Scheme and Syllabus

POSTGRADUATE DEGREE COURSE

M.Tech.

Transportation Engineering

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

With Effective from Session 2020-21

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Students of the Programme will be prepared to develop a solid foundation in mathematical, scientific and engineering fundamentals required to formulate, analyse and solve transportation engineering related problems.
2. Students of the Programme will be able to observe and examine critically and take professional decisions as per local and global needsand will have aptitude to pursue further higher education and research in transportation engineering discipline
3. Students of the Programme will contribute for the development of transportation infrastructure that is sustainableand will continue to learn to harness evolving technologies.
4. Studentsof the Programme will be professional Transportation Engineers with ethical and societal responsibility with aptitude of lifelong learning.

PROGRAMME OUTCOMES (POs)

Post-Graduates of the Transportation Engineering Programme will be able to:

a) Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to efficiently manage Transportation Engineering projects in multidisciplinary environments after consideration of public health, safety, cultural, societal, environmental, economic and financial factors

b) Evaluate, analyse and synthesise existing and new knowledge and integrate the same for solution offamiliar and unfamiliar problems in transportation engineering

c) Apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually and in groups to the development of scientific and technological knowledge in Transportation Engineering.

d) Create, select, learn and apply appropriate techniques, resources, and modern engineering tools such as CAD, GISetc including prediction and modeling to complex Transportation Engineering activities with an understanding of the limitations

e) Communicate effectively and confidently on complex Transportation Engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
I Semester

SN	Category	Course		Contact hrs./ week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PCC	1MTR1-01	Transportation Planning	3		-	3	30	70	**100**	**3**
2	PCC	1MTR1-02	Advanced Highway Material Characterization	3		-	3	30	70	**100**	**3**
3	PEC	1MTR2-11	Railway, Airports, Ports and Harbours	3	0	0	3	30	70	100	**3**
4		1MTR2-12	Statistical Methods in Transportation Engineering								
5		1MTR2-13	Road transport management and economics								
6	PEC	1MTR2-14	Management of quality and safety in highway construction	3	0	0	3	30	70	100	**3**
7		1MTR2-15	Tunnel engineering								
8		1MTR2-16	Geometric Design								
9	MCC	1MCC3-21	Research Methodology & IPR	2	-	-	2	30	70	**100**	**2**
10	PCC	1MTR1-06	Highway Material Testing Laboratory	-	-	4	-	60	40	**100**	**2**
11	PCC	1MTR1-07	Pavement Design Laboratory	-	-	4	-	60	40	**100**	**2**
12	SODECA	1MTR5-00	SODECA	-	-					**100**	**0.5**
		TOTAL								**800**	**18.5**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
II Semester

SN	Category	Course		Contact hrs./ week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PCC	2MTR1-01	Pavement Analysis, Design and Construction	3	-	-	3	30	70	**100**	**3**
2	PCC	2MTR1-02	Traffic Engineering & Modeling	3	-	-	3	30	70	**100**	**3**
3	PEC	2MTR2-11	Transportation-Environment Interaction and Analysis	3	0	0	3	30	70	100	3
4		2MTR2-12	Urban Mass Transportation System								
5		2MTR2-13	Sustainable Construction Engineering								
6	PEC	2MTR2-14	Road construction equipment	3	0	0	3	30	70	100	3
7		2MTR2-15	Pavement Maintenance and Management System								
8		2MTR2-16	Planning, Design and Construction of Rural Roads								
9	MCC	2MCC3-XX	Audit Course-I								
10	PCC	2MTR1-06	Traffic engineering lab	-	-	4	-	60	40	**100**	**2**
11	PCC	2MTR1-07	Statistical and Numerical analysis lab	-	-	4	-	60	40	**100**	**2**
12	REW	2MTR4-50	Mini project with Seminar	-	-	4	-	60	40	**100**	**2**
14	SODECA	2MTR5-00	Social Outreach discipline & Extra Curriculum Activities							**100**	**0.5**
		TOTAL								**800**	**18.5**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
III Semester

SN	Category	Course		Contact hrs./week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PEC	3MTR2-11	Remote sensing and GIS	3	0	0	3	30	70	100	3
		3MTR2-12	Advanced Concrete Technology								
		3MTR2-13	Ground improvement technique								
2	MCC	3MCC3-XX	Open Elective (Choose from attached list)	3	-	-	3	30	70	**100**	**3**
3	MCC	3MCC3-XX	Audit Course-II								
4	REW	3MTR4-60	Dissertation phase I - Industrial project	0	0	x	-	240	160	**400**	**10**
		TOTAL								**600**	**16**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
IV Semester

SN	Category	Course		Contact hrs./week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	REW	4MTR4-70	Dissertation II	0	0	x	-	360	240	**600**	**16**
		TOTAL								**600**	**16**

TRANSPORTATION ENGINEERING
1MTR1-01: TRANSPORTATION PLANNING

Course Objectives:

- To learn the fundamentals of transportation planning
- To understand the classical methods of urban transportation planning
- To be acquainted with the transportation landuse interaction

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction to transportation planning:** Fields of transportation Engineering; System- Environment Ensemble; Transportation planning process; Transportation problems and problem solving process.	7
3	**Transportation data and survey methods:** Type of Transportation data and its sources, Data quantity and quality, Accuracy and Precision, Sampling techniques, sample sizes, Transportation Planning surveys – Documentation searches, Person surveys, Household surveys, In-transit surveys, Road-side surveys, etc.	8
4	**Transportation Modes and Technologies:** Technologies of Transport and System Components, Network Analysis; Minimum Path Algorithms, Path Characteristics, Path-Vehicle Interaction – Discrete Flows and Continuous Flows, Vehicle and its Performance, System Performance, Vehicle and Container, Weight to Volume relation, Terminal Planning, Operational Planning.	8
5	**Four-stage Sequential Planning:** Urban transportation planning process; trip generation, correlation analysis and regression analysis; trip distribution, Growth factor methods and Synthetic methods; modal split models, first generation, second generation, behavioural models; minimum travel path computations; Trip assignments, route assignment, multiple assignment and network assignment.	8
6	**Land use–Transportation Planning:** Urban Forms, mobility and activity hierarchy; accessibility-based early-era models; Lowery's model and its derivatives; Modern era models.	8
	Total	**40**

Textbooks:

1. B. G. Hutchinson, "Principles of Urban Transport Systems Planning" Scripta Book Co., Washington – 1974
2. Anthony J. Richardson, Elizabeth S. Ampt and Arnim H. Meyburg, "Survey Methods for Transport Planning" Eucalyptus Press, Australia- 1995
3. Roy Thomas, "Traffic Assignment Techniques", Avebury Technical, Aldershot, England – 1991

Reference books:

1. C A O'Flaherty, ed , "Transport Planning and Traffic Engineering", Butterworth Heinemann, Elsevier, Burlington, MA - 2006

2. C Jotin Khisty and B Kent Lall, “Transportation Engineering – An Introduction”, Prentice Hall of India Pvt Ltd., New Delhi -2003

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand urban activity system and travel patterns
- know four stage travel demand modeling
- define the classical methods of urban transportation planning

TRANSPORTATION ENGINEERING
1MTR1-02: Advanced Highway Material Characterization

Course Objectives:

- To study the properties and characteristics of aggregate and soil.
- To be introduced to the bitumen sources and its manufacturing, constituents, structure and Rheology, Mechanical and engineering properties and tests on bitumen, Emulsions and Tar
- To learn the procedure for bituminous and PCC mix design

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Aggregates:** Classification, physical and strength characteristics, proportioning of aggregates, Aggregate texture and skid resistance, polishing of aggregates.	7
3	**Soil:** Classification, Structural and Constructional problems in soil subgrade, Identification and strength tests, Soil-moisture movement, Sub-soil drainage, Soil stabilization, Characteristics and use of Fly Ash, Bottom ash and Pond Ash	8
4	**Bitumen:** Bitumen sources and manufacturing, Bitumen constituents, structure and Rheology, Mechanical and engineering properties of bitumen, Tests on bitumen, Emulsions, Tar – Properties, types, modifications, Durability of bitumen, Adhesion of bitumen, Modified bitumen.	8
5	**Bituminous Mixes:** Desirable properties of mixes, Design of bituminous mixes, Tests on bituminous mixes, Fillers, Theory of fillers and specifications. Marshall, Hubbard Field & Hveam Methods.	8
6	**Cement Concrete:** Constituents and their requirements, Physical, plastic and structural properties of concrete, Factors influencing mix design, Design of concrete mixes for DLC and PQC with appropriate admixtures like flyash and high range water reducing admixtures etc.	8
	Total	**40**

Textbooks:

1. Krebs, Robert D. And Walker, R. D., “*Highway Materials*”, McGraw Hill Book Co., New York-1971

2. Her Majesty's Stationery Office, "*Soil Mechanics for Road Engineers*", Ministry of Transport, Road Research Laboratory, UK- 1966
3. Her Majesty's Stationery Office, "*Bituminous Materials in Road Construction*", Ministry of Transport, Road Research Laboratory, UK -1966
4. Her Majesty's Stationery Office, "*Concrete Roads Design and Construction*", Ministry of Transport, Road Research Laboratory, UK-1966

Reference books:

1. Read, J. And Whiteoak, D., "*The Shell Bitumen Handbook*", Fifth edition, Shell Bitumen, Thomas Telford Publishing, London-2003
2. Relevant IRC and IS codes

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the properties and characteristics of aggregate and soil subgrade .
- know bitumen sources and its manufacturing, constituents, structure and Rheology, Mechanical and engineering properties and tests on bitumen, Emulsions, and Tar
- do bituminous and PCC mix design

TRANSPORTATION ENGINEERING
1MTR2-11: RAILWAY, AIRPORTS, PORTS AND HARBOURS

Course objectives

- To understand the various modes of transportation with their relative merits and demerits.
- To explain the factors affecting development of railways, airports and harbours and ports and role of various elements in their planning.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Railway: Transportation and its development, Long term operative plans for Indian Railways. Classification of Railway lines and their track standards, Railway terminology, Traction and tractive Resistance, Hauling capacity and tractive effort of locomotives, different Types of Tractions. Permanent Way: Alignment Surveys, Requirement, gauges, track section, Coning of wheels, Stresses in railway track, high speed track. Geometric design of railway track, Gauge, Gradient, speed, super elevation, cant deficiency, Negative super elevation, curves, length of transition curves, grade compensations.	15

3	Airports: Development of Air Transportation in India :, Airport site election. Modern aircraft's. Airport obstructions: Zoning Laws, Imaginary surfaces, Approach and Turning zone, clear zone, vert. Clearance for Highway & Railway. Runway and taxiway design : Windrose, cross wind component, Runway Orientation and confuguration. Basic runway length and corrections, runway geometric design standards. Taxiway Layout and geometric design standards. Taxiway and other areas. Air traffic control : Need, Network, control aids, Instrumental landing systems	14
4	Ports and Harbours: Importance of ports and harbours. Impact on Indian trade and economy, Plan of harbour, various components, jetty, dolphins, bollards, their design and functions.	10
	Total	**40**

Textbooks:

1. Railway Engineering, Saxena;, Dhanpat Rai Publication,
2. Airport Planning & Design, Goyal & Praveen Kumar, Galgotia Publication
3. Harbour, Dock And Tunnel Engineerin, R. Srinivasan ,Charoter publishing house

Reference books:

1. Railway Engineering by Rangwala
2. Airport Engineering Planning And Design (Pb 2020) by SAXENA S.C.

Course outcomes:

After completion of this course the student will be able to

- List, explain and compare the various modes of transportation with their relative merits and demerits.
- List and discuss on factors affecting development of railways, airports and harbours and ports and explain on elements in railways, airports and harbour and port planning.

TRANSPORTATION ENGINEERING
1MTR2-12: STATISTICAL METHODS IN TRANSPORTATION ENGINEERING

Course Objectives:

- To learn the different numerical techniques
- To be introduced to the fundamentals of probability
- To know the concepts of sampling and regression

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Probability distributions:**Introduction to probability and random variables, Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Normal distribution, Log-Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution, and Weibull distribution.	7
3	**Parameter Estimation and hypothesis Testing:** Random samples, sampling distributions of mean and variance. Point estimators, the method of maximum likelihood, and the method of moments. Confidence interval. Statistical hypothesis tests, Operations characteristic curve. Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions, The paired t-test, Tests of hypothesis on one variance, Tests of hypothesis for the equality of two variances, The testing of goodness of fit.	12
4	**Design and Analysis of Experiments:** Fundamental assumptions of analysis of variance, single factor experiments, Latin square and Greeco-Latin square designs, Design of experiments with several factors- Two factor factorial experiments.	10
5	**Regression and Correlation Analysis**: Introduction, Bi-Variate Normal distribution and the associated marginal and conditional distributions, estimation and analysis of simple regression models, correlation coefficients, analysis of correlation coefficients, Hypothesis tests associated with regression and correlation coefficients, curvilinear regression models, Multiple regression models, multiple and partial correlation coefficients. Applications should be taken from transportation planning and traffic engineering.	10
	Total	**40**

Textbooks:

1. Hines, W. W. and Montgomery, D. C., et. al.; "Probability and Statistics in Engineering andManagementScience", John Wiley and Sons, New York, (1990).
2. Freund, J. E.; "Mathematical Statistics", PHI, New Delhi, (1998)
3. Montgomery, D. C.; "Design and Analysis of Experiments", 5th edition, John Wiley and Sons,INC., New York. (2007).

Reference books:

1. Johnston, J. and Dinardo, J.; "Econometric Methods", 4th edition, McGraw-Hill InternationalEditions,

(1997).

2. Benjamin, J. R. and Cornell, C. A.; “Probability Statistics and Decision for Civil Engineers”,McGraw-Hill, (1960).

Course Outcomes:

Upon completion of this course, the students should be able to:

- apply the different numerical techniques to transportation problems
- understand applications of probability theory
- use regression and correlational analysis to process transportation data

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TRANSPORTATION ENGINEERING

1MTR2-13: ROAD TRANSPORT MANAGEMENT AND ECONOMICS

Course Objectives:

- To be aware of the organisational structure of transport corporations and their interactions.
- To learn about depot facilities and terminals.
- To understand economic analysis of transport projects.

Syllabus	Contact hours
INTRODUCTION : Objective, scope and outcome of the course	1
Motor Vehicles Act - statutory provision for road transport and connected organisations. Route scheduling, Freight transport, Vehicle scheduling, Optimum fleet size, Headway control strategies, Crew scheduling.	7
Depots and Terminals - Principles and types of layout, Depot location, Twin depot concept, Crew facilities. Design of parking facilities – Bus terminal, bus stops and bus bays	8
Transportation costs - Supply and demand - elasticity of demand; Supply of transport services - Economics of traffic congestion - Pricing policy. Vehicle operating costs - Fuel costs - Maintenance and spares - Depreciation - Crew costs - Value of travel time savings - Accident costs.	8
Economic analysis of projects - Methods of evaluation - Cost-benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects.	8
Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Build-Operate-Transfer Schemes – Risk Analysis - Case Studies.	8
Total	**40**

Textbooks:

1. Winfrey, Economic analysis for Highways, International Textbook Company, Pennsylvania, 1969.

Reference books:

1. CRRI, Road User Cost Study in India, New Delhi, 1982

2. IRC, Manual on Economic Evaluation of Highway Projects in India, SP30, 2007

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the Motor Vehicle Act and statutory provision for road transport. Also the students will be able to do scheduling of route, vehicle and crew.
- design the depots and terminals
- understand the concepts of the Private Public Partnership in road sector
- evaluate transportation projects economics.

TRANSPORTATION ENGINEERING

1MTR2-14: MANAGEMENT OF QUALITY AND SAFETY IN HIGHWAY CONSTRUCTION

Course objectives:

- To understand the importance of adhering to quality standards and specifications during the construction for achieving satisfactory level in the road works.
- To understands the importance ofProject quality management.
- To understand the probable accidents during construction
- To understand the ways of bringing in safety in construction at work places, safety auditing procedures etc

Syllabus	Contact hours
INTRODUCTION : Objective, scope and outcome of the course	1
Total quality Management (TQM) to the construction industry: Evolution, philosophy and principles for building client, the Deming Philip Crosby, J. M. Juran contribution to TQM. Quality as a management process, contractual options and integration.	7
TQM to Construction Projects : General application, TQM in pre contract, post contract, commissioning and maintenance phase, Project quality management.	8
Auditing: First party auditing, second party auditing, Contraction management adjudication. Accidents: types, causes, direct and indirect cost of accidents, objective of accident prevention programmes.	8
Preventative measures: personal protective equipments, job requirements, tools, equipments and fire protection measures. Protection from radioactive,/ toxic material, laser and X-ray equipments.	8
Safety Organization and Management: Safety policies, safety organization, safety committees, safety representatives, outside agencies – Govt. intervention, international agreements	8
Total	**40**

Textbooks:

1. Total Quality in Construction Projects, Ron Baden Hellard ,Thomas Telford, London
2. Engineering Quality in Construction,Michael T Kubal,Mc Graw Hill Inc.

Reference books:

1. Handbook of OSHA Construction Safety & Health, Charles D Reese & James V Eidson

Course outcomes:

After studying this course, students will be able to:

- Understand the importance of adhering to quality standards and specifications during the construction for achieving satisfactory level in the road works.
- Apply theProject quality management standards.
- Understand the probable accidents during construction and remedial measures
- Apply the safety standardsin construction and do safety auditing procedures etc.

TRANSPORTATION ENGINEERING
1MTR2-15: TUNNEL ENGINEERING

Course Objectives:

- To. Study Natural caves, archeological caves and their construction.
- To understand Need for Underground
- To know about Underground ring roads in mega cities, submerged and floating tunnels, underground libraries, museums, dwelling units, resorts.
- To understand Traffic surveillance and control system (TSCS) in tunnels.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Historical: Natural caves, archeological caves and their construction, tunnels for road, rail and hydropower.	9
3	Need for Underground Space: Congestion driven needs for development of infrastructure for transport, water, power supply, vehicle movement in cities, storage of materials.	10
4	Modern Developments: Underground ring roads in mega cities, submerged and floating tunnels, underground libraries, museums, dwelling units, resorts.	10
5	Traffic surveillance and control system (TSCS) in tunnels: Traffic control signs, signals, lights, cameras.	10
	Total	**40**

Textbooks:

1. Engineering Geology & Tunnels Engineering, Jaafar Mohammed
2. Tunnel Engineering Handbook, John O. Bickel and T. R. Kuesel, Krieger Publishing Company

Reference books :

1. Art of Tunnelling, K. Szechy

Course outcomes:

After studying this course, students will be able to:

- Know about natural caves, archeological caves and their construction.
- Understand Need for Underground construction
- Know and apply about modern day developments in underground ring roads in mega cities, submerged and floating tunnels etc.
- Apply the Traffic surveillance and control system (TSCS) in tunnels.

TRANSPORTATION ENGINEERING
1MTR2-16: GEOMETRIC DESIGN

Course objectives:

- To plan the urban, rural and hill road network.
- To determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves cross section elements.
- To understand concept of highway capacity
- To design of parking facilities, bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck lay-bye, Container terminal, Toll Plaza, Foot-over bridge and sky-walk.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Design Controls - Topography and physical features, traffic, vehicular characteristics, speed and safety; Space standards for urban, rural and hill roads, Sight distance requirements, Access controls	7
3	**Cross-section Elements :** Single lane, Two lane, Multi-lane highways, Expressways, Urban roads; Street design concepts, bicycle tracks, pedestrian facilities, street furniture, Design of Speed Breaker	6
4	**Alignment : Horizontal Alignment -** Curve design, Super-elevation design, Transition	6

	curve design, Attainment of super-elevation, Pavement widening, Sight distance on horizontal curves; Vertical Alignment - Gradients, Grade compensation, Design of vertical curves, Combination of horizontal and vertical alignment, vertical clearance for underpasses and elevated structures	
5	**Highway Capacity:** Two lane, Four lane, Six lane non-urban highways, Urban roads, Expressways, HCM USA and IRC Specifications	6
6	**Intersection Geometry:** Visibility requirements, Principles of channelization, Layout design for types of intersections, on-ramps and off-ramps (flyovers and Access controlled facilities), Acceleration and deceleration lanes, Two-way turn lanes	6
7	**Design of Facilities:** Design of on-street and off-street parking facilities, multi-storyed Parking; Design of bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck lay-bye, Container terminal, Toll Plaza, Foot-over bridge and sky-walk	8
	Total	**40**

Textbooks:

1. Wright, P.H. & Dixon, K.K., "Highway Engineering", 7th Ed., John Wiley & Sons. 2004
2. Transportation Research Board (TRB), Highways Capacity Manual, National Research Council, Washington D.C. 2010

Reference books:

1. Khisty, C.J. and Lal, B.K., "Transportation Engineering - An Introduction", Prentice Hall of India Pvt. Ltd. 2006
2. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers. 2008

Course Outcomes:

After studying this course, students will be able to:

- Plan the road network.
- Determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves,cross section elements.
- Justify and apply the geometric design standards adopted for roads.
- Design various on street and off street facilities.

TRANSPORTATION ENGINEERING
1MCC3-21: RESEARCH METHODOLOGY AND IPR

Course objectives:

- To understand research problemformulation.
- To analyze research related information
- To follow researchethics
- To develop research proposals.

- To understand about Patents, Designs, Trade and Copyright. Process of Patenting and Development
- To know patent rights and IPR

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	5
3	Effective literature studies approaches, analysis, Plagiarism, Research ethics.	6
4	Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	6
5	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	6
6	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.	6
	Total	**30**

Text books:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science &engineering students’”

2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

Reference books:

1. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”

2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Asimov, “Introduction to Design”, Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in NewTechnological Age”, 2016.
7. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

Course Outcomes:

At the end of this course, students will be able to

- Understand research problemformulation.
- Analyze research related information
- Understand and follow researchethics
- Develop research proposals.
- Understand about Patents, Designs, Trade and Copyright. Process of Patenting and Development
- Know patent rights and IPR

TRANSPORTATION ENGINEERING
1MTR1-06: HIGHWAY MATERIAL TESTING LABORATORY

Course Objectives:

- To conduct various standard tests on soil, aggregate and bitumen.
- To learn bituminous and concrete mix design

List of Practical:

S No.	Tests for Characterization anduse of Highway materials
1	To conduct identification tests on soils; Heavy compaction test on subgrade soil
2	To perform triaxial test on pure subgrade soil
3	To perform California Bearing Ratio test
4	To perform tests on flyash, pondAsh and bottomash- gradation and other engineering properties required for use as embankment material
5	To perform tests on Bitumen – Penetration Test and Ductility test
6	To perform tests on Bitumen – Softening point test and Thin Film Oven test
7	To perform Elastic recovery/recovery test on binder
8	To conduct Marshall Bituminous Mix design, Bitumen viscosity test (Rotational viscometer);Retained stability test
9	To perform Concrete Mix design – Sample preparations for DLC and PQC with proper ingredients and admixtures for economy.
10	To perform PQC Mix design – as per IRC

Textbooks:

1. Highway Engineering – S.K. Khanna & C.E.G. Justo. New Chand & Brothers.

Reference books:

1. Highway material Testing - S.K. Khanna & C.E.G. Justo.

Course Outcomes:

Upon completion of this course, the students should be able to:

- perform laboratory test on subgrade soil, aggregates and bitumen as per standards
- carry out bituminous and concrete mix design as per standards

- select proper road material as per standards
- carry out proper mix design with selected road material as per standards

TRANSPORTATION ENGINEERING
1MTR1-07: PAVEMENT DESIGN LAB

Course Objectives:

- To enable students to estimate Group Index value, design MSA for a road and design CBR value.
- To enable students to design flexible and rigid pavement.
- To enable students to conduct Plate load test, Benkelman Beam test and assess road safety features on a stretch of road
- To study california Resistance Value Method

List of Practical:

S No.	Tests for Pavement design and Evaluation
1	To do estimation of Design MSA for a road
2	To do estimation of Design CBR
3	To perform Design of flexible pavement
4	To perform Design of Rigid pavement
5	To conduct Benkelman Beam test on road
6	To assess road safety features on a stretch of road
7	To perform Plate load test for calculating modulus of subgrade reaction
8	To do estimation of Group Index Value
9	To study california Resistance Value Method

Textbooks:
1. Highway Engineering – S.K. Khanna & C.E.G. Justo. New Chand & Brothers.

Reference books:
1. Highway material Testing - S.K. Khanna & C.E.G. Justo.

Course Outcomes:
Upon completion of this course, the students should be able to:

- Estimate Group Index value, design MSA for a road and design CBR value.
- Design flexible and rigid pavement as per standard codes
- Conduct Plate load test, Benkelman Beam test and
- Assess road safety features on a stretch of road

TRANSPORTATION ENGINEERING
2MTR1-01: PAVEMENT ANALYSIS, DESIGN AND CONSTRUCTION

Course Objectives:

- To study the Components of pavement structure and Functions of sub-grade, sub-base, base course and wearing course.
- To study stresses in Flexible Pavements
- To design the flexible and rigid pavements using different Empirical, semi-empirical and theoretical approaches
- To understand bituminous and concrete road construction methods.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Components of pavement structure, importance of sub-grade soil properties on pavement performance. Functions of sub-grade, sub-base, base course and wearing course.	4
3	**Stresses in Flexible Pavements:** Stresses in homogeneous masses and layered systems, deflections, shear failures, equivalent wheel and axle loads.	5
4	**Elements in Design of Flexible Pavements:** Loading characteristics-static, impact and repeated loads, effects of dual wheels and tandem axles, area of contact and tyre pressure, modulus or CBR value of different layers, equivalent single wheel load, equivalent stress and equivalent deflection criterion, equivalent wheel load factors, climatic and environmental factors.	5

5	**Design Methods for Flexible Pavements:** California bearing ratio (CBR), U.S. Navy method. Triaxial method, Mcleod method, Boussinesq's and Burmister's analysis and design method, IRC method for Flexible Pavement Design	5
6	**Rigid Pavements:** Wheel load stresses, Westergaard's analysis, Bradbury's approach Arlington test, Pickett's corner load theory and charts for liquid, elastic and soil of finite and infinite depths of subgrade. IRC Method of rigid pavement design.	5
7	**Temperature Stresses:** Westergaard's and Thomlinson's analysis of warping stresses, Combination of stresses due to different causes, Effect of temperature variation on Rigid Pavements.	5
8	**Reinforced Concrete Slabs:** Prestressed concrete slabs-general details. Design of Tie Bars and Dowel Bars.	3
9	**Road Construction:** Bituminous road construction procedures and specifications, Quality control requirements. Concrete Road construction: Construction methods, Quality control requirements, Joints in cement concrete pavements, reinforced cement concrete road construction. IRC & MORTH recommendations for construction of Bituminous and Concrete roads. Present practices being followed for quality assurance and speedy construction in the country like by NHAI.	7
	Total	**40**

Textbooks:

1. Yoder, E.J. and Witczak, M.W., "Principles of Pavement Design 2nd Ed", John Wiley & Songs, Inc. – 1975
2. O'Flaherty, A. Coleman, "Highways : the Location, Design, Construction and Maintenance of Road Pavements", 4th Ed., Elsevier - 2006
3. Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press Taylor & Francies Group – 2006

Reference books:

1. Khanna, S.K. and Justo, C.E.G., "Highway Engineering Nem Chand Jain & Bros, - 2005
2. Papagiannakis, A.T. and Masad, E.A., "Pavement Design and Materials, John Wiley & Sons Inc - 2008

Course Outcomes:

Upon completion of this course, the students should be able to:

- Understandrole and functions of sub-grade, sub-base, base course and wearing course.
- know the stresses, strains and deflections in rigid and flexible pavements and traffic loading
- design methodologies for both rigid and flexible pavements
- know bituminous and concrete road construction methods.

TRANSPORTATION ENGINEERING
2MTR1-02: TRAFFIC ENGINEERING & MODELING

Course Objectives:

- To be aware of various methods of collecting traffic data
- To workout problems related to design of intersection & facilities
- To learn the importance of Traffic Management Techniques

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Elements of traffic engineering, issues for traffic	6

	engineers; road users, vehicles, highways and control devices, modelling concepts.	
3	**Traffic Stream Characteristics**: Traffic stream parameters, Time Space diagram, relationship among q,k,u, Macroscopic Fundamental Diagrams (MFD).	6
4	**Traffic Studies:** Traffic volume studies, speed, travel time and delay studies, parking studies, RSI Survey, WTP Survey, accident data collection and analysis, pedestrian studies	6
5	**Design concept for intersection & facilities**: Concept of capacity and LOS, Operational analysis of two-way and all-way stop controlled intersections and Roundabouts by US and Indian methods, design of parking facilities, types of signals, Design of signals by Indian, US and British methods, signal coordination.	9
6	**Time Series Analysis:** Basic Components of Time Series, Smoothening and Decomposition Methods, Data Filters, Auto Correlations and Moving Averages.	6
7	**Management Techniques:** Traffic calming; Congestion and road user pricing; priority movements; traffic regulations and control systems; use of intelligent systems.	6
	Total	**40**

Textbooks:

1. William R. Mcshane and Roger P. Roess, "Traffic Engineering", Pearson (4th Edition). 2013
2. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers. 2012
3. C A O'Flaherty, Ed , "Transport Planning and Traffic Engineering", ButterworthHeinemann, Elsevier, Burlington, MA2006

Reference books:

1. May, A.D., "Fundamentals of Traffic Flow", Prentice Hall, Inc. 2nd Ed. 1990
2. Carlos F. Daganzo. "Fundamentals of Transportation and Traffic Operations", Pergamon 1997
3. Simon P. Washington, Matthew G. Karlaftis and Fred L. Mannering, "Statistical and Econometric Methods for Transportation Data Analysis", 2nd Edition, CRC Press2011

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the concept of capacity
- conduct traffic surveys
- design the intersections
- build safety into every aspect of design

TRANSPORTATION ENGINEERING
2MTR2-11: TRANSPORTATION ENVIRONMENT INTERACTION AND ANALYSIS

Course Objectives:

- To know the impact of transportation systems and facilities on environment.
- To understand the necessity of EIA studies

- To understand energy issues related to transportation.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Interaction of transportation systems and facilities with surrounding environment, Impact of transportation on surrounding environment, impact of surrounding environment on transportation systems.	7
3	**Impact on Natural Environment:** Air quality impacts - sources of air pollutants, effects of air pollutants, key legislations and regulations, impact prediction approaches, identification and incorporation of mitigation measures; Noise Impacts - Basic information, key legislation and guidelines, impact prediction methods, identification and incorporation of mitigation measures, Noise barriers and their design; Ground water and marine pollution impacts; Environmental capacities of streets, Environmental Impact statements.	8
4	**Impact on Land Use and Value:** Conceptual approach for addressing socio-economic impacts; Visual impacts and criteria, scoring methodologies for visual impact analysis; Relocation impacts; Land value impacted due to transportation facility; Spatial reorganization and Regional Development impacts.	8
5	**Environmental Impact Analysis:** Concepts of environmental impact analysis, key features of National environmental policy act and its implementation, screening in the EIA process, utility and scope of EIA process, Environmental protection acts EIA at national level, Conceptual approach for environmental impact studies, planning and management of impact studies, matrix and network methodologies for impact identification, description of the affected environmental – environmental indices; Public Participation – Objectives, and techniques for conflict management and dispute resolution, verbal communication in EIA studies .	8
6	**Energy Issues in Transportation:** Energy consumption, alternate transportation fuels, energy conservation, energy contingency strategies, energy analysis information and methods, Transportation alternatives.	8
	Total	**40**

Textbooks:

1. CANTER, L.W., Environmental impact assessment, McGraw-Hill, 1997
2. Peter Morris & Riki Therivel, Methods of Environmental Impact Assessment, Routledge, 2001.
3. Denver Tolliver, Highway Impact Assessment, Greenwood Publishing Group, 1993.
4. Edward K Morlok, Introduction to transportation Engineering and Planning, Mc-Graw Hill Book Company, New Delhi

Reference books:

1. John W. Dickey and others, Metropolitan Transportation Planning, Tata McGraw-Hill Publishing Compant Ltd., New Delhi
2. C. Jotin Khisty and B Kent lall, Transportation Engineering – An introduction, Prentice-Hall of India Pvt Ltd, New Delhi.

Course Outcomes:

Upon completion of this course, the students should be able to:

- Know and assess the impact of transportation systems and facilities on environment
- Understand the necessity of EIA studies.
- Understand and apply energy issues related to transportation.

TRANSPORTATION ENGINEERING

2MTR2-12: URBAN MASS TRANSPORTATION SYSTEM`

Course objectives:

- To understand the various options for urban mass transportation and recommend suitable modefor the given situation.
- To conduct economic analysis between different transport modes and suggest most economical and efficient mode under the given set of conditions.
- To understand Transit Networks and System Analysis
- To carry out the evaluation of capacities of transit lines.
- To forecast the future transportation needs and variations in system components so as to plan for the transportation system requirements.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Mass transit systems, Elements / components of transit systems; Urban Mass Transit systems- types, characteristics, suitability and adaptability of these systems; Evolution of urban transportation.	5
3	**Transit System Planning:** Planning needs; Short-range and long-range planning; Planning procedures and methodology, Data collection; Medium performance transit systems and high performance transit systems; trends in transit planning	6
4	**Transit Demand Estimation and Evaluation:** Transit demand forecasting; transit mode evaluation; comparison and selection of most suitable transit mode.	6
5	**Transit System Operations:** Basic operational elements; transit travel characteristics; transit scheduling; transit line analysis – planning objectives, geometry, types and their characteristics, capacity of transit lines, system procedures for improving transit line capacity.	6
6	**Transit Networks and System Analysis:** Transit networks – types and their characteristics; transfers in transit networks; system analysis in transit – conceptual models, modeling procedures; terminal or station location planning – issues, objectives, station spacing decisions.	6
7	**Economics and Financing of Transit Systems:** Transit system performance and economic measures; transit fares – structure, collection and levels; financing of transit services; public and private integration of transit services.	6
8	**Case studies of urban mass transportation systems adopted in India in recent years including Delhi Metro, Jaipur Metro, metro bus service, mono rail etc.**	4
	Total	**40**

Textbooks:

1. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA - 2004

2. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA - 1980
3. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA -2006

Reference books:

1. C Jotin Khisty and B Kent Lall, “Transportation Engineering” PrenticeHall of India Pvt Ltd., New Delhi - 2003

Course outcomes:

After studying this course, students will be able to:

- Understand the various options for urban public transportation and recommend suitable mode
- Conduct economic analysis between different transport modes and suggest most economical and efficient mode under the given set of conditions.
- Understand Transit Networks and System Analysis
- Carry out the evaluation of capacities of transit lines.
- Forecast the future transportation needs and variations in system components so as to plan for the transportation system requirements.

TRANSPORTATION ENGINEERING
2MTR2-13: SUSTAINABLE CONSTRUCTION ENGINEERING

Course Objectives:

- To be aware of various fundamentals of Sustainable Construction Engineering
- To be aware of Construction Product, Process Design and Development
- To understand Sustainability assessment using standard approaches
- To study Socio-economic feasibility of sustainable construction products

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Fundamentals of Sustainable Construction Engineering- Sustainability and resources, need, present practices at national and international level, The Sustainability Quadrant- challenges & Issues, Government initiatives	7
3	Construction Product, Process Design and Development- Sustainability of construction resources, process modifications, product performance evaluation.	8
4	Sustainability assessment using standard approaches- LEED/GRIHA rating evaluation process.	8
5	Socio-economic feasibility of sustainable construction products- Innovative & customized sustainable product design based on social constraints, tools & aids available for sustainable construction products.	8
6	Life Cycle Assessment and Costing-Various aspects related to construction	8

	cost, present value analysis, life cycle stages, cost calculation & measures, evaluation criteria, uncertainty assessment, sensitivity analysis, break even analysis.	
	Total	**40**

Textbooks:

1. Sustainable Engineering Practice ASCE Publication 2010.
2. Hagger Sustainable Industrial Design and Waste Management, Techniz Book 2010.
3. Helmut Rechberger, Practical handbook of Material Flow Analysis, Taylor & Francis. 2010

Reference books:

1. Michael Z. Hou, Heping Xie, Jeoungseok Yoon Underground Storage of CO2 and Energy Taylor & Francis, 2010
2. LEED for India: Reference Guide, 2011.

Course Outcomes :

After studying this course, students will beable to:

- understand various fundamentals of Sustainable Construction Engineering
- know Construction Product, Process Design and Development
- understand Sustainability assessment using standard approaches
- know Socio-economic feasibility of sustainable construction products

TRANSPORTATION ENGINEERING

2MTR2-14: ROAD CONSTRUCTION EQUIPMENT

Course objectives:

- To understand major equipment used for road construction works along with their working principle.
- To distinguish the advantages and limitations of the equipment used for earth excavation and grading.
- To evaluate the production capacity of the plants producing aggregates
- To understand the knowledge of pavers and form works used to lay flexible and rigid pavements.
- To workout the cost of hiring the equipment and evaluate optimum turnout from the equipment.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1

2	**Introduction:** Working principle, capacity, rate of production, applications, advantages and limitations of various types of construction equipment	7
3	**Equipment for earthwork excavation, hauling and spreading :** Dozers; power shovels, Scrappers, Tippers and trucks, Motor graders, - application, types, production capacity, factors affecting production, optimum number of equipments for construction. Different types of soil compactors and their applications	8
4	**Plants for aggregates production** – different types of crushers, Mixing plants: Pug mill for WMM, other cold mix plants, Hot mix Plants for bituminous mixes; factors affecting production capacity, Optimum number and location. Mixing plants for cement concrete	8
5	**Paving and compacting equipment:** Different types of pavers and compacting equipment for bituminous mixes, Fixed form type paver and Slip form type paver for CC pavements –their advantages **Miscellaneous Equipment:** Kerb casting equipment, road marking equipment, bitumen sprayers, water tankers	8
6	**Equipment Management:** Equipment planning, forecasting equipment requirement, maintenance, workshop, work study, Selection of Construction Equipment – task considerations, cost considerations, equipment acquisition options	8
	Total	**40**

Textbooks:

1. Peurifoy/ Schexnayder "Construction Planning, Equipment and Methods"- McGraw-Hill Higher Education
2. Sharma S.C. "Construction Equipment and its Management"- Khanna Publishers, Delhi

Reference books:

1. K.K. Chitkara, "Construction Project Management,-Planning, Scheduling and Controlling"- Tata McGraw –Hill Publications
2. "Operation Manuals of various equipment manufacturers".

Course Outcomes:

After studying this course, students will be able to:

- Apply the knowledge of major equipment used for road construction works along with their working principle.
- Distinguish the earth excavation and grading equipment based on their advantages and limitations
- Work out the production capacity of the mixing plants for flexible and rigid pavements producing different sizes of aggregates.
- Understand the use of pavers and form works to lay flexible and rigid pavements and the precautions to be taken while using them.
- Estimate and find the cost of hiring equipment for construction activity.

TRANSPORTATION ENGINEERING
2MTR2-15: PAVEMENT MAINTENANCE AND MANAGEMENT SYSTEM

Course Objectives:

- To understand the concept of Pavement Management System, pavement performance and its evaluation
- To understand the concept of Pavement Overlays

S. N.	Course Content	Contact

		Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Pavement Evaluation and Performance:** General concept of pavement evaluation, evaluation of pavement performance, evaluation of pavement structural capacity, evaluation of pavement distress, evaluation of pavement safety.	5
3	**Types of Distress:** Structural and functional, serviceability, fatigue cracking, pavement deformation and behaviour in flexible and rigid pavements. Low temperature shrinkage cracking, Factors affecting performance, relation between performance and distress.	6
4	**Pavement Evaluation & Measuring Equipments:** Functional & Structural Evaluation, Functions Parameters such as Roughness, Distress, Rutting, Skid Resistance etc. Structural Parameters such as Structural Capacity. Benkelman Beam, Bump Integrators of various types, dynaflect. Demonstration of equipments for dynamic testing of pavements. Digital ultrasonic concrete tester. Radiographic and infra red testing. Pavement skid resistance measuring equipments, fatigue testing equipments, on-site and on- line testing with sensors, strain-gages LVDTs and data acquisition system.	8
5	**Pavement Overlays:** Flexible overlays and determination of overlay thickness. Rigid overlays and determination of overlay thickness including thin toppings. Design of Overlay by Benkelman Beam and Falling Weight Deflectometer.	4
6	**Design Alternatives –** Analysis, Evaluation and Selection: Framework for pavement design, design objectives and constraints, Basic structural response models, characterization of physical design inputs, Generating alternative pavement design strategies. Economic evaluation of alternative pavement design strategies, analysis of alternative design strategies. Predicting distress, predicting performance, selection of optimal design strategies.	8
7	**Pavement Management System:** Introduction to Pavement Management System (PMS) & Maintenance Management System (MMS), construction, maintenance and rehabilitation. Feedback data system. Examples of Working Design and Management Systems. Implementation of a pavement management system.	8
	Total	**40**

Textbooks:

1. Hass, R., Hudson, W.R. and Zaniewski, J. “Modern Pavement Management” Krieger.-1994
2. Fwa, T.F., “The Hand Book of Highway Engineering”, CRC Press, Taylor & Francies Group.-2006
3. Shain, M.Y., “Pavement Management for Airports, Roads and Parking Lots”, Kluwer Academic Publishers Group-2004
4. Khanna, S.K. and Justo, C.E.G., “Highway Engineering” Nem Chand & Bros, Roorkee (U.A.) 8th Ed. -2005

Reference books:

1. Hudson, W.R., Haas, R. and Uddin, W., “Infrastructure Management”, McGraw Hill -1997
2. Hass R. & Hudson, W.R., “Pavement Management System”, Mc Graw Hill Company, Inc. New York - 1978

Course Outcomes:

Upon completion of this course, the students should be able to:

- Determine overlay thickness for both flexible and Rigid overlays
- Identify the factors influencing performance of pavements
- Carry out structural and functional evaluation of pavements
- Develop a framework for efficient pavement management system

TRANSPORTATION ENGINEERING
2MTR2-16: PLANNING, DESIGN AND CONSTRUCTION OF RURAL ROADS

Course objectives:

- To know classification of Roads and various 20 year Plans.
- To learngeometric Design Standards for Rural Roads and Hill Roads.
- To design pavements for rural roads.
- To understand mix design methods.
- To dnow conventional materials, Marginal and Waste Materials including Fly Ash, GBFS, BFS, SMS, Bagasse, CRMB, etc
- To learn Design of drains, Minor CD Works, Filter Design etc
- To understand Type and Causes of Failures of rural roads

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Planning of Rural Roads:** Classification of Roads, Brief introduction to earlier 20 year Plans, System's Approach, NATPAC Model, Gravity Model, CRRI Model, FBRNP Model, Concepts of PMGSY	5
3	Geometric Design: Geometric Design Standards for Rural Roads with special reference to PMGSY, Hill Road Standards	4
4	**Pavement Design**: Various pavement design methods for Rural roads including Flexible and Rigid pavements using IRC:SP-20, IRC-72, IRC-37, IRC:SP-62, CRRI Nomograms	4
5	**Mix Design Methods:** CRRI Method, Triangular Chart Method, Fuller's Method, Rothfuch method, PI based Method	4
6	**Materials:** Brief introduction to conventional materials, Marginal and Waste Materials including Fly Ash, GBFS, BFS, SMS, Bagasse, CRMB, etc	4
7	**Construction:** Case Studies of Waste Material Utilization in Rural Roads, Low Cost Techniques for Rural Road Construction, Tractor Bound Technology, Special Considerations for Hill Areas	8
8	**Drainage:** Transverse and Longitudinal Drainage, Design of drains, Minor CD Works, Filter Design etc	6
9	**Maintenance:** Type and Causes of Failures, Remedies	4
	Total	**40**

Textbooks:

1. Khanna S.K., Justo C.E.G, "Highway Engineering", Nem Chand & Bros, Roorkee- 2004
2. L R Kadiyali, "Traffic Engineering and Transport Planning", Khanna Publishers, Delhi - 1999

3. Quality Assurance Handbook for Rural Roads, NRRDA, Govt. of India – 2007

Reference books:

1. Rural Roads Manual , SP-20, IRC - 2002
2. Document on Rural Road Development, Vol I & II, CRRI -1990
3. PMGSY Operation Manual, NRRDA, Govt of India -2005
4. Specifications for Rural Roads, MoRD, IRC -2004

Course Outcomes:

Upon completion of this course, the students should be able to:

- Apply geometric Design Standards for Rural Roads and Hill Roads.
- Design pavements for rural roads and understand and prepare mix design as per code.
- Know and apply conventional materials, Marginal and Waste Materials
- Design the drains, Minor CD Works, Filter Design etc.
- Identifytype and causes of Failures of rural roads

TRANSPORTATION ENGINEERING
2MTR1-06: TRAFFIC ENGINEERING LAB

Course Objectives:

- To organise traffic surveys and collect wide variety of traffic data, subjecting them to analysis and interpretation.

Experiments related to traffic data collections on speed, volume, travel time, delay, etc. Demonstrations of various equipments including possible visits to labs in national Institutes like CRRI, IITs and road systems. Traffic flow, traffic capacity modeling, transportation analysis and planning, intersection design, signals, Lab. work includes study of softwares, their application to solution of transportation engineering problems.

S No.	The experiments may include:
1	To conduct Traffic volume data collection at midblock section in urban area and its analysis
2	To conduct Traffic volume data collection at rural highway section and its analysis
3	To conduct Categorized vehicle speed data collection at urban and rural sections and its analysis
4	To Derive flow relationships between flow characteristics based on volume and speed data collected

5	To do Speed and delay study using Moving observed method
6	To peform Volume study at a roundabout to examine its capacity
7	To perform Volume and speed study at a four legged intersection
8	To perform Parking study in a market or commercial area (accumulation and duration analysis)
9	To Analysis accident data procured from police stations

Course Outcomes:

Upon completion of this course, the students should be able to:

- identify and understand the practical problems related to traffic engineering
- conduct the traffic surveys, roadside and household interviews
- analyse and synthesize the data collected
- interpret the results and their impact on life

TRANSPORTATION ENGINEERING
2MTR1-07: STATISTICAL AND NUMERICAL ANALYSIS LAB

Course Objectives:

- To study various statistical and numerical analysis methods

S No.	The experiments/activities may include:
1	To study Newton's forward interpolation method
2	To study Newton's backward interpolation method
3	To study Lagrange's interpolation method
4	To study Newton Raphson method

5	To determine Solution of ODE by Runge-Kutta method
6	To perform Calculation of eigen values and eigen vector method
7	To Analysis variance and application
8	To study Linear regression analysis and their application
9	To study Multiple regression analysis and their application

Course Outcomes:
Upon completion of this course, the students should be able to:

- understand the basic concept of various statistical and numerical methods
- apply the statistical and numerical methodsengineering subjects

TRANSPORTATION ENGINEERING
2MTR4-50: MINI PROJECT WITH SEMINAR

Course objectives:

- To demonstrate a sound technical knowledge of their selected mini project topic.
- To undertake problem identification, formulation and solution.
- To design engineering solutions to complex problems utilising a systems approach.
- To communicate with engineers and the community at large.
- To demonstrate the knowledge, skills and attitudes of a professional engineer

Student is required to work on mini project concerned with his/her course and also deliver a seminar of the same.

S No.	Some suggested topics are:
1	To Study and perform evaluation of an intersection in a city
2	To Study and evaluate mode of transport in a city
3	To Study accidents in a city and remedial measures
4	To conduct study on Futuristic transportation planning
5	To analysis Parking pattern of a given area
6	To conduct Study of congestion and to suggest remedial measures
7	To Study various road safety measures adopted

Note: The student can take real time problem, collect data, analyze and present in a seminar.
Latest developments in the area of transportation can be studied from literature and presented in the form of seminar.

Course outcomes

On successful completion of the course, students will be able to:

- Demonstrate a sound technical knowledge of their selected mini project topic.
- Undertake problem identification, formulation and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large and presentation.
- Demonstrate the knowledge, skills and attitudes of a professional engineer

TRANSPORTATION ENGINEERING
3MTR2-11: Remote sensing and GIS

Course Objectives:

- To understand the basics of advanced tools such as Remote sensing and GIS

- To highlight applications of GIS in the field of Civil engineering
- To be introduced to various GIS Data Processing, Analysis and Modeling concepts

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction: Definitions of GIS** – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo referencing - data acquisition.	9
3	**Geographic Data Representation, Storage, Quality and Standards**: Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards.	10
4	**GIS Data Processing, Analysis and Modeling:** Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modeling – DTM.	10
5	**GIS Applications:** Applications of GIS in Environment monitoring – Natural hazard management, Transport Planning, Analysis and monitoring. Use of softwares related to GIS applications in Transportation Engineering.	10
	Total	**40**

Text books:

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.
2. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S.Publications, Hyderabad, 2001.
3. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersy, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.

Reference books:

1. Geo Information Systems – Applications of GIS and Related Spatial Information Technologies, ASTER Publication Co., Chestern (England), 1992
1. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990
2. Marble, D.F., Galkhs HW & Pequest, Basic Readings in Geographic Information Systems, Sped System Ltd., New York, 1984.

Course Outcomes:

Upon completion of this course, the student will be able to:

- describe the methods and applications of remote sensing in Civil engineering.
- define the significance of GIS in civil engineering.

TRANSPORTATION ENGINEERING
3MTR2-12: ADVANCED CONCRETE TECHNOLOGY

Course Objectives:

- To understand the composition and reaction mechanism in cement
- To understand reaction mechanism and properties of fresh and hardened concrete
- To understand concepts related to High Strength concrete, high performance concrete, Self-compacting concrete, ready mix concrete and polymer concrete
- To gainKnowledge about durability of concrete as well as shrinkage and creep of concrete.

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Cement:** composition and reaction mechanism	4
3	**Concrete containing cementitious material:** Use of fly ash, silica fume and GGBFS in concrete, reaction mechanism, properties of fresh and hardened concrete	8
4	**Structural Concrete:** High Strength concrete, high performance concrete, Self-compacting concrete, ready mix concrete, polymer concrete: materials, admixtures, applications and properties of fresh and hardened concrete	8
5	**Fiber Reinforced Concrete**: constituent materials and properties, mechanics of fiber reinforced concrete, properties of fresh and hardened concrete	7
6	**Durability of concrete:** Carbonation, chloride ingress, corrosion, sulphate attack, freezing and thawing: Factors affecting, effects, mechanisms, prevention and control	6
7	**Creep and Shrinkage**: Factors affecting, effects, mechanisms, prevention and control	6
	Total	**40**

Text Books:

1. A.M. Neville, “Properties of Concrete”, Pearson Education, 1995

2. A.M. Neville & J.J. Brooks, “Concrete Technology”, Addison- Wesley, 1999

Reference books:

1. P.K. Mehta & P.J.M. Monterio, “Concrete”, ICI, 1999

Course Outcomes:

Upon completion of this course, the student will be able to:

- Understand the composition and reaction mechanism in cement
- Understand reaction mechanism and properties of fresh and hardened concrete
- Understand concepts related to High Strength concrete, high performance concrete, Self-compacting concrete, ready mix concrete and polymer concrete
- Gain Knowledge about durability of concrete as well as shrinkage and creep of concrete.

TRANSPORTATION ENGINEERING
3MTR2-13: GROUND IMPROVEMENT TECHNIQUE

Course Objectives:

- To learn how to improve weak soils by modern ground improvement techniques
- To study the role of soil reinforcement in soil stabilization
- To know the importance of Geo-membranes, Geo-cells, Geonets, Geosynthetic walls in ground improvement

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Typical situations where ground improvement becomes necessary, Historical review of methods adopted in practice, Current status and the scope in the Indian context.	7
3	**Methods of Ground Improvement:** Mechanical compaction, Dynamic compaction, Impact loading, Compaction by blasting, Vibro-compaction; Pre-compression, Dynamic consolidation, Design aspects of stone columns; Use of admixtures, Injection of grouts; Design guidelines and quality control, Design examples on preloading with sand drains, Road designs with Geo-synthetics.	8
4	**Reinforced Earth:** Basic mechanism, Constituent materials and their selection; Engineering applications – Shallow foundations on reinforced earth, Design of reinforced earth retaining walls, Reinforced earth embankments structures, Wall with reinforced backfill, Analysis and design of shallow foundations on reinforced earth.	8
5	**Geo-textiles:** Selection and engineering applications, Design examples, Stabilisation/Improvement of ground using Geo-membranes, Geo-cells, Geonets,	8

	Geosynthetic walls.	
6	**Soil Nailing:** Construction of underground structures, Landslide controls, Deep vertical cuts, contiguous piles.	4
7	**Problematic Soils:** Use of ply soils, Improvement of saline soils, Improvement of black cotton soils, Collapsible soil, Dune Sand.	4
	Total	**40**

Text Books:

1. Moseley, M. P. and Kirsch K.," Ground Improvement", Spon Press, Taylor and Francis2004

2. Mittal, Satyendra, "Ground Improvement Engineering", Vikas Publishing House 2010

3. Koerner, R.M.," Designing with Geosynthetics"' Prentice Hall 1990

4. Saran, S., "Reinforced Soil and Its Engineering Applications", I.K. International 2005

Reference books:

1. Rao, G.V., Geosynthetics – An Introduction, Sai Master Geoenvironmental Services(P) Ltd. 2007

2. Jones, CJFP, "Earth Reinforcement and soil structure", Thomas Telford 1996

3. Shukla, S.K., Yin, Jian-Hua, "Fundamentals of Geosynthetic Engineering", Taylor &Francis

Course Outcomes:

Upon completion of this course, the students should be able to:

- understand the importance of ground improvement techniques in civil engineering construction activities.
- do reinforced wall design using steel strip or geo-reinforcement
- perform any modern ground improvement design including soil stabilization