M. TECH. DEGREE

TRANSPORTATION ENGINEERING AND MANAGEMENT

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(With effect from 2013 - 2014)

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620015 INDIA

VISION AND MISSION OF THE INSTITUTE

Vision of the Institute

To provide valuable resources for industry and society through excellence in technical education and research.

Mission

To offer state-of-the-art undergraduate, postgraduate and doctoral programmes

To generate new knowledge by engaging in cutting-edge research

To undertake collaborative projects with academia and industries

To develop human intellectual capability to its fullest potential

VISION AND MISSION OF THE DEPARTMENT

Vision of the Department

Shaping infrastructure development with societal focus

Mission

Achieve International Recognition by:

Developing Professional Civil Engineers

Offering Continuing Education

Interacting with Industry with emphasis on R&D

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates of the Programme will contribute to the development of transportation infrastructure that is sustainable.

2. Graduates of the Programme, as part of an organization or as Entrepreneurs, will continue to learn to harness evolving technologies.

3. Graduates of the Programme will be professional Transportation Engineers with ethical and societal responsibility.

PROGRAMME OUTCOMES (POs)

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

a) Acquire in-depth knowledge of Transportation Engineering, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

b) Analyse complex Transportation Engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

c) Think laterally and originally, conceptualise and solve Transportation Engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in Transportation Engineering.

d) Extract information pertinent to unfamiliar problems through literature survey and experiments, 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.

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

f) Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

g) 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 and in multidisciplinary environments after consideration of economical and financial factors.

h) 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.

i) Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

j) Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

k) Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn to improve without depending on external feedback.

M. Tech. (TRANSPORTATION ENGINEERING AND MANAGEMENT)

The total minimum credits required for completing the M. Tech. (Transportation Engineering and Management) Course is 66.

SEMESTER I

Code	Course of Study	L	T	P	C
MA601	Numerical Methods and Applied Statistics	3	0	0	3
CE601	Highway Traffic Analysis and Design	3	0	0	3
CE603	Pavement Analysis and Design	3	1	0	4
	Elective – I	3	0	0	3
	Elective – II	3	0	0	3
	Elective – III	3	0	0	3
CE609	Traffic and Pavement Engineering Laboratory	0	0	6	2
		18	**1**	**3**	**21**

SEMESTER II

Code	Course of Study	L	T	P	C
CE602	Road Transport Management and Economics	3	0	0	3
CE604	Transportation Planning	3	1	0	4
CE606	Computational Techniques in Transportation Engineering	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
	Elective - VI	3	0	0	3
CE610	CAD in Transportation Engineering	1	0	3	2
		19	**1**	**3**	**21**

SUMMER TERM

	Practical Training (4 weeks)	-	-	-	-

SEMESTER III

Code	Course of Study	L	T	P	C
CE647	Project Work – Phase I	0	0	24	**12**

SEMESTER IV

Code	Course of Study	L	T	P	C
CE648	Project Work – Phase II	0	0	24	**12**

ELECTIVES

Code	Course of Study	L	T	P	C
CE611	Geospatial Techniques	3	0	0	3
CE612	Intelligent Transportation Systems	3	0	0	3
CE613	Pavement Materials	3	0	0	3
CE614	Ground Improvement Techniques	3	0	0	3
CE615	Bridge Engineering	3	0	0	3
CE616	Traffic Flow Theory	3	0	0	3
CE617	Transportation Network Analysis and Optimization	3	0	0	3
CE618	Advanced Highway Materials	3	0	0	3
CE619	Transportation Systems	3	0	0	3
CE714	Environmental Impact Assessment	3	0	0	3
HM712	Human Resource Management	3	0	0	3
MB794	Project Management	3	0	0	3
	Any other elective				

SEMESTER I

MA601 NUMERICAL METHODS AND APPLIED STATISTICS

Course Objectives:

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

Course Content:

Linear system – Gaussian elimination and Gauss – Jordan methods – matrix inversion – Gauss seidel method – Nonlinear equations – Regula falsi and Newton- Raphson methods – interpolation – Newton's and Lagrange's interpolation

Linear Programming – Graphical and Simplex methods – Measures of central tendency, dispersion, skewness and Kurtosis – Probability – conditional probability – Bayes' theorem

Random variable – two dimensional random variables – standard probability distributions – Binomial Poisson and normal distributions - moment generating function

Sampling distributions – confidence interval estimation of population parameters – testing of hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test – curve fitting-method of least squares

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design – Time series analysis.

References:

1. Bowker and Liberman, *Engineering Statistics,* Prentice-Hall, 1972.
2. Venkatraman, M.K., *Numerical Methods in Science and Engineering*, National Publisher Company.

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

CE601 HIGHWAY TRAFFIC ANALYSIS AND DESIGN

Course Objectives:

- To be aware of various methods of collecting traffic data
- To understand the basics of highway planning and design, and workout problems in design of road geometrics
- To learn the importance of road safety.

Course Content:

Elements of Traffic Engineering - road user, vehicle and road way and driver characteristics. - Design speed, volume. Passenger Car Units - Static and Dynamic- Highway capacity and level of service - capacity of urban and rural roads - Road user facilities - Parking facilities - Cycle tracks - Pedestrian facilities.

Traffic volume studies, origin destination studies, speed studies, travel time and delay studies, Parking studies, Accident studies.

Elements of design - Alignment - Cross sectional elements - Stopping and passing sight distance. Horizontal curves - Vertical curves. Design problems. Traffic regulation and control - Signs and markings - Traffic System Management.

Design of intersections – At-grade intersections- Principles of design – Channelization - Design of rotaries - Traffic signals - pre-timed and traffic actuated. Design of signal setting - phase diagrams, timing diagram – Signal co-ordination – Area raffic Control System. Grade separated interchanges - Geometric elements for divided and access controlled highways and expressways.

Traffic Safety – Principles and Practices – Safety along links - Safety at intersections. Road Safety Audit – Countermeasures, evaluation of effectiveness of counter-measures– Road safety programmes.

References:

1. ITE Hand Book, *Highway Engineering Hand Book*, Mc Graw - Hill.
2. AASHTO *A Policy on Geometric Design of Highway and Streets*
3. Pignataro, L.J., *Traffic Engineering – Theory & Practice*, John Wiley, 1985
4. R. J. Salter and N. B. Hounsel, *Highway Traffic Analysis and Desig*n, Macmillan Press Ltd, 1996.
5. Relevant IRC codes

Course Outcomes:

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

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

CE603 PAVEMENT ANALYSIS AND DESIGN

Course Objectives:

- To study the behaviour of pavements under various loads
- To design the flexible and rigid pavements using different Empirical, semi-empirical and theoretical approaches
- To understand the concept of Pavement Management System, pavement failures and its evaluation

Course Content:
Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airfield pavements, Requirements and desirable properties of aggregates, bitumen, emulsion and modified bitumen, Characterisation of different pavement materials

Pavement Design Factors: Design wheel load, strength characteristics of pavement materials, climatic variations, traffic - load equivalence factors and equivalent wheel loads, aircraft loading, gear configuration and tyre pressure. Drainage – Estimation of flow, surface drainage, sub-surface drainage systems, design of sub-surface drainage structures

Flexible Pavement Design: Empirical, semi-empirical and theoretical approaches, design of highway and airport pavements by IRC, AASHTO Methods, Mechanistic –Empirical design, applications of pavement design software

Rigid Pavement Design: Types of joints and their functions, joint spacing; design of CC pavement for roads, highways and airports as per IRC, AASHTO, design of joints. Design of continuously reinforced concrete pavements. Reliability; Use of software for rigid pavement design
Pavement Management: Distresses in pavements, maintenance of highways, structural and functional condition evaluation of pavements, performance prediction models, ranking and optimization in pavement management.

References:
1. Yoder and Witczak, *Priniciples of Pavement Design*, John Wiley and Sons
2. Yang. H. Huang, *Pavement Analysis and Design*, Second Edition, Prentice Hall Inc.
3. Rajib B. Mallick and Tahar El-Korchi, *Pavement Engineering – Principles and Practice*, CRC Press (Taylor and Francis Group)
4. W.Ronald Hudson, Ralph Haas and Zeniswki , *Modern Pavement Management*, Mc Graw Hill and Co
5. Relevant IRC Codes

Course Outcomes:
Upon completion of this course, the students should be able to:
- know the stresses, strains and deflections in rigid and flexible pavements; traffic loading; and material characterization.
- design methodologies for both rigid and flexible pavements
- understand the structural and functions failure and the evaluation of pavements

CE609 TRAFFIC AND PAVEMENT ENGINEERING LABORATORY

Course Objectives:
- To organise traffic surveys and collect wide variety of traffic data, subjecting them to analysis and interpretation.
- To conduct various standard tests on soil, aggregate and bitumen.

Course Content:
Traffic Surveys: Volume count, Speed study, Parking study, Intersection turning movements, Speed and Delay study, Moving observer survey, Traffic noise measurement, Vehicle emission testing, Road lighting, User perception surveys, Origin Destination (O-D) Surveys, Roadside and Household interviews

Tests on sub grade soil, aggregates, bitumen, modified binders - Soil stabilization - Pavement evaluation.

Mix Design: Granular Sub-base, Bituminous – DBM, SDBC, BC, etc., Cement concrete.

Mini project report based on field and laboratory studies and data collected

Course Outcomes:

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

- conduct the traffic surveys, roadside and household interviews
- perform laboratory test on subgrade soil, aggregates and bitumen
- carry out mix design for the CC pavement, GSB, DBM, SDBC, BC, etc.

SEMESTER II

CE602 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.

Course Content:

Motor Vehicles Act - statutory provision for road transport and connected organizations. Route scheduling, Freight transport, Vehicle scheduling, Optimum fleet size, Headway control strategies, Crew scheduling.

Depots and Terminals - Principles and types of layout, Depot location, Twin depot concept, Crew facilities. Design of terminal facilities – Bus terminal, bus stops and bus bays, Freight Terminal Design

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.

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.

Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Design-Build-Operate-Transfer Schemes – Risk Analysis – Value for Money analysis - Case Studies.

References:

1. Winfrey, *Economic analysis for Highways*, International Textbook Company, Pennsylvania, 1969.
2. CRRI, *Road User Cost Study in India*, New Delhi, 1982
3. 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
- do economic evaluation of the transportation projects and will understand the concepts of the Private Public Partnership

CE604 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

Course Content:

Urban morphology - Urbanization and travel demand – Urban activity systems and travel patterns – Systems approach – Trip based and Activity based approach - Urban Transportation Planning – Goals, Objectives and Constraints - Inventory, Model building, Forecasting and Evaluation - Study area delineation – Zoning - UTP survey

Trip generation models – Trip classification - productions and attractions – Trip rate analysis - Multiple regression models - Category analysis - Trip distribution models – Growth factor models, Gravity model and Opportunity modes.

Modal split models – Mode choice behavior – Trip end and trip interchange models - Probabilistic models - Utility functions - Logit models - Two stage model. Traffic assignment – Transportation networks – Minimum Path Algorithms - Assignment methods – All or Nothing assignment, Capacity restrained assignment and Multi path assignment - Route-choice behavior.

Landuse transportation models – Urban forms and structures - Location models - Accessibility – Landuse models - Lowry derivative models - Quick response techniques - Non-Transport solutions for transport problems.

Preparation of alternative plans - Evaluation techniques - Plan implementation - Monitoring - Financing of Project – urban development planning policy - Case studies.

References:

1. Hutchinson, B.G., *Principles of Urban Transport Systems Planning*, Scripta, McGraw-Hill, NewYork, 1974.
2. Khisty C.J., *Transportation Engineering - An Introduction*, Prentice Hall, NJ, 2007.
3. Papacostas C.S. and Prevedouros, P.D., *Transportation Engineering & Planning*, PHI, New Delhi,2002.

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

CE606 COMPUTATIONAL TECHNIQUES IN TRANSPORTATION ENGINEERING

Course Objectives:

- To be introduced to systems approach.
- To learn the fundamentals of simulation and the GPSS language.
- To be introduced to advanced computational techniques such as GA and ANN.

Course Content:

Introduction to systems approach - Typical transportation systems - Mathematical models. Fundamentals of simulation - Monte Carlo method - Continuous and discrete models - Simulation languages. Probability concepts - Random numbers - Pseudo random generators - Arrival patterns - Service time distributions – Manual simulation of simple queuing system

GPSS Fundamentals - Creating and moving transactions - Queues and facilities - Event scheduling – Standard numerical attributes – Parameters and savevalues - Functions - Priority - Preemption - Collection of statistics - Report preparation. Internal logic of GPSS processor - Program control statements.

Applications of GPSS - Simple queuing problems - Inventory problems - Simulation of ports - Railway platforms and level crossings - Traffic signals. Analysis of simulation results - Model validation - Replication of random conditions - Time series analysis.

Genetic Algorithm - Terminology in GA – Strings, Structure, Parameter string - Data Structures – Operators - Algorithm – Application in Transportation. Fuzzy Logic.

Artificial Neural Networks - Basics of ANN – Topology - Learning Processes - Supervised and unsupervised learning. Least mean square algorithm, Back propagation algorithm - Applications.

References:

1. Gordon, G., *System Simulation,* Prentice-Hall of India, 2005
2. GPSS/PC, *User Manual, Minuteman Software,* USA, 2005
3. David E. Goldberg, Genetic Algorithms in Search, Optimisation and Machine Learning, Addison-Wesley, 1989
4. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers, 2006

Course Outcomes:

Upon completion of this course, the students should have:

- a working knowledge of simulation and GPSS programming.
- a good understanding of GA applications
- the ability to apply ANN

CE610 CAD IN TRANSPORTATION ENGINEERING

Course Objectives:

- To be acquainted with transportation software, and the latest developments such as GIS and Remote sensing
- To be introduced to various software packages on Windows.
- To learn the fundamentals of CAD and DBMS.

Course Content:

Transportation Software – Mx Road, REI heads, HDM4, KENPAVE, M-E design of pavements as per AASHTO, TRIPS, MIGRAN, VISSIM, CUBE

GIS and Remote Sensing Packages – ArcGIS, Geo-Concept, GRAM++, ENVI, ERDAS Imagine, GPS

Computer Aided Drafting - DBMS concepts - Civil Engineering Databases – Data entry & Reports. Spreadsheet concepts – Worksheet calculations in Civil Eng, - Regression & Matrix Inversion, SPSS.

Development of C programs to solve problems using numerical techniques

a. Roots of an equation using Newton – Raphson method.
b. Solution of linear simultaneous equations using Gauss elimination.
c. Matrix inversion using Gauss Jordan method
d. Linear regression line of given points.

References:

1. Rajaraman, V., *Computer Oriented Numerical Methods*, Prentice – Hall of India, 1995
2. Chapra S.C., and Canale R.P., *Numerical Methods for Engineers*, McGraw – Hill, 2004
3. Software Manuals

Course Outcomes:

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

- work on the various transportation software
- understand various GIS and Remote Sensing packages
- develop C programs for various numerical techniques

ELECTIVES

CE611 GEOSPATIAL TECHNIQUES

Course Objectives:

- To understand the basics of advanced tools such as Remote sensing, GIS and GPS
- To highlight their applications in the field of Civil engineering
- To be introduced to various Remote Sensing/GIS/GPS equipment & processing packages.

Course Content:
Concepts and foundations of remote sensing – energy source EMS – Remote Sensing System – EMR interaction with particulate matter – Spectral Signature curves – Data Acquisition and interpretation – Visual Image Interpretation – Photogrammetry – Radar, LIDAR, SAR systems

Platform/Sensors – Classification – satellite system/sensor parameters – earth resources and meteorological satellites – microwave remote sensing techniques – Data Processing – Digital Image processing – Characteristics of Digital Satellite Image – ground truthing.

History of Development – Maps – Types of Maps, Projections – Components/Architecture of GIS – Data – Spatial and Non–Spatial – Data Input Sources – Raster and Vector data structures – DBMS – Data Output – Data quality – Sources/ types of errors

Data handling in GIS –processing, analysis and Modelling – Raster and Vector spatial analysis – Density analysis – Spatial autocorrelation – network analysis – nearest neightbour analysis – Surface modeling – DTM – Introduction to Geodesy – Space Geodetic Techniques – GPS

Application of Remote Sensing, GIS and GPS – Survey, mapping and monitoring – Transportation planning – Infrastructure development – Structural engineering – Geotechnical Engineering – Earthquake Engineering – Environmental studies – Water resources

References:
1. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
2. C.P. Lo and Albert K. W. Yeung, *Concepts and Techniques of Geographical Information Systems*, Prentice–Hall India, 2006.
3. Thomas. M. Lillesand and Ralph. W. Kiefer, *Remote Sensing and Image Interpretation*, John Wiley and Sons, 2003.
4. Joseph G., *Fundamentals of Remote Sensing*, University Press, 2005.
5. Panigrahi, N., *Geographical Information systems*, University Press, 2005.

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 and summarize surveying techniques using global positioning systems
- define the significance of GIS in civil engineering.

CE612 INTELLIGENT TRANSPORTATION SYSTEMS

Course Objectives:
- To learn the fundamentals of ITS.
- To study the ITS functional areas
- To have an overview of ITS implementation in developing countries

Course Content:
Introduction to Intelligent Transportation Systems (ITS) – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

Telecommunications in ITS – Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System

ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).

ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.

References:

1. ITS Hand Book 2000: *Recommendations for World Road Association (PIARC)* by Kan Paul Chen, John Miles.
2. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).

Course Outcomes:

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

- understand the sensor and communication technologies.
- apply the various ITS methodologies
- define the significance of ITS under Indian conditions

CE613 PAVEMENT MATERIALS

Course Objectives:

- To learn the characteristics, properties and testing procedures of highway materials such as soil, aggregate and bitumen.
- To study Bituminous Mix design
- To study the design of mix for CC pavement

Course Content:

Subgrade soil - Soil composition and structure - Soil classification for engineering purposes - Origin, Classification, requirements, properties and tests on road aggregates

Origin, preparation, properties and tests, constitution of bituminous road binders, requirements - Bituminous Emulsions and Cutbacks: Preparation, characteristics, uses and tests

Bituminous Mixes: Mechanical properties - Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes.

Weathering and Durability of Bituminous Materials and Mixes - Performance based Bitumen Specifications - Superpave mix design method

Cement Concrete for Pavement Construction: Requirements, design of mix for CC pavement, joint filler and sealer materials.

References:

1. RRL, DSIR, *Bituminous Materials in Road Construction*, HMSO Publication, 1955
2. IS and IRC Publications on relevant topic.

Course Outcomes:

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

- understand the properties and the various test for the subgrade soil, road aggregates and the bitumen.
- do Bituminous Mix design and will understand the fatigue behaivious of bituminous mixes
- perform superpave mix design and design the mix for the CC pavement and will know about the fillers in joints

CE614 GROUND IMPROVEMENT TECHNIQUES

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-synthetics in ground improvement

Course Content:

Introduction: Engineering properties of soft – weak and compressible deposits – problems associated with weak deposit – Requirements of ground improvements – introduction to engineering ground modification, need and objectives.

Soil Stabilization: Science of soil stabilization – Mechanical modification – Hydraulic modification – Dewatering systems – Chemical modification – Modification by admixtures like lime, Cement, Bitumen etc. – Grouting – Deep jet mixing methods

Recent Ground improvement techniques: stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

Soil reinforcement: Historical background, RCC – Vidalean concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies –

Internal & External stability criteria – Design Principles of steep reinforced soil slops – pavements – Embankments on soft soils.

Geo-Synthetics: Geo-synthetic clay liner – Construction details – Geo Synthetic Materials – Functions – Property characterization – Testing Methods for Geo – Synthetics – Recent research and Developments. Control of Improvement – Field Instrumentation – design and analysis for bearing capacity and settlement of improved deposits.

References:

1. Hausmann, M.R., *Engineering Principles of Ground Modification*, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, *Ground Improvement Techniques*, Laxmi Publications, New Delhi
3. Sharma.S.K., Priniciples, *Practice and Design of Highway Engineering*, S.Chand & Co. New Delhi,1985.
4. Jones C. J. F. P, *Earth Reinforcement and Soil Structures*, Butterworths, London.

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

CE615 BRIDGE ENGINEERING

Course Objectives:

- To develop an understanding of basic concepts in bridge engineering like components, classification, importance, investigation of bridges and loading conditions.
- To study the design of Culvert, Foot Bridge, Slab Bridge, T-beam Bridge and Box Culvert using IRC.
- To study the design of various sub-structures like piers, abutments, foundations and study the importance of the bearing and joints in construction of the bridge.

Course Content:

Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type

Specification of road bridges – width of carriageway – loads to be considered – dead load – IRC standard live load – Impact effect

General design considerations – Design of culvert – Foot Bridge - Slab Bridge – T-beam bridge – Pre-stressed concrete bridge – Box Culvert - Fly over bridges

Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations

Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Electrometric bearing – Joints – Expansion joints. Construction and Maintenance of bridges – Lessons from bridge failures

References:

1. Ponnuswamy, s., *Bridge Engineering*, Tata McGraw - Hill, New Delhi, 1997
2. Victor, D.J., *Essentials of Bridge Engineering*, Oxford & IBH Publishers Co., New Delhi, 1980.
3. N. Rajagopalan, *Bridge Superstructure*, Narosa Publishing House, New Delhi, 2006.

Course Outcomes:

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

- prepare a detailed project report for the construction of bridge giving hydraulic particulars of the river and soil details and be able to select the suitable site and type of the bridge.
- design various types of bridges like Culvert, Slab Bridge and T-beam Bridge using provisions of IRC.
- design pier, abutment, foundations, bearing and detailing of joints.

CE616 TRAFFIC FLOW THEORY

Course Objectives:

- To be introduced to traffic flow theory.
- To study macroscopic and microscopic modeling.
- To learn the fundamentals of ITS.

Course Content:

Traffic stream parameters - Fundamental diagram of volume-speed-density surface. Discrete and continuous probability distributions. Merging manoeuvres - critical gaps and their distribution.

Macroscopic models - Heat flow and fluid flow analogies - Shock waves and bottleneck control approach.

Microscopic models - Application of queuing theory - regular, random and Erlang arrival and service time distributions - Queue discipline - Waiting time in single channel queues and extension to multiple channels.

Linear and non-linear car following models - Determination of car following variables - Acceleration noise.

Geographical Information System – Global Positioning System – Intelligent Transportation Systems - Area Traffic Control – Automatic Toll Collection – Smart Cards – Collision Detection System.

References:

1. Drew, D.R., *Traffic Flow Theory and Control*, McGraw Hill., 1978.
2. TRB, *Traffic Flow Theory* - A Monograph, SR165, 1975.
3. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
4. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.

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

- analyze the traffic stream parameters.
- apply the queuing theory
- define the significance of ITS under Indian conditions.

CE617 TRANSPORTATION NETWORK ANALYSIS AND OPTIMIZATION

Course Objectives:

- To learn the fundamental definitions of networks.
- To study the different Shortest Path Algorithms and network assignment techniques.
- To be exposed to various network analysis software.

Course Content:
Network flows: Applications, definitions, graphs, paths, trees, cycles, loops, walk, network representation (adjacency list and matrices) and basic network transformations; Network algorithms; Complexity, Search Algorithms, Strategies for designing polynomial algorithms.

Shortest Path Algorithms: Label setting, Dijkstra's and Dial's algorithms, Optimality conditions, label correcting algorithms and optimality conditions, detecting negative cycles, all-pair shortest path algorithms; pre-flow push polynomial time algorithms, capacity scaling techniques.

Minimum cost network assignment: optimality conditions, cycle-canceling algorithm, Successive shortest path algorithm, other polynomial time variants; Network equilibrium analysis; principles and optimisation formulations, Frank-Wolfe algorithm; Special cases and variants.

Applications: Applications of min-cost, max-flow, and shortest path algorithms to transportation and infrastructure networks: transportation networks, airline, freight, facility location, logistics, network design, project scheduling, reliability of distribution systems, telecommunication/power networks etc.

Computer Software: Principles of TRIPS, SATURN, EMME/2, CUBE; Demo Versions, Case studies

References:

1. Ahuja, R.., Magnanti, T.L., and Orlin, J.B., *Network Flows: Theory, Algorithms and Application*, Prentice Hall, New Jersey, 1993.
2. Bell, M.G., *Transportation Networks*, Elsevier Science Publishers, 1999.

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

- define and analyze different types of networks.
- apply the Shortest Path and Minimum cost algorithms
- have a working knowledge of various network analysis software.

CE618 ADVANCED HIGHWAY MATERIALS

Course Objectives:

- To study the properties and test on aggregate, bituminous materials, composites and recycled waste products
- To be introduced to the principles of bituminous pavement construction
- To learn the procedure for bituminous and PCC mix design

Course Content:

Aggregate: Nature and properties – aggregate requirements – types and processing – aggregates for pavement base – aggregate for bituminous mixture – aggregate for Portland Cement Concrete – light weight aggregate – tests on aggregate – specification.

Bituminous Materials: conventional and modified binders – production – types and grade – physical and chemical properties and uses – types of asphalt pavement construction – principles of bituminous pavement construction – tests on bituminous materials. Bituminous Mix design – modified mixtures – temperature susceptibility and performance.

Cement /concrete based materials: Cement – properties – PCC mix design and properties – modified PCC – Mix Design – Behaviour – Performance – Tests on Cement and Concrete mixes. High Performance Concrete – low shrinkage – increased strength.

Composites, Plastics and Geosynthetics: Plastics and polymerization process – properties – durability and chemical composition – Reinforced Polymer Composites – Geosynthetics – Dry Powdered Polymers – Enzymes.

Reclaimed / Recycled Waste Products: Reclaimed Materials – waste products in civil engineering applications – effect of waste products on materials, structure and properties – self healing and smart materials – locally available materials.

References:

1. P. T. Sherwood, *Alternative Materials in Road Construction*, Thomas Telford Publication, London, 1997.
2. RRL, DSIR, *Soil Mechanics for Road Engineers*, HMSO, London , 1995
3. Koerner, R. M. *Designing with Geosynthetics*, Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.
4. Shan Somayaji, *Civil Engineering Materials*, second edition, Prentice Hall Inc., 2001.

Course Outcomes:

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

- understand the properties and test procedures of aggregate, bituminous materials, composites and recycled waste products
- know the different types of bituminous pavement construction and its principles
- do bituminous and PCC mix design

CE619 TRANSPORTATION SYSTEMS

Course Objectives:

- To be aware of the development of transport, various road development plans and policies in India.
- To learn the planning, operation and maintenance of different modes of transport and their integration, interaction and impact on environment.
- To study the characteristics and operation of different urban transportation systems.

Course Content:

Historical development of transport in India - Road Development Plans, National Transport Policy Recommendations, Vision 2021, NHDP, PMGSY - IRC, CRRI. Characteristics of different modes of transport and their integration and interactions - impact on environment.

Planning of railway - Passenger and goods terminals - layout - passenger facilities - traffic control.

Airport Planning, requirements and components. Design of runway and taxiway - Apron - parking configuration - terminal requirements - Airport marking and lighting - Air traffic control.

Planning of Harbours and ports – Harbour infrastructures - Port facilities - Containerization - Navigation aids - Inland waterways - Pipeline transportation.

Urban transportation systems - Mass rapid transit system - Light rail transit - Personal rapid transit, guided way systems, cabin taxi, dual mode bus - Para transit systems - Demand responsive system - Intermediate public transport.

References:

1. Paquette, R.J., et al, *Transportation Engineering Planning and Design*, John Wiley & Sons, New York, 1982.
2. Horenjeff Robert; *The planning & Design of Airports*, McGraw Hill Book Co., 2007
3. Alan Black, *Urban Mass Transportation Planning*, McGraw-Hill, 1995.

Course Outcomes:

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

- understand different transport plans and policies
- characterize different modes of transport and their impact
- define and differentiate various urban transportation systems