inertia-Continuous bridges with variable Moment of Inertia-Method of Analysis-Girders with Parabolic Soffit -Method of plotting Influence lines-Girders with straight Haunches-Design steps for continuous Bridges.
5. **Analysis of Bridge Decks :** Harmonic analysis and folded plate theory -Grillage analogy -Finite strip method and FEM.
6. **Sub-structure of bridges :** Substructure -Beds block-Piers-Pier Dimensions-Design loads for piers -Abutments -Design loads for Abutments.
7. **Pre-Stressed Concrete Bridges :** Basic principles -Method of Pre-stressing -Pre-tensioning and Post-tensioning - Comparison - Freyssinet Method -Mangel-Blanet System -Lee-Mc call system -Basic Assumptions - Losses in Prestress equation based on Initial and final stress conditions -Cable Zone -Design of sections-Condition of first crack-Ultimate load design-Shear-Vertical Prestressing -Diagonal Tension in I-section-End Block -Mangel's method-Empirical Method-
8. **General Design requirements:** Mild steel reinforcement in prestressed concrete member-concrete cover and spacing of pre-stressing steel-slender beams-composite Section-Propped-Design of propped Composite Section-Unpropped composite section-Two-stage Prestressing -shrinking stresses -General Design requirements for Road Bridges With Numerical Examples.

**References :**

1. Design of Concrete Bridges by M. G. Aswani, V. N. Vasirani and M. M. Ratwani
2. Bridge Deck Behaviour by E. C. Hambly
3. Concrete Bridge Design and Practice by V. K. Raina



II SEMESTER

**Environmental Impact Assessment for Transportation Projects**  
**ELECTIVE - III**

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 Limitations of EIA.
2. **Environmental Indicators :** Indicators for climate - Indicators for terrestrial subsystems Indicators for aquatic subsystems - Selection of indicators - Socio-economic indicators - Basic information - Indicators for economy - Social indicators - Indicators for health and nutrition - Cultural indicators - Selection of Indicators.
3. **Environmental Impact Assessment For Transportation Projects :** Basic Concepts Objectives, Transportation Related Environmental Impacts - Vehicular Impacts - Safety & Capacity Impacts - Roadway Impacts - Construction Impacts, Environmental Impact Assessment - Environmental Impact Statement, Environment Audit, Typical case studies.
4. **Environmental Issues in Industrial Development :** On-site and Off-site impacts during various stages of industrial development, Long term climatic changes, Green house effect, Industrial effluents and their impact on natural cycle, Environmental impact of Highways, Mining and Energy development.
5. **Methodologies for carrying Environmental Impact Assessment :** Overview of Methodologies Adhoc, Checklist, Matrix, Network, Overlays, benefit Cost Analysis, Choosing A methodology, Review Criteria.

**References :**

1. Jain, R. K. Urban, L.V., Stracy, G.S., (1991), "Environmental Impact Analysis", Van Nostrand Reinhold Co., New York.
2. Rau, J. G. and Wooten, D.C., (1996), "Environmental Impact Assessment", McGraw Hill Pub. Co., New York.
3. UNESCO, (1987), "Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development", UNESCO/UNEP, Paris.
4. Canter, L.W., (1997), "Environmental Impact Assessment", McGraw Hill Pub. Co., New York.



II SEMESTER

Advanced Modeling Techniques in Highway Engineering  
ELECTIVE - IV

1. Introduction to Artificial Intelligence (AI), Significance of AI in Transportation Engineering and uses of AI for solution of Transportation Engineering problems. Comparison between statistical methods and various AI techniques.
2. Fuzzy-logic: Introduction to Fuzzy-logic, merits and limitations of Fuzzy-logic, crisp sets: types and properties of crisp sets, Partition and covering, Fuzzy sets: membership function, basic fuzzy set operations, Fuzzy Relations, Fuzzy Logic applications in Highway Engineering.
3. Artificial Neural Networks (ANN): Introduction to Artificial Neural Networks (ANN), merits and limitations of ANN, Model of an Artificial Neuron, Neural Network Architectures: Single layer, Multi-layer feed-forward and Recurrent Networks, Learning methods (in Brief), Back-propagation Technique: Single and multi layer feed-forward Neural Network, Backpropagation learning, Computations of Input, hidden and output layers, Calculation of error, Training of Neural Network, method of steepest descent and applications of Back-propagation Learning Algorithm in Highway Engineering.
4. Genetic Algorithms (GA): Basic concepts of Genetic Algorithms (GA), Working Principle, types of Encoding, cross-over, Fitness function, Methods of Reproduction (in brief) and Applications of GA in Highway Engineering.
5. Expert Systems (ES): Introduction to Expert Systems (ES), basic concepts of ES and their Applications in Highway Engineering.

References :

1. Neural Networks, Fuzzy Logic and genetic Algorithms, Synthesis and Applications, by S. Rajasekaran and G. A. Vijayalakshmi Pai, Prentice hall of India Pvt. Ltd. New Delhi, 2003.
2. Fuzzy Logic With Engineering Applications, Timothy J. Ross, Mcgraw-Hill, 1995.
3. Artificial Intelligence in Business-Expert System, Harmon P and D. King, John Willey & Sons
4. Relevant IRC and TRB publications.



II SEMESTER

**Airport Planning and Design**  
**ELECTIVE - IV**

1. Airport Planning - Growth of Air Transport, Technological Developments, Institutional Development for Planning, Regulatory Practices; Aircraft characteristics related to airport planning and design, Future trends in Air craft design and Airport Planning; Airport master plan, site selection, planning surveys etc. Airport Obstructions: Zoning Laws, Classification, Approach and Turning Zones.
2. Runway Design: Runway Orientation, Basic Runway Length and Factors affecting, Correction for elevation, temperature and gradient as per ICAO and FAA, Run way Geometric Design.
3. Airport Capacity: Classification and Standards; Capacity of Airport, Runway, Taxiway and Gate; Delays; Configuration of Airport and Configuration; Runway Intersection Design; Terminal Facilities and Standards: Planning Concepts.
4. Taxiway Design: Factors affecting Taxiway Design, Geometric Design as per ICAO, Exit taxiways, Fillets, Separation clearance, Holding Apron, Turn Around.
5. Design of Airport Pavements: Design factors, Calculation of ESWL with different wheel load configurations and methods, Repetition of loads, failure criteria; Flexible Pavements Design: US corps of Engineers Method, FAA method; Rigid Pavement Design methods: US corps of Engineers method, PCA Method, FAA method, LCN Method and CAN-PCN System.; Overlays; Drainage: Surface and subsurface methods, filter materials, Special characteristics and requirements of Airport Drainage.
6. Airfield Pavement Maintenance and Rehabilitation : Need, Failures, Evaluation of flexible and Rigid Pavements, Strengthening of Airfield Pavements and maintenance operations.
7. The Demand Analysis, Microanalysis of Air Travel Demand, Calibration of Macro analysis of Air Travel Demand, Disaggregate Models Route Frequency planning. Air travel choice Models, Simultaneous Models of Demand and supply. Optimal Route Frequency Planning.
8. Air Traffic Controls (ATC): Visual Aids: marking and lighting; Need, Network and Aids for ATC, Radio equipment; Design of Heliports and STOLPORTS: Design Factors, Planning, Site selection, Geometric Designs, Visual Aids.



# References:

1. Principles of Pavement Design, Yoder E.J. and Witczak M. W. John Wiley & Sons, 1975.
2. Elementary Hand Book of Aircraft Engines, A. W. Judge, Chapman and Hall Ltd, London.
3. Airplanes Structures, A.S. Niles and J.S. Newell, M. W. John Wiley & Sons, New York.
4. Relevant IRC codes.
5. Air Port Engineering, Norman Ashford and Paul H Wright, M. W. John Wiley & Sons.
6. The Planning and Design of Airports, Robert Horojeff, McGraw Hill Book Co.
7. Airport Planning and Design, S. K. Khanna, Arora and S.S. Jain, Nem Chand & Bros. Roorkee.



II SEMESTER

**GIS Applications in Transportation Engineering  
ELECTIVE - IV**

1. **Introduction to GIS :** Introduction, GIS over view, use of GIS in decision making, Data processing, components of GIS, The GIS and the organization
2. **Data Input and Output :** Data input - Key board entry, Manual digitizing, scanning, Remotely and sensed data, existing digital data, census related data sets, Data output - Hard copy and soft, copy devices.
3. **Data Quality :** Components of data quality - Micro level, Macro level components, Sources of error, A note about data accuracy.
4. **Data Management :** The data base approach, 3 classic data models, Nature of geographic data, spatial data models, Databases for GIS
5. **GIS Analysis and Functions :** Organizing geographic data for analysis, Maintenance and analysis of the spatial data and non-spatial attribute data and its integration output formatting.
6. **Implementing a GIS :** 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.
7. **Application of GIS in Transportation Engineering -I :** Intelligent information system for road accessibility study, GIS data base design for physical facility planning, Decision support systems for land use planning.
8. **Application of GIS in Transportation Engineering - II :** GIS applications in environment impact assessment, GIS based Highway alignment, GIS based road network planning, GIS based traffic congestion analysis and accident investigation

**References :**

1. GIS for Urban & Regional Planning, Scholten & Stillwen 1990, Kulwer Academic Publisher
2. GIS A Management, Perspenfisent Stan Aronoff, WDL Publisher
3. GIS by Stonffer
4. Hand book of T.E. Myer Kutz, Editor McGraw Hill, 2004.



II SEMESTER

**HIGHWAY ENGINEERING LAB - II**

**I. Tests on Bituminous Mixes:**

1. Marshall Mix method, using following binders
  - a) Bitumen
  - b) Tar-bitumen
  - c) Rubberised tar and bitumen
  - d) Polymer modified Bitumen (PMB)
2. Determination of Creep Compliance and Strength of Hot Mix Asphalt (HMA)  
Using Indirect Tensile Test Device or Diametral Static Creep Test
3. The Confined Static Creep Test (also known as the Triaxial Creep Test)
4. Introduction to Superpave Bituminous Mix Design Technology.

**II. Tests on Cement Concrete Mixes :**

1. Design of cement concrete mix for Highway construction as per Indian Roads Guidelines.
2. Design of cement concrete mix using fly-ash and admixtures.

**III. Demonstrations (Field Tests)**

1. Measurement of rebound surface deflections using Benkelman Beam
2. Measurement of road unevenness using Automatic Road unevenness recorder (ARUR)
3. Measurement of engineering properties of Highway pavement layers using
  - a) Lodman (or) Portable Falling weight Deflectometer (PFWD)
  - b) Nuclear soil density meter
  - c) Moisture and Temperature probes
  - d) Nuclear Asphalt Content Gauge
  - e) Dynamic Cone Penetrometer (DCP)
4. Axle Load Survey using Portable Weigh-pad

**IV. Software Packages related to Highway Engineering**

1. Primavera
2. MX Roads
3. KENPAVE