



JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India

DEPARTMENT OF CIVIL ENGINEERING

COURSE STRUCTURE & SYLLABUS

M.Tech Highway Engineering Programme

(Applicable for batches admitted from 2019-2020)



JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA



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I - Semester

S.No	Course No	Category	Course Name	L	T	P	C	Marks
1	MHEI-1	Core1	Highway Infrastructure Design	3	0	--	3	100
2	MHEI-2	Core2	Advanced Traffic Engineering	3	0	--	3	100
3	MHEI-3	Elective I		3	0	--	3	100
			a). Applied Statistics					
			b). Project Management					
			c). Bridge Engineering					
4	MHEI-4	Elective II		3	0	--	3	100
			a). Remote Sensing & Global Positioning Systems					
			b). Engineering of Ground					
			c). Advanced Concrete Technology					
5	MHEMC		Research Methodology and IPR	2	0	0	2	100
6	MHEPI-1	Lab 1	Highway Engineering Lab	-	0	4	2	100
7	MHEPI-2	Lab 2	Bituminous Testing Lab	-	0	4	2	100
8	MHEA-1	Audit Course –1		2	0	0	0	100
Total Credits /Marks							18	800

II – Semester

S.No.	Course No	Category	Course Name	L	P	C	Marks
1	MHEII-1	Core 3	Pavement Analysis & Design	3	--	3	100
2	MHEII-2	Core 4	Pavement Construction, Maintenance & Management	3	--	3	100
3	MHEII-3	Elective III		3	--	3	100
			a). Highway Safety Engineering				
			b). Land use and Transportation Modeling				
			c). Transportation Systems and Management				
4	MHEII-4	Elective IV		3	--	3	100
			a). Environmental Impact Assessment for Transportation Projects				
			b). GIS Applications in Transportation Engineering				
			c). Highway Project Formulation and Economics				
5	MHEPII-1	Lab 3	Advanced Highway Engineering Lab	--	4	2	100
6	MHEPII-2	Lab 4	Transportation Simulation Lab	--	4	2	100
7	MHEMP	Core	Mini Project with Seminar	0	4	2	100
8	MHEA-2	Audit Course -2		2	0	0	100
Total Credits /Marks						18	800



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III - Semester

S.No	Course No	Category	Course Name	L	T	P	C	Marks
1	MHEIII-1	Elective-V		3	--	--	3	100
			a). Urban Transportation					
			b). Traffic Flow Analysis					
			c). Road Safety Engineering					
2	MHEIII-2	Open Elective	Open Elective /MOOCS** a). Composite Materials b). Industrial Safety c). Operations Research	3	--	--	3	100
3	DISSERTATION	Core	Dissertation Phase-I / Industrial Project (To be continued and Evaluated next Semester)*	--	--	20	10	--
Total Credits /Marks				16			200	

* Evaluated and displayed in 4th Semester marks list

** Students Going for Industrial Project / Thesis will complete these courses through MOOCS

IV- Semester

S. No.	Course No	Category	Course Name	L	T	P	C	Marks
1	DISSERTATION	Core	Dissertation Phase II (Continued from III Semester)	0	0	32	16	100
Total Credits /Marks							16	100

Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.



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I Year - I Semester		L	T	P	C
		3	0	0	3
HIGHWAY INFRASTRUCTURE DESIGN					

UNIT-I:

Highway Cross Section Elements and 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. 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.

UNIT-II:

Horizontal and Vertical Alignment: Objectives of horizontal curves; Super elevation – Need for Super elevation; Method of computing super elevation; Minimum Radius of Curve; Methods of attainment of super elevation; Extra widening on Curves; Transition Curves – Objectives and Design. 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 Distances – Stopping Sight Distance, Overtaking Sight Distance and Intermediate Sight Distance; Importance of Sight Distances for Horizontal and Vertical Curves.

UNIT-III:

Intersection Design: Types of Intersections; Design Principles for Intersections; Design of At-grade Intersections – Channelisation, Objectives; Traffic Islands and Design standards; Rotary Intersection – Concept and Design, Advantages and Disadvantages; Grade separated Interchanges – Types, warrants and Design standards.

UNIT-IV:

Traffic Signs and Road Markings : Types of Road Signs; Guidelines for the provision of Road Signs; Cautionary Signs, Regulatory Signs, Information Signs – Design standards; Road markings – Objectives of Road Markings; Types of Road Markings; Role of Road markings in Road Safety and Traffic Regulation; Specification for Road Markings. Highway Appurtenances – Delineators, Traffic Impact Attenuators, Safety Barriers.

UNIT-V:

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.



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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.Kadiyali, 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.

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I Year - I Semester		L	T	P	C
		3	0	0	3
Advanced Traffic engineering					

UNIT-I

Basic Aspects of Traffic Engineering Aim of traffic engineering, traffic stream components and characteristics, road user characteristics, vehicle characteristics, acceleration characteristics, measures of quality, measures of separation, relationship among traffic parameters and empirical relationships, mechanics of traffic flow, macroscopic approach, microscopic-approach and human factors approach, discrete distributions, binomial distribution, Poisson's distribution, exponential distribution, normal distribution.

UNIT-II

Traffic Studies, Measurement and Analysis; Volume studies, speed studies, travel forecasting principles and techniques, design hourly volumes and speed, origin and destination studies, presentation of data and analysis, testing of hypothesis relating to improvements.

UNIT-III

Travel Time amid Delay Studies; Various uses, travel time and delay studies, various methods, data collection and analysis, density studies and headways, gap acceptance studies, intersection delay studies, traffic flow theory, queuing theory and simulation models.

UNIT-IV

Capacity Analysis of Traffic Facilities; Uninterrupted facilities, interrupted facilities, Level of Service, quality of service as per HCM, factors affecting LOS, computation of capacity and LOS, Measure of effectiveness, highway capacity and performance characteristics, intersection design.

UNIT-V

Traffic Control, Design and Regulation; Traffic signals, types, principles of phasing, tune diagram, signalized intersection, saturation flow, saturation headway, capacity of lane group, concept of critical lane group, signal timing, phase plan, phase diagram, splitting of phase, clearance interval, pedestrian requirement, guidelines for protected movements, signal co-ordination, emerging themes, inter-modalism, access management, congestion management, environmental impact assessment.



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Suggested Reading

1. Introduction to Traffic Engineering, R. Srinivasa Kumar, Universities Press, 2018.
2. Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, D.C., 2010.
3. Daganzo, C.R, Fundamentals of Transportation and Traffic Operations, Pergamon, Elsevier Science Inc., New York, 1997.
4. Salter, R.J., Traffic Engineering: Worked Examples, Macmillan, London, 1989.
5. Pignataro, L.J., Traffic Engineering: Theory and Practice, Prentice Hall, Englewood cliffs, 1973.
6. Wohl, M. and Martin, B.V, Traffic System Analysis for Engineers and Planners, McGraw Hill, New York, 1983.
7. Drew, D.R., Traffic Flow Theory, McGraw Hill, New York, 1964.

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I Year - I Semester		L	T	P	C
		3	0	0	3
Applied Statistics					

UNIT-I:

Introduction & Sampling Techniques: Frequency distribution; Mean; Standard deviation; Standard error, Skewness; Kurtosis; Definitions and Applications; Simple random sampling; Stratified sampling; Systematic sampling; Sample Size determination; Applications in Traffic Engineering,

UNIT-II:

Statistical Distributions and Probability : Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions; Mean and variance; Chi-square test of goodness-of-fit; Applications in Traffic Engineering. Probability - Laws of Probability; Conditional probability and Independent events; Laws of expectation.

UNIT-III:

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.

UNIT-IV:

Multi Variate Data Analysis and Exact Sampling 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. Exact Sampling Distributions - Chi-square distribution; Students T-distribution; Snedecor's F-distribution.

UNIT-V:

Tests Of Significance & Confidence Interval – I & II: 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. Tests Of Significance & Confidence Interval

– II -Intervals for mean, variance and regression coefficients; Applications in 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 & Cohens P.R; John Wiley & Sons.



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I Year - I Semester		L	T	P	C
		3	0	0	3
Project Management					

UNIT-I

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.

UNIT-II

Construction Cost and Value Engineering: Types of Estimates, Implementation of Cost Controls, Project Cost Forecasting, Cost Optimisation 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.

REFERENCES:

1. Herold Kerzner - Project Management - A systems approach to Planning, Scheduling and Controlling. CBS 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. Choudhary, S. Project Management, Tata McGraw Hill Publishing Co., Ltd.,
6. Raina UK, Construction management Practices, Tata McGrawhill Publishing Company Ltd.
7. Sengupta B and Guha H, Construction Management and Planning, Tata McGraw-Hill Publishing Company Limited, New Delhi.



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I Year - I Semester		L	T	P	C
		3	0	0	3
Bridge Engineering					

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 culverts- culvert alignment- culvert entrance structure- Hydraulic design and structural design of pipe culverts- reinforcements in pipes .(Ref: IRC: SP-13)

REFERENCES:

1. Design of concrete bridges- Aswini, Vazirani, Ratwani
 2. Essentials of bridge engineering- Jhonson Victor D
- Design of bridges- Krishna Raju



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		3	0	0	3
Remote Sensing & Global Positioning Systems					

UNIT-I:

Remote Sensing Technology : 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. - Remote Sensing Platforms & Sensors - Introduction, Characteristics of imaging remote sensing instruments, satellite remote sensing system – a brief over view , other remote sensing satellites.

UNIT-II:

Pre-Processing and Enhancement Techniques for Remotely Sensed Data: Introduction, cosmetic operation; Geometric correction and registration, atmospheric correction. Enhancement Technique - Introduction, human visual system, contrast enhancement; Pseudo color enhancement.

UNIT-III:

Image Transforms: Introduction, arithmetic operations, empirically based image transforms, Principal component analysis , Multiple discriminant analysis etc.

UNIT-IV:

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.

UNIT-V:

G.P.S.: Introduction, Elements of satellite surveying, the 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 Jurnani, ELBS , 1985.
3. Computer Processing of Remotely sensed Images An Introduction – Paul M.Mather, John Wiley & Sons 1989.



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I Year - I Semester		L	T	P	C
		3	0	0	3
Engineering of Ground					

UNIT-I:

Introduction to Engineering Ground Modification: Need and objectives, Identification of soil types, In situ and laboratory tests to characterise problematic soils; Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods, and their applications.

UNIT-II:

Mechanical Modification – Deep Compaction Techniques- Blasting Vibrocompaction, Dynamic Tamping and Compaction piles.

UNIT-III:

Hydraulic Modification – Objectives and techniques, traditional dewatering methods and their choice, Design of dewatering system, Electro-osmosis, Electro-kinetic dewatering.

Filtration, Drainage and Seepage control with Geosynthetics, Preloading and vertical drains,

UNIT-IV:

Physical and Chemical Modification – Modification by admixtures, Shotcreting and Guniting Technology, Modification at depth by grouting, Crack Grouting and compaction grouting, Jet grouting, Thermal Modification, Ground freezing.

UNIT-V:

Modification by Inclusions and Confinement - Soil reinforcement, reinforcement with strip, and grid reinforced soil. In-situ ground reinforcement, ground anchors, rock bolting and soil nailing.

Text Books

1. Hausmann, M. R. (1990) – Engineering Principles of Ground Modifications, McGraw Hill publications
2. M. P. Moseley and K. Krisch (2006) – Ground Improvement, II Edition, Taylor and Francis

References:

1. Koerner, R. M (1994) – Designing with Geosynthetics – Prentice Hall, New Jersey
2. Jones C. J. F. P. (1985) – Earth Reinforcement and soil structures – Butterworths, London.
3. Xianthakos, Abreimson and Bruce - Ground Control and Improvement
4. K. Krisch & F. Krisch (2010) - Ground Improvement by Deep Vibratory Methods, Spon Press, Taylor and Francis
5. Donald P Coduto – Foundation Design Principles and Practices, 2nd edition, Pearson, Indian edition, 2012.



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		3	0	0	3
Advanced Concrete Technology					

UNIT-I:

Cement and Admixtures : Portland cement - chemical composition – Bogue's compounds - hydration - structure of hydrated cement - mechanical strength of cement gel - water held in hydrated cement paste - heat of hydration of cement - influence of compound composition on properties of cement - different types of cements. Admixtures - Classification – Mineral and chemical admixtures - Classification of mineral admixtures – properties – dosage - uses – Chemical admixtures – classification – properties – uses – High range water reducing agents – effect of dosage – multiple dosage of admixtures and their effects – effects of admixtures in RMC.

UNIT-II:

Aggregates: Classifications of aggregates - particle shape and texture - bond, strength and other mechanical properties of aggregate - specific gravity, bulk density, porosity, absorption and moisture content of aggregate - bulking of sand - deleterious substance in aggregate - soundness of aggregate - alkali-aggregate reaction - thermal properties - sieve analysis - fineness modulus - grading curves - grading of fine and coarse aggregates - gap graded aggregate - maximum aggregate size – combined grading – BIS grading.

UNIT-III:

Fresh Concrete and Hardened Concrete: workability - factors affecting workability - measurement of workability by different tests - effect of time and temperature on workability - segregation and bleeding - Mixing of concrete - different types of mixing – vibration of concrete – revibration – setting times of fresh concrete – steps in manufacture of concrete – quality of mixing water. Hardened Concrete - water/cement ratio - Abram's law – Gel space ratio Maturity concept - effective water in mix - nature of strength of concrete - strength in tension and compression - Griffith's hypothesis - autogenous healing - curing of concrete - influence of temperature on strength - steam curing - testing of hardened concrete – relation between compressive and tensile strength - factors affecting strength - non-destructive testing methods. Durability of concrete - code provisions.

UNIT-IV:

Elasticity, Shrinkage and Creep: Modulus of elasticity – static and dynamic modulus of elasticity - Poisson's ratio - early volume changes - swelling - shrinkage - mechanism of shrinkage - factors affecting shrinkage - differential shrinkage - moisture movement - creep of concrete - factors influencing creep - relation between creep and time - nature of creep - effects of creep in structural concrete – Code provisions – Rheology of creep.



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UNIT-V:

Concrete Mix Design and Special Concrete Issues : factors in the choice of concrete mix proportions – statistical quality control – Acceptance criteria as per IS 456-2000 – various mix design methods for normal concrete – BIS method – Road note no.4 method, ACI method – High strength concrete mix design – durability aspects in concrete mix design as per IS 456-2000. Special Concrete - Light weight concrete – Light weight aggregates – Light weight concrete mix design – Cellular concrete – Fiber reinforced concrete – Different types of fibres – Factors affecting properties of F.R.C. – Applications – Polymer concrete – Types of polymer concrete – Properties of polymer concrete – Applications – High Performance Concrete -Self Compacting concrete – smart concrete.

TEXT BOOKS:

1. Properties of Concrete by A.M.Neville, ELBS publications.
Concrete Technology by M.S.Shetty, S.Chand & Co

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I Year - I Semester		L	T	P	C
		3	0	0	3
Research Methodology and IPR					

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.

References:

- 1.C.R Kothari, "Research Methodology, Methods & Technique", New Age International Publishers, New Delhi, 2004.
- 2.R. Ganesan, "Research Methodology for Engineers", MJP Publishers, Chennai, 2011.
- 3.RatanKhananabis and SuvasisSaha, "Research Methodology", Universities Press, Hyderabad, 2015.
- 4.Y.P. Agarwal, "Statistical Methods: Concepts, Application and Computation", Sterling Publishing Pvt. Ltd., New Delhi, 2004.
- 5.Vijay Upagade and AravindShende, "Research Methodology", S. Chand & Company Ltd., New Delhi, 2009.
- 6.G. Nageswara Rao, "Research Methodology and Quantitative methods", BS Publications, Hyderabad, 2012.



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I Year - I Semester		L	T	P	C
		0	0	4	2
Highway Engineering Lab					

1. Aggregate tests. (Shape, soundness abrasions, impact & creasing)
2. Tests on sub grade soils.
3. Soil stabilization tests.
4. California Bearing Ratio Test
5. Soil Classification & Grain size analysis.
6. Standard procter test
7. Mini project based on field and laboratory studies and data collected.

Note: All tests as per IS, ASTM, AASHTO, TRL, IRC procedures/specifications and guidelines

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		0	0	4	2
Bituminous Testing Lab					

1. Bitumen and Tar Tests as per IS code provisions.
2. Benkelman beam test
3. Stone Polishing Value test
4. International Roughness Index test
5. Mix design for Bituminous mixes
6. Falling Weight Deflectometer.
7. Mini project based on field and laboratory studies and data collected.

Note: All tests as per IS, ASTM, AASHTO, TRL, IRC procedures/specifications and guidelines

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I Year - II Semester		L	T	P	C
		3	0	0	3
Pavement Analysis & Design					

UNIT-I

Pavement Types, 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, AASHTO Method of Flexible Pavement Design, IRC Method for Rigid Pavements, 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 Benkelman Beam Deflection Methods as per IRC – 81 - 1997 – pavements on problematic soils.

REFERENCES:

1. Yoder and Witzorack, "Principles of Pavement Design", John Willey and Sons.
2. Yang, H. Huang, "Pavement Analysis and Design", Prentice Hall Publication, Englewood Cliffs, New Jersey.
3. Sargious, M.A. Pavements and Surfacing for Highways and Airports – Applied science Publishers limited
4. Ralphs Hass and Hudson, W.R. "Pavement Management System" Mc-Graw Hill Book Company.
5. IRC codes of practice.



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		3	0	0	3
Pavement Construction, Maintenance & Management					

Unit I

Pavement Management System: Components of PMS and their activities; Major steps in implementing PMS; Pavement Maintenance Management Components of Maintenance Management and Related Activities – Network and Project Level Analysis; Prioritization Techniques and Formulation of Maintenance Strategies

Unit II

Pavement Inventories and Evaluation : Serviceability Concepts ;Visual Rating ;Pavement Serviceability Index; Roughness Measurements ;Distress Modes – Cracking, Rutting etc; Pavement Deflection – Different Methods, Skid Resistance, Roughness, Safety – Aspects; Inventory System – Assessment of Deficiencies

Unit III

Pavement Maintenance and Quality Control : Causes of Deterioration, Traffic and Environmental Factors, Methods of Maintaining WBM, Bitumen and Cement Concrete Roads, Quality Assurance; Quality Control – ISO 9000 , Sampling Techniques – Tolerances and Controls related to Profile and Compaction

Unit IV

Construction of Base, Subbase, Shoulders and Drain : Roadway and Drain Excavation, Excavation and Blasting, Embankment Construction, Construction of Gravel Base, Cement Stabilised Sub- Bases, WBM Bases, Wet Mix Construction; Crushed Cement Bases, Shoulder Construction; Drainage Surface, Turfing Sand Drains; Sand Wicks; Rope Drains, Geo- Textile Drainage; Preloading Techniques

Unit V

Bituminous Pavement Construction and Cement Concrete Pavement Construction:

Preparation and Laying of Tack Coat; Bituminous Macadam ,Penetration Macadam, Built up Spray Grout, Open Graded Premix, Mix Seal, Semi-Dense Asphalt Concrete-Interface Treatments and Overlay Construction, IRC Specifications, Introducing Mechanical Mixers, Pavers, Finishers ; Cement Concrete Pavement Analysis - Construction of Cement Roads, Manual and Mechanical Methods, Joints in Concrete and Reinforced Concrete Pavement and Overlay Construction –Related Equipment

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
 Bent Thagesan, 1996- Highway and Traffic engineering for developing countries



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I Year - II Semester		L	T	P	C
		3	0	0	3
Highway Safety Engineering					

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 Data:

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.

UNIT V

Mitigation Measures:

Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety; Safety in urban areas; Public transport and safety; Road safety policy making, Stakeholders involvement; Road safety law.

References:

1. Athelstan Popkess, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997 (Digitized 2008)
2. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002).
3. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
4. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
5. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.



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I Year - II Semester		L	T	P	C
		3	0	0	3
Land use and Transportation Modeling					

UNIT-I:

Land Use and Transportation Engineering: Transportation modeling in Planning; Models and their role, Characteristics of Transport demand and supply, Equilibrium of supply and demand, Modeling and decision making, Issues in Transportation modeling and structure of the classic transport model.

UNIT-II:

Land Use Transportation Models: Introduction to Land Use Planning; Relation between Transportation and Land Use Planning; The economic base mechanism and allocation mechanism; Spatial allocation and employment interrelationship; Grain Lowry models.

UNIT-III:

General Travel Demand Models: Aggregate, Disaggregate models ; Behavioral models; Recursive and direct demand Models; Linear, Non-Linear models; Logit, discriminant and probit models; Mode split models - Abstract mode and mode specific models.

UNIT-IV:

Regional Transport Models: Factors affecting goods and passenger traffic; Prediction of traffic; Growth factor models; Time function iteration models; Internal volume forecasting models.

UNIT-V:

Regional Network Planning: Problems in Developing Countries, Network Characteristics - Circuitry, Connectivity, Mobility, Accessibility and Level of Service Concepts - Network Structures and Indices – Network Planning – Evaluation - Graph Theory – Cut sets – Flows & Traversing – Optimum Network - Inter-modal Co-ordination. – Rural Road Network Planning.

REFERENCES

1. Modelling Transport by Jhan De Dios Ortuzar. Luis E. Willumsen. John Wiley & Sons. 1970/1975.
2. Urban Development Models - Ed. By R. Baxter, M. Echenique and J. Owers; The Institute of Transportation Engineering, University of California.
3. Economic Models and Economic Forecast - Robert S. Pindyck, Daniel L. Rubin Field; McGraw Hill.
4. Land Use Transportation Planning Notes - S.R. Chari, REC Warangal.
5. Regional and Urban Models- A.G. Wilson; Pion, London.
6. Urban Modeling - Michael Batty.
7. Behavioral Travel Demand Models - Peter R. Stopher ARNIM.H.MEYBURG.
8. Introduction to Transportation Engineering and Planning, Morlok EK, McGraw Hill



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I Year - II Semester		L	T	P	C
		3	0	0	3
Transportation Systems and Management					

UNIT-I:

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 actions.

UNIT-II:

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.

UNIT-II:

Measures To Promote Transit and Non-Auto Modes: 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. 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.

UNIT-IV:

Bus Route Network Planning And Management: Types of Bus Route Net works; 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.

UNIT-V:

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.R.Chari, REC, Warangal
2. Metropolitan Transportation Planning, John W Dickey, Tata McGraw Hill
3. The Bicycle Planning, Mike Hudson, Open Books, UK



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I Year - II Semester		L	T	P	C
		3	0	0	3
Environmental Impact Assessment for Transportation Projects					

UNIT-I:

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

UNIT-II:

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.

UNIT-III:

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

UNIT-IV:

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

UNIT-V:

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
- Canter, L.W., (1997), "Environmental Impact Assessment", McGraw Hill Pub. Co., New York



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I Year - II Semester		L	T	P	C
		3	0	0	3
GIS Applications In Transportation Engineering					

UNIT-I:

Introduction to GIS and Data Input & Output: Introduction, GIS over view, use of GIS in decision making, Data processing, Components of GIS, The GIS and the organization. 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.

UNIT-II:

Data Quality and Management: Components of data quality - Micro level, Macro level components, Sources of error, A note about data accuracy. Data Management - The data base approach, 3 classic data models, Nature of geographic data, Spatial data models, Databases for GIS.

UNIT-III:

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.

UNIT-IV:

Implementing 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.

UNIT-V:

Application of GIS in Transportation Engineering – I & II: Intelligent information system for road accessibility study, GIS data base design for physical facility planning, Decision support systems for land use planning. 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 Academie Publisher.
2. GIS A Management, Perspenfi Stan Aronoff, WDL Publisher.
3. GIS By Stonffer



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I Year - II Semester		L	T	P	C
		3	0	0	3
Highway Project Formulation and Economics					

Unit I:

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

Unit II:

Transport Projects Formulation and Economic Evaluation of Transportation Plans : - development of cash flow diagrams, Cost and benefit components, Discounting criteria, Preparation of Project, Highway Planning, Traffic infrastructure, Project formulation, Road Network project development - Economic evaluation of Transportation plans; Need for Economic Evaluation; Principles of economic evaluation; Welfare economics; Social costs, Vest change, Rate of return.

Unit III:

Value of Travel time Savings and Accident Costs: 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.

Unit IV:

Basic methods of economic analysis and Project Appraisal : 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. Applications of these methods to highway projects. - Project appraisal by shadow pricing with case studies.

Unit V:

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.; Mc Graw Hill Publishers.
2. Economic Analysis for Highways - Winfrey.R; International TextBook 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.



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I Year - II Semester		L	T	P	C
		0	0	4	2
Lab 3 : Advanced Highway Engineering Lab					

1. Volume Studies – Straight Roads and at Intersections
2. Speed Studies - Spot Speed Studies by Stop Watch, Enoscope and Radar Speed Meter
3. Journey Time and Delay Studies - Floating Car Method
4. Parking Surveys and Parking Turnover Studies
5. Study of Gaps and Lags – Critical Gaps and Lags at Intersections
6. Delay Measurement at Signalised and Unsignalised Intersections
7. Traffic Diversion Analysis using diversion curves.
8. Videography Survey.
9. Road safety Audit.
10. Highway capacity estimation
11. Mini Project based on above studies.

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I Year - II Semester		L	T	P	C
		0	0	4	2
Lab 4 : Transportation Simulation Lab					

1. Driver testing Experiments
2. Intersection designs
3. Signal Design.
4. Origin and Destination Studies
5. Computer Software: Principles of TRIPS, CUBE, Demo Versions, Case studies.
6. Traffic Simulation studies using VISSIM.
7. Cellular applications.
8. Accident Studies.

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II Year -I Semester		L	T	P	C
		3	0	0	3
Urban Transportation					

UNIT-I:

Urban Transportation Problem Travel Demand: Urban Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach. 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, Aggregate and Disaggregate Techniques.

UNIT-II:

Data Collection And Inventories: Collection of data – Organisation 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, Economic data – Income – Population – Employment – Vehicle Owner Ship.

UNIT-III:

Trip Generation and Distribution : UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates. Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models. By- pass Trips.

UNIT-IV:

Mode Choice and Traffic Assignment: Mode Choice Behaviour, Competing Modes, Mode Split Curves, Models and Probabilistic Approaches. Traffic Assignment: Basic Elements of Transport Networks, Coding, Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes, Equilibrium Assignment, Diversion Curves.

UNIT-V:

Plan Preparation And Evaluation: Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities. Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis, Economic Impacts of Transportation.

REFERENCES:

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



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II Year - I Semester		L	T	P	C
		3	0	0	3
Traffic Flow Analysis					

UNIT-I

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, Normalised 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 Behaviour of Traffic Flow, Car-Following Theory, Linear and Non-Linear Car-Following 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, Anti-blocks, 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.



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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 Signalised Intersections, Pedestrian Crossings and Transit scheduling.

REFERENCES:

1. Traffic Flow Theory: A Monograph , TRB Special Report 165
2. Fundamentals of Transportation Engineering – C.S.Papacostas, Prentice Hall India Publication
3. Principles of Highway Engineering and Traffic Analysis – F.L.Mannering&W.P.Kilareski, John Wiley Publishers.
4. Traffic Flow Fundamentals – A.D.May, , Prentice Hall India Publicatio
5. Fundamentals of Traffic Engineering – McShane& Rogers

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II Year -I Semester		L	T	P	C
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Road Safety Engineering					

Unit I:

Fundamentals of Traffic Engineering - Basic Characteristics of Motor-Vehicle Traffic, Highway Capacity, Applications of Traffic Control Devices, Traffic Design of Parking Facilities, Traffic Engineering Studies; Statistical Methods in Traffic Safety Analysis – Regression Methods, Poisson Distribution, Chi- Squared Distribution, Statistical Comparisons.

Unit II:

Accident Investigations and Risk Management, Collection and Analysis of Accident Data, Condition and Collision Diagram, Causes and Remedies, Traffic Management Measures and Their Influence on Accident Prevention, Assessment of Road Safety, Methods to Identify and Prioritize Hazardous Locations and Elements, Determine Possible Causes of Crashes, Crash Reduction Capabilities and Countermeasures, Effectiveness of Safety Design Features, Accident Reconstruction

Unit III:

Road Safety in Planning And Geometric Design: Vehicle And Human Characteristics, Road Design and Road Equipments, Redesigning Junctions, Cross Section Improvements, Reconstruction and Rehabilitation of Roads, Road Maintenance, Traffic Control, Vehicle Design and Protective Devices, Post Accident Care

Unit IV:

Role of Urban infrastructure design in safety: Geometric Design of Roads; Design of Horizontal and Vertical Elements, Junctions, At Grade and Grade Separated Intersections, Road Safety in Urban Transport, Sustainable Modes and their Safety.

Unit V:

Traffic Management Systems for Safety, Road Safety Audits and Tools for Safety Management Systems, Road Safety Audit Process, Approach to Safety, Road Safety Improvement Strategies, ITS and Safety.

References:

1. Traffic Engineering and Transportation Planning – L.R. Kadiyali, Khanna Publishers
2. Fundamentals of Transportation Engineering - C.S.Papacostas, Prentice Hall India.
3. Transportation Engineering – An Introduction, C.Jotin khisty, B. Kent Lall
4. Fundamentals of Traffic Engineering, Richardo G Sigua
5. Handbook of Road Safety measures, second Edition, Rune Elvik, Alena Hoye, Truls Vaa, Michael Sorenson
6. Road Safety by NCHRP



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II Year - I Semester		L	T	P	C
		3	0	0	3
Open Elective: a). COMPOSITE MATERIALS (Common to M. Tech - Soil Mechanics & Foundation Engineering, Highway Engineering, Transportation Engineering, and Environmental Engineering)					

Course Outcome:

At the end of the course the students will be able to:

- Use of different material to design composites
- Use of different techniques to process different types of composites and know the limitations of each process.
- Understand and describe the basic concept and classification of composite.
- Acquire the knowledge in polymer matrix composites and its processing methods.
- Acquire the knowledge in metal matrix composites and its processing methods.
- Acquire the knowledge in ceramics matrix composites and its processing methods.

UNIT I

INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II

REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT III

Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. **Manufacturing of Ceramic Matrix Composites:** Liquid Metal Infiltration – Liquid phase sintering. **Manufacturing of Carbon – Carbon composites:** Knitting, Braiding, Weaving. Properties and applications.

UNIT IV

Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and preregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT V

Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hydrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.



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REFERENCES:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
3. Hand Book of Composite Materials-ed-Lubin.
4. Composite Materials – K.K.Chawla.
5. Composite Materials Science and Applications – Deborah D.L. Chung.
6. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

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II Year - I Semester		L	T	P	C
		3	0	0	3
Open Elective: b). INDUSTRIAL SAFETY (Common to M. Tech - Soil Mechanics & Foundation Engineering, Highway Engineering, Transportation Engineering, and Environmental Engineering)					

OUTCOMES:

- Student can know how to take safety measures in executing works
- Can identify the need for maintenance (or) replacement of equipment
- Can understand the need for periodic and preventive maintenance

UNIT-I

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT-II

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT-III

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT-IV

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one



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machine tool, ii. Pump iii. Air compressor iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT-V

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, Advantages of preventive maintenance. Repair cycle concept and importance.

REFERENCE:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.



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II Year - I Semester	L	T	P	C
	3	0	0	3
Open Elective: c). OPERATIONS RESEARCH (Common to M. Tech - Structural Engineering & Structural Design, Soil Mechanics & Foundation Engineering, Highway Engineering, and Transportation Engineering)				

OUTCOMES:

At the end of the course, the student will be able to

- Formulate a linear programming problem for given problem and solve this problem by using Simplex techniques
- apply the dynamic programming to solve problems of discrete and continuous variables
- apply the concept of non-linear programming for solving the problems involving non-linear constraints
- carry out sensitivity analysis
- model the real world problem and simulate it

UNIT-I

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT-II

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT-III

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT-IV

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT-V

Competitive Models, Single and Multi-Channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

REFERENCE:

1. Kanthi Swarup, P.K. Gupta and Man Mohan, Operations Research, 14 th Edition, Sultan Chand and Sons, New Delhi, 2008.
2. S. D. Sharma, Operations Research, Kedar Nath and Ram Nath, Meerut, 2008.
3. H.A. Taha, Operations Research, An Introduction, PHI, 2008
4. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
5. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
6. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
7. Pannerselvam, Operations Research: Prentice Hall of India 2010
8. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010