Master of Technology (Transportation Engineering and Management)

CURRICULUM
(Effective from 2024 - 25 Onwards)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015, INDIA.

VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

Shaping infrastructure development with societal focus

MISSION OF THE DEPARTMENT

Achieve International Recognition by:

- Developing Professional Civil Engineers
- Offering Continuing Education
- Interacting with Industry with emphasis on R&D

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates of the Programme will contribute to the development of transportation infrastructure that is sustainable.
PEO2	Graduates of the Programme, as part of an organization or as Entrepreneurs, will continue to learn to harness evolving technologies.
PEO3	Graduates of the Programme will be professional Transportation Engineers with ethical and societal responsibility.

PROGRAMME OUTCOMES (POs)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

CURRICULUM STRUCTURE

M. Tech. (TRANSPORTATION ENGINEERING AND MANAGEMENT)

Components	Number of Courses	Credits	Total Credits
Programme Core (PC)	3 / Semester (6 / Year)	24	42
Programme Elective (PE)*	3 / Semester (6 / Year)	18	
Essential Laboratory Requirements (ELR)	3 / Year	6	6
Internship/Industrial Training/ Academic Attachment (I/A)	1	2	2
Open Elective (OE) / Online Course (OC)#@	2 (I – IV Semester)	6	6
Project Phase-I	1	12	12
Project Phase-II	1	12	12
Total	**20**	**80**	**80**

Note:

**** ONLINE COURSES EQUIVALENT TO PROGRAMME ELECTIVES (Optional):*** *Out of 6 programme electives, students have the option to study two online courses (Maximum of 1 per semester in the 1st year of Study) equivalent to programme elective courses through NPTEL / Swayam.*

 # OPEN ELECTIVES (OE) / ONLINE COURSE (OC) (Compulsory): *Students must complete 6 credits between I and IV semester either through online courses of their choice from NPTEL / Swayam (discipline electives / other electives) or through open electives offered by the PG programmes of the institute other than the progamme specialization.*

@ ***MICROCREDITS (Optional):*** *Students may opt 3 courses of 1 credit (4-week duration) each as microcredits or 2 courses (2 credits (8-week duration) & 1 credit (4-week duration) instead of 1 OE/OC).*

CURRICULUM

SEMESTER I

Code	Course of Study	Credit
MA601	Numerical Methods and Applied Statistics	4
CE601	Highway Traffic Analysis and Design	4
CE603	Pavement Analysis and Design	4
	Programme Elective I	3
	Programme Elective II	3
	Programme Elective III / Online (NPTEL)	3
CE607	Traffic Engineering and Transportation Planning Laboratory	2
CE609	Pavement Engineering Laboratory	2
		25

SEMESTER II

Code	Course of Study	Credit
CE602	Urban Transportation Systems	4
CE604	Transportation Planning	4
CE606	Pavement Construction and Maintenance	4
	Programme Elective IV	3
	Programme Elective V	3
	Programme Elective VI / Online (NPTEL)	3
CE610	Computer Aided Design in Transportation Engineering	2
		23

SUMMER TERM (evaluation in the III semester)

Code	Course of Study	Credit
CE645	Internship / Industrial Training / Academic Attachment (I/A) (6 weeks to 8 weeks)	2

SEMESTER III

Code	Course of Study	Credit
CE647	Project Work (Phase I)	12

SEMESTER IV

Code	Course of Study	Credit
CE648	Project Work (Phase II)	12

OPEN ELECTIVES (OE) / ONLINE COURSE (OC)

Code	Course of Study	Credit
	# (To be completed between I to IV semester)	6

PROGRAMME ELECTIVES

Sl. No.	Code	Course of Study	Credit
1.	CE611	Traffic Flow Theory	3
2.	CE612	Introduction to Computational Techniques in Transportation Engineering	3
3.	CE613	Transportation Network Analysis and Optimization	3
4.	CE614	Transportation Systems	3
5.	CE615	Transportation Economics	3
6.	CE616	Waterway Transportation	3
7.	CE617	Airport Planning and Design	3
8.	CE618	Advanced Highway Materials	3
9.	CE619	Intelligent Transportation Systems	3
10.	CE620	Advanced Surveying and Cartography	3
11.	CE621	Geospatial Techniques	3
12.	CE622	Statistical Methods for Civil Engineers	3
13.	CE623	Basics of Machine Learning and its Application in Civil Engineering	3
14.	CE624	Urban Planning Techniques and Practices	3
15.	CE625	Design and Construction of Low Volume Rural Roads	3
16.	CE626	Pavement Evaluation and Management	3
17.	CE627	Behavioral Travel Modeling	3
18.	CE628	Sustainable Transportation	3
19.	CE629	Logistics in Transportation Engineering	3
20.	CE630	Road Safety System	3
21.	CE631	Railways Infrastructure Planning and Design	3

OPEN ELECTIVES (OE) (List some courses from Programme Electives, that will be Open Electives for other Specialization, if it is offered as Programme Elective for the respective specialization)

Sl. No.	Code	Course of Study	Credit
1.	CE619	Intelligent Transportation Systems	3
2.	CE621	Geospatial Techniques	3
3.	CE622	Statistical Methods for Civil Engineers	3
4.	CE623	Basics of Machine Learning and its Application in Civil Engineering	3
5.	CE624	Urban Planning Techniques and Practices	3

MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4-week duration) each as microcredits or 2 courses (2 credits (8-week duration) & 1 credit (4-week duration) instead of 1 OE/OC)

Code	Course of Study	Credit
	Equivalent to OC (May be completed between Semester I to Semester IV)	3

ELECTIVE COMBINATIONS

1. Program Elective Courses

Option 1:

Semester	No. of Programme Electives	No. of Online Programme Electives	Credits for Programme Elective Courses
I	3	0	9
II	3	0	9

Option 2:

Semester	No. of Programme Electives	No. of Online Programme Electives	Credits for Programme Elective Courses
I	2	1	9
II	3	0	9

Option 3:

Semester	No. of Programme Electives	No. of Online Programme Electives	Credits for Programme Elective Courses
I	3	0	9
II	2	1	9

Option 4:

Semester	No. of Programme Electives	No. of Online Programme Electives	Credits for Programme Elective Courses
I	2	1	9
II	2	1	9

2. Online Courses (OC) / Open Elective (OE) Courses

Option 1:

Semester	No. of Open Elective Courses	No. of online Courses		
		3 Credit courses	2 credit courses	1 credit course
I - IV	-	2	-	-
	-	1	1	1
	-	1	-	3

Option 2:

Semester	No. of Open elective Courses	No. of online Courses		
		3 credit courses	2 credit courses	1 credit course
I - IV	1	1	-	-
	1	-	1	1
	1	-	-	3

Option 3:

Semester	Open elective Courses	No. of online Courses		
		3 credit courses	2 credit courses	1 credit course
I - IV	2	-	-	-

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE

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

Course Code	Course Title	CO	Course outcomes: At the end of the course student will be able to	PO1	PO2	PO3
MA601	Numerical Methods and Applied Statistics	CO1	compute solution for linear, nonlinear and system of equations	2	1	2
		CO2	solve the mathematical problems through linear programming approaches	2	1	2
		CO3	utilize the knowledge of standard distributions for solving real life case studies	2	2	3
		CO4	use statistical knowledge in testing hypotheses on large and small samples	2	2	2
		CO5	compute and interpret relationship between parameters in the design of experiments	3	3	3
CE601	Highway Traffic Analysis and Design	CO1	apply the concept of traffic characteristics	3	2	2
		CO2	conduct traffic surveys	3	2	3
		CO3	design the intersections	2	3	3
		CO4	apply the concepts of traffic operation and management	3	1	2
		CO5	build safety into every aspect of design	2	3	3
CE602	Urban Transportation Systems	CO1	compare and select suitable urban transportation systems	3	2	3
		CO2	design route network	3	1	3
		CO3	schedule the transit units and crew	3	1	3
		CO4	apply the concepts of terminal planning	2	2	3
		CO5	have a knowledge of sustainable transportation systems	2	2	3

CE603	Pavement Analysis and Design	CO1	understand the factors affecting pavement design and evaluate pavement design factors	2	1	3
		CO2	analyze the stresses, strains and deflections in flexible pavements	3	2	3
		CO3	analyse the rigid pavement slab and joints	3	2	3
		CO4	design flexible pavements using various methods	3	3	3
		CO5	design rigid pavement slab and joints	3	3	3
CE604	Transportation Planning	CO1	interpret the urban activity system and travel patterns	2	1	2
		CO2	understand the trip generations and trip distribution concepts	3	3	2
		CO3	understand various mode choice models	3	3	2
		CO4	predict the route choice of trip makers	3	3	2
		CO5	understand various land use transport models	3	2	3
CE606	Pavement Construction and Maintenance	CO1	carry out the construction control and quality control checks of subgrade and stabilised layers	3	2	3
		CO2	carry out the construction of subbase, base and wearing courses in flexible pavements	3	2	3
		CO3	understand the construction of interlocking block pavements, quality control tests; construction of various types of joints	3	2	3
		CO4	understand various distresses and the evaluation of pavements	3	3	3
		CO5	propose suitable maintenance and rehabilitation strategies for pavement failures	3	3	3

ESSENTIAL LABORATORY REQUIREMENTS (ELR)

Course Code	Course Title	CO	Course Outcomes: At the end of the course student will be able to	PO1	PO2	PO3
CE607	Traffic Engineering and Transportation Planning Laboratory	CO1	collect fundamental and derived characteristics of traffic in the given facilities	3	3	2
		CO2	collect and evaluate the traffic pattern at mid-block, controlled and uncontrolled intersections, and highways	2	3	2
		CO3	gather the road user perception by performing questionnaire survey	2	3	2
		CO4	audit the given road with respect to road safety	2	3	2
		CO5	collect and analyses the air and noise pollution associate with traffic	3	3	3
CE609	Pavement Engineering Laboratory	CO1	understand soil properties and classification methods	3	2	1
		CO2	evaluate the physical and mechanical properties of aggregates	3	3	2
		CO3	comprehend the rheological properties of bitumen	3	3	3
		CO4	assess the Marshall parameters of bituminous mixes	3	3	3
		CO5	evaluate the structural strength properties of pavements	3	3	3
CE610	Computer Aided Design in Transportation Engineering	CO1	employ various traffic analysis software	3	2	3
		CO2	operate various GIS and Remote Sensing packages	3	2	3
		CO3	use various highway alignment and transportation planning software	3	3	3
		CO4	develop programs for various numerical techniques	3	3	2
		CO5	design the flexible and rigid pavements using different approaches	3	3	3

PROGRAMME ELECTIVES

Course Code	Course Title	CO	Course outcomes: At the end of the course student will be able to	PO1	PO2	PO3
CE611	Traffic Flow Theory	CO1	analyze the traffic stream parameters	3	1	3
		CO2	apply macroscopic models in fluid flow analogy and shockwave approaches	3	2	3
		CO3	apply the queuing theory for developing the microscopic models	2	2	3
		CO4	analyze vehicle interactions in the form of car following concepts and apply the various delay models at intersections	2	2	3
		CO5	simulate, calibrate and validate the traffic for the given stream with statistical analysis	2	1	3
CE612	Introduction to Computational Techniques in Transportation	CO1	explain the role and significance of computational methods in modern traffic and transportation systems	2	2	1
		CO2	design and optimize transportation networks using computational algorithms	3	1	2
		CO3	have a good understanding of GA applications	2	2	1
		CO4	apply fuzzy logic techniques to model and solve complex transportation problems	2	3	2
		CO5	apply ANN for solving transportation related problems	3	2	1
CE613	Transportation Network Analysis and Optimization	CO1	define and analyze different types of networks	1	2	2
		CO2	characterize different types of networks based on network properties	2	2	3
		CO3	apply the Shortest Path and Minimum cost algorithms	3	2	2
		CO4	able to formulate, analyze and	3	3	3

			solve real-world transportation problems using the network analysis tools			
		CO5	understand the concepts of network equilibrium and optimization techniques	3	2	2
CE614	Transportation Systems	CO1	understand different transport plans and policies	2	2	2
		CO2	understand the traffic operations and maintenance	3	2	3
		CO3	understand the concepts of capacity and level of service	3	2	2
		CO4	characterize different modes of transport and their impact	3	2	3
		CO5	controls and terminal facilities of transportation system	3	2	3
CE615	Transportation Economics	CO1	understand the concepts of decision making	2	1	1
		CO2	calculate transportation demand and supply	3	2	2
		CO3	estimate vehicle operation cost and accident cost	3	2	2
		CO4	perform economic analysis of a transportation project	2	3	2
		CO5	apply various financing methods in road projects	1	2	1
CE616	Waterway Transportation	CO1	understand the concept of harbour planning	3	1	2
		CO2	gain knowledge on various harbour infrastructures	2	2	3
		CO3	understand the navigational aids	2	1	3
		CO4	understand dredging and coastal protection	2	2	3
		CO5	plan port and other facilities in the port	3	2	3
CE617	Airport Planning and Design	CO1	understand the various aircraft characteristics	3	2	1
		CO2	apply the concept of airport planning and demand forecasting	3	2	3
		CO3	design the runways, taxiways and aprons	3	2	3

		CO4	design the components of airport terminal	2	3	1
		CO5	plan air traffic management	3	3	2
CE618	Advanced Highway Materials	CO1	understand the properties and test procedures of aggregate	2	1	1
		CO2	understand the properties of bituminous materials	2	1	3
		CO3	perform bituminous mix design using various methods	3	2	3
		CO4	perform PQC mix design and can conduct various tests on cement and concrete	2	2	2
		CO5	use recycled and other materials in road construction	3	2	3
CE619	Intelligent Transportation Systems	CO1	understand the sensor technologies	2	1	2
		CO2	understand the communication techniques	3	2	2
		CO3	apply the various ITS methodologies	3	2	3
		CO4	understand the user needs	3	1	3
		CO5	define the significance of ITS from developed countries perspective and implications for Indian conditions	3	3	2
CE620	Advanced Surveying and Cartography	CO1	describe the methods and applications of advanced surveying in the field of transportation engineering	2	3	3
		CO2	define the correct coordinate system and methods of transformation	3	1	3
		CO3	define the significance of topographical survey	3	1	3
		CO4	describe in detail about geodesy	3	1	3
		CO5	define the significance of GPS in transportation engineering	3	1	3
CE621	Geospatial Techniques	CO1	describe the concept and application of remote sensing in civil engineering	3	2	3
		CO2	define the importance of GIS and its use in civil engineering	3	2	3

			applications			
		CO3	describe the principle of GPS with more reference to positioning, method of measurement and satellite structure	3	2	3
		CO4	describes the use of various software packages in Remote sensing, GIS, GPS in real time applications	3	3	3
		CO5	summarize the application of Remote sensing, GIS and GPS in civil engineering	3	3	3
CE622	Statistical Methods for Civil Engineers	CO1	apply the concepts of data and preliminary analysis with civil engineering data	3	2	3
		CO2	perform the sampling, distribution and curve fitting for the large and small samples	2	2	3
		CO3	determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data point	3	1	3
		CO4	obtain the value of the point estimators using method of maximum likelihood and apply the time series approach	2	1	2
		CO5	apply probability distributions to analyze civil engineering data	2	1	3
CE623	Basics of Machine Learning and its Application in Civil Engineering	CO1	understand and explain the fundamental concepts of Machine learning algorithms	3	2	3
		CO2	deploy ML-Algorithms to predict binary and multiclass responses	3	2	1
		CO3	learn data handling and pre-processing options for successful application and running of ML-algorithms	1	1	2
		CO4	compare the performances of	3	2	1

			different ML algorithms to find the best-performing/applicable option			
		CO5	get exposure to the Shapely Additive explanation Values used for interpreting each parameter's effect on the ML algorithm's predictive performance	2	1	2
CE624	Urban Planning Techniques and Practices	CO1	identify and describe the key characteristics of urban areas	2	1	3
		CO2	differentiate various types of plans	3	1	3
		CO3	identify different types of planning surveys and demonstrate how to collect, analyze, and use survey data for the preparation of various urban plans	3	1	3
		CO4	compare the different town planning theories	3	1	3
		CO5	apply development control measures and planning guidelines to urban renewal projects	2	1	3
CE625	Design and Construction of Low Volume Rural Roads	CO1	plan low-volume road network	2	1	2
		CO2	design low volume road geometrics	2	2	3
		CO3	identify appropriate materials and cost-effective technologies for LVRs	3	2	3
		CO4	analyse and design flexible and rigid pavements for LVRs	3	3	3
		CO5	select an appropriate pavement construction technique and perform quality control tests	3	3	3
CE626	Pavement Evaluation and Management	CO1	comprehend principles for evaluating pavement performance and assessing pavement distresses.	2	2	3

		CO2	gain knowledge of pavement structure evaluation techniques and field tests	3	3	3
		CO3	learn to develop and utilize performance prediction models for pavement management	2	2	3
		CO4	utilize performance prediction models for pavement management	3	3	3
		CO5	conduct life cycle cost analysis and optimize maintenance and rehabilitation strategies	3	3	3
CE627	Behavioral Travel Modeling	CO1	demonstrate comprehensive knowledge on behavioral travel modeling	2	2	3
		CO2	design and implement travel surveys	3	2	2
		CO3	perform discrete choice modelling	3	3	2
		CO4	understand advanced modelling techniques	3	3	3
		CO5	understand integrated land use and transport modeling	3	3	3
CE628	Sustainable Transportation	CO1	explain effect of transport sector on sustainability and specify transport planning strategies for sustainable development	2	1	3
		CO2	evaluate strategies for development of non-motorised transport	3	2	3
		CO3	specify actions for planning for pedestrian facilities	2	1	2
		CO4	specify actions for planning for bicyclists' facilities	2	1	2
		CO5	elaborate on sustainable policies and technologies	3	3	3
CE629	Logistics in Transportation Engineering	CO1	apply the concepts of logistics and freight transport	3	3	2
		CO2	develop the various freight models in small and large scaling	2	1	3

		CO3	apply the concepts of supply chain in design of freight facility and distribution management	2	2	3
		CO4	apply the IT and IoT facilities in logistics management	2	1	2
		CO5	develop the various ITS solutions in freight transport and movement	3	1	2
CE630	Road Safety System	CO1	apply the knowledge of science and engineering fundamentals in developing an efficient road safety system & conduct research pertinent to road safety and management	3	1	3
		CO2	explain concepts and analysis of accident data collection and analysis techniques with various advanced methods	2	2	2
		CO3	conduct research pertinent to road accident costing and road safety audit and management system with case studies	2	2	2
		CO4	apply the big data analytics in road safety system and management	1	1	1
		CO5	perform advanced techniques in accident analysis	2	2	3
CE631	Railways Infrastructure Planning and Design	CO1	explain railway line network planning concepts and components of railway tracks	2	1	2
		CO2	perform geometric design of railway track	3	2	2
		CO3	understand various track construction and maintenance practices	2	2	3
		CO4	comprehend railway signalling and interlocking	2	2	2
		CO5	elaborate on modernization of railways	3	2	3

3 - High; 2 - Medium; 1 – Low

PROGRAMME CORE

SEMESTER I

Course Code	**:**	MA601
Course Title	**:**	**Numerical Methods and Applied Statistics**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize with various numerical methods for solving linear, non-linear and system of linear equations
CLO2	To learn linear and integer programming
CLO3	To recall the basic probability concepts, introduce random variables and some of the special distributions
CLO4	To impart knowledge on hypothesis testing for large and small sample
CLO5	To discuss about experimental design and time series analysis

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 – Big-M method - Two phase method - Dual simplex method - Dual theory – Sensitivity analysis – Integer programming – applications.

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. Introduction and hands-on practice on popular / available tools in the context of engineering applications.

References

1.	Bowker, A. H., Lieberman, G. J., *Engineering Statistics*. Prentice Hall, 1972.
2.	Venkatraman, M. K., *Numerical Methods in Science and Engineering*. National Publisher Company, 5th Edition, 1999.

3.	Jain, M. K., Iyengar, S. R. K., Jain, R. K., *Numerical Methods for scientific and engineering computation*. 6th edition, New Age International (p) Limited, 2012.
4.	Hamdy A. Taha, *Operations Research: An introduction*. 10th edition Pearson Prentice Hall, 2007.
5.	S. C. Gupta, *Fundamentals of Statistics*. Himalaya Publishing House, 7th Revised and Enlarged Edition, 2014.
6.	S.C. Gupta., V. K. Kapoor, *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	compute solution for linear, non-linear and system of equations
CO2	solve the mathematical problems through linear programming approaches
CO3	utilize the knowledge of standard distributions for solving real life case studies
CO4	use statistical knowledge in testing hypotheses on large and small samples
CO5	compute and interpret relationship between parameters in the design of experiments

Course Code	**:**	CE601
Course Title	**:**	**Highway Traffic Analysis and Design**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts of traffic characteristics
CLO2	To study the various methods of collecting traffic data
CLO3	To learn the principles of intersection design
CLO4	To understand the concepts of traffic operation and management
CLO5	To learn the importance of road safety

Course Content

Elements of traffic engineering - Characteristics of Road user, vehicle, roadway - Geometric Design – Overview - Passenger Car Units - Static and Dynamic Traffic Stream Characteristics - Capacity - LOS - Headway concepts and applications.

Conventional and Modern Methods of Traffic Survey and Studies – Types of Data - Volume Studies, Speed Studies - Travel time and delay studies - Pedestrian Studies- Parking studies- Accident studies -Vehicle detection methods - Origin and Destination – Fundamental derived parameter.

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 traffic Control

System. Grade separated interchanges - Geometric elements for divided and access-controlled highways and expressways.

Traffic Regulation and control, Cost Effective Management Measures – Traffic System Management and Travel Demand Management - Congestion Management, Traffic Calming and Pricing, Pedestrian Facilities, Parking Facilities – On Street and Off-Street Multi-level car Parking – Street Lighting.

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

References

1.	Roger. P. Roess, Elena S. Prassas and William R. McShane, *Traffic Engineering*, 5th edition, Pearson Education India, 2019.
2.	R Srinivasa Kumar, *Introduction to Traffic Engineering*, The Orient Blackswan; South Asian edition, 2018.
3.	Nicholas T.G., Lester A. H., *Traffic and Highway Engineering*, Revised 2nd Edition, ITP, California, USA,2008.
4.	Thomas C., *An Introduction Traffic Engineering–A Manual for Data Collection and Analysis*, Books Cole, UK, 2001.
5.	Indo-HCM, 2017 and relevant IRC codes
6.	ITE Handbook, Highway Engineering Handbook, Mc Graw - Hill.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	apply the concept of traffic characteristics
CO2	conduct traffic surveys
CO3	design the intersections
CO4	apply the concepts of traffic operation and management
CO5	build safety into every aspect of design

Course Code	**:**	CE603
Course Title	**:**	**Pavement Analysis and Design**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the pavement design factors and loading characteristics
CLO2	To study the behaviour of flexible pavements under various loads

CLO3	To study the stress and strain of rigid pavement under load and temperature variations
CLO4	To design the flexible pavements using different Empirical, semi-empirical and theoretical approaches
CLO5	To design the rigid pavement and the joints

Course Content

Introduction of Pavements: Types and component parts of pavements, Characteristics of Pavement Materials. Factors affecting design and performance of pavements - strength characteristics of pavement materials, climatic variations, traffic - Design wheel load, load equivalence factors and equivalent wheel loads, tyre pressure. Highway and airfield pavements,

Stresses in Flexible Pavements: Visco-Elastic Theory and Assumptions, Layered system concepts, Stress solution for one, two and three-layered systems, Fundamental design concepts

Stresses in Rigid Pavements: Wheel load stresses, Westergaard's analysis, Pickett's load theory and influence charts, Warping stresses and frictional stresses. Stresses in Dowel Bars & Tie Bars.

Flexible Pavement Design: Empirical, semi-empirical and theoretical approaches, design of highway and airport pavements by IRC 37, AASHTO Methods, Mechanistic –Empirical design, applications of pavement design software.

Design of Rigid Pavements: Factors effecting Design - Wheel load & its repetition, subgrade strength & proportion, strength of concrete - modulus of elasticity. Reinforcement in slab. Design of joints. Design of Dowel bars. Design of Tie bars. design of CC pavement as per IRC 58, AASHTO.

References

1.	Yoder and Witczak, *Priniciples of Pavement Design*, John Wiley and Sons, 2nd Edition, 1975.
2.	Yang. H. Huang, *Pavement Analysis and Design*, 2nd Edition, Prentice Hall Inc., 2008.
3.	Rajib B. Mallick and Tahar El-Korchi, *Pavement Engineering – Principles and Practice*, CRC Press, 4th Edition, 2023.
4.	Norbert J. Delette, *Concrete Pavement Design, Construction, and Performance*, CRC Press. 2nd Edition, 2017.
5.	Srinivasa Kumar, *Pavement Design*, Orient Black swan Pvt. Ltd., 2013.
6.	Relevant IRC Codes

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the factors affecting pavement design and evaluate pavement design factors
CO2	analyze the stresses, strains and deflections in flexible pavements
CO3	analyse the rigid pavement slab and joints

CO4	design flexible pavements using various methods
CO5	design rigid pavement slab and joints

Course Code	**:**	CE607
Course Title	**:**	**Traffic Engineering and Transportation Planning Laboratory**
Type of Course	**:**	Laboratory
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To conduct the traffic survey for examining the traffic fundamental parameters and derived characteristics
CLO2	To perform the surveys for understating the traffic pattern at mid-block, controlled and uncontrolled intersections, and highways
CLO3	To conduct the various stated preference survey and user perception survey
CLO4	To demonstrate the road safety audit procedure in the given scenarios
CLO5	To perform the air and noise pollution survey and analyze the association with traffic

Course Content

Traffic Volume studies and Turning Movement Studies: Direction, Duration and Classification of Traffic Volume at Mid-Block Section and Intersection

Speed studies: Spot Speed Studies

Journey time and delay studies: Travel Time and Delay Studies by Moving Car Observer Method

Intersection delay studies: Delay Measurement at Intersections

Arrival pattern studies of vehicles, Queue discharge characteristics

Gap acceptance studies at Uncontrolled Intersections: Study of Gaps, Lags, Critical Gaps

Highway Capacity Estimation: Videographic method, Dynamic PCU

Origin – Destination Study

Parking Studies – On street and off-street methods

Questionnaire based survey – Pedestrian, Driver Behavior, Facility Evaluation, Mode Shift Decision, Experts Opinion

Road Safety Audit

Measurement of Air Pollution and Noise Levels and Correlation with Traffic Conditions

Data Presentation, Data Sampling and Description, Data Analysis and Statistical Inference

References

1.	Khanna S. K., Justo C.E.G., and Veeraragavan A., *Highway Materials and Pavement Testing*, Nem Chand and Bros., Roorkee, 2013.
2.	Kadyali, L.R., *Traffic Engineering and Transport Planning*, Khanna Publication, Delhi, 2011.
3.	Relevant IRC Codes
4.	Indo-HCM, 2017
5.	MoRTH reports

Course Outcomes (CO)

At the end of the course student will be able to

CO1	collect fundamental and derived characteristics of traffic in the given facilities
CO2	collect and evaluate the traffic pattern at mid-block, controlled and uncontrolled intersections, and highways
CO3	gather the road user perception by performing questionnaire survey
CO4	audit the given road with respect to road safety
CO5	collect and analyses the air and noise pollution associate with traffic

Course Code	**:**	CE609
Course Title	**:**	**Pavement Engineering Laboratory**
Type of Course	**:**	Laboratory
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the soil characteristics and classification
CLO2	To assess the physical, mechanical properties of aggregates
CLO3	To understand the rheological properties of bitumen
CLO4	To evaluate the Marshall parameter of bituminous mixes
CLO5	To assess pavement structural strength properties of road

Course Content

Tests on Soils - Density of soil, CBR, Determination of Field CBR using Dynamic Cone Penetrometer, classification of soils.

Tests on Aggregate - Gradation, Shape tests, Specific gravity, Water absorption, Aggregate crushing value, Los Angeles abrasion value, Aggregate impact value.

Tests on Bitumen - Penetration, viscosity, Flash and fire point, Ductility and elastic recovery, Softening point, Specific gravity, Ageing of Bitumen, Rheology of Bitumen using Dynamic Shear Rheometer.

Tests on Bituminous Mixes - Marshall mix design, Bitumen content determination using centrifuge extractor.

Pavement Evaluation - Identification of distresses along with its density and severity, pavement condition rating, skid resistance measurement, roughness measurement using Merlin, structural evaluation of the flexible and rigid pavement: Field core characterisation, Benkelman beam test.

References

1.	Khanna S. K., C.E.G Justo, A. Veeraragavan, *Highway Materials and Pavement Testing*, Nem Chand & Bros, 2013.
2.	MoRTH Specification for Road and Bridge works, Fifth Revision, 2023.
3.	Bhavanna Rao. D.V., G. Venkatappa Rao., K. Ramachandra Rao., Kausik Pahari *Highway Material Testing and Quality Control*, Dreamtech Press, 2019
4.	Pradeep Kumar and Satish Chandra, Manual on Pavement Evaluation Techniques, Khanna Publishers, 1st Edition, 2022.
5.	Relevant IRC and IS Codes

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand soil properties and classification methods
CO2	evaluate the physical and mechanical properties of aggregates
CO3	comprehend the rheological properties of bitumen
CO4	assess the Marshall parameters of bituminous mixes
CO5	evaluate the structural strength properties of pavements

SEMESTER II

Course Code	**:**	CE602
Course Title	**:**	**Urban Transportation Systems**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the characteristics of various urban transportation systems
CLO2	To learn the concepts of route network design
CLO3	To familiarize with scheduling
CLO4	To study the planning aspects of terminals
CLO5	To be acquainted with sustainable urban transportation systems

Course Content

Transport Systems: Urban modes and service types - Technological and operational Characteristics – environmental considerations – relative cost economics – criteria for selection

Route Network Design: Transportation Demand estimation, Data requirements, Network planning - Corridor identification - Route Systems and Capacity, Comprehensive mobility plan

Scheduling: Components –Scheduling procedure and patterns –Fleet Requirement – Bus and Crew scheduling - Rail operation design – Scheduling – Frequency and Headway

Terminal Planning: Planning and design of terminals - Bus stop capacity – Depot location - Depot layout, Parking patterns, Rail Transit: Station Arrangements - Way capacity and Station Capacity

Sustainable Urban Transportation: Preferential treatment for high occupancy modes, promoting non-motorized modes of transport - Integrated land use and transport planning – Demand management techniques - Integrated public transport planning; case studies- Smart Cities.

References

1.	Black, Alan, *Urban Mass Transportation Planning*, McGraw- Hill,Inc., New York,1995.
2.	Vukan, R. Vuchic, *Urban Transit Systems and Technology*, John –Wiley & Sons, New Jersey, 2007.
3.	Sigurd Grava, *Urban Transportation Systems – Choices for Communities*, The McGraw-Hill Companies, 2004.
4.	National Urban Transport Policy

5.	Black, William R. *Sustainable transportation: problems and solutions*, The Guilford Press, 2010.
6.	Ceder, Avishai. *Public Transit Planning and Operation: Theory, modelling and practice*, Butterworth-Heinemann publications, 2007.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	compare and select suitable urban transportation systems
CO2	design route network
CO3	schedule the transit units and crew
CO4	apply the concepts of terminal planning
CO5	have a knowledge of sustainable transportation systems

Course Code	**:**	CE604
Course Title	**:**	**Transportation Planning**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To interpret the urban activity system and travel patterns
CLO2	To understand the trip generations and trip distribution concepts
CLO3	To understand various mode choice models
CLO4	To predict the route choice of trip makers
CLO5	To understand various land use transport models

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 and Multi path assignment - Route-choice behavior.

User Equilibrium assignment- System optimum assignment- Incremental assignment- Capacity restraint assignment- Stochastic user equilibrium assignment- Dynamic Assignment.

Landuse transportation models – Urban forms and structures - Location models - Accessibility – Landuse models - Lowry derivative models – Micro level Planning- International Practices.

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, 2015.
4.	Ortuzar, J.D., Willumsen, L.G., *Modeling Transport*, 4th edition, John Wiley & Sons, 2011.
5.	P.K. Sarkar, Vinay Maity, G.J.Joshi., *Transportation Planning: Principles, Practices and Policies,* 3rd edition, PHI, New Delhi, 2017.
6.	Transport analysis guidance: WebTAG

Course Outcomes (CO)

At the end of the course student will be able to

CO1	interpret the urban activity system and travel patterns
CO2	demonstrate the classical methods of urban transportation planning
CO3	apply four stage travel demand modeling
CO4	understand the trip generations and trip distribution concepts
CO5	understand the mode and route choice of trip makers

Course Code	**:**	CE606
Course Title	**:**	**Pavement Construction and Maintenance**
Type of Course	**:**	Programme Core
Prerequisites	**:**	-
Contact Hours	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concept of earthwork and subgrade formation for constructing pavements.
CLO2	To learn the concept of flexible pavement layer construction.
CLO3	To learn the concept of cement concrete pavement and its joints
CLO4	To analyse the defects in road construction and general pavement failures
CLO5	To understand the concept and of Pavement maintenance

Course Content

Earthwork and Subgarde: Earthwork, compaction and construction of embankments - specifications of materials, construction methods and field control checks, Subgrade construction, construction of surface and sub-surface drainage system; Soil Stabilized Pavement Layers: soil-aggregate mixes and compaction; soil-cement, soil-bitumen and soil-lime stabilisation methods.

Flexible pavement construction: Construction procedure Subbase (Granular sub base), Drainage layer, Base course-WBM, WMM, Lime stabilized, cement stabilized (Granular layer), Bituminous mix – Binder course and wearing course, its selection, its gradation, compaction, density requirements and construction procedure.

Cement Concrete Pavement Layers: Specifications and method of Dry lean concrete and Pavement quality concrete construction; Construction of various types of joints Quality control tests; Interlocking Concrete Block Pavement (ICBP) - procedure of laying, requirements, Pattern of blocks, Strength requirement.

Pavement Evaluation - Pavement Distress - Functional and structural condition of pavements, Pavement distress survey, Functional condition evaluation of pavements-Roughness, Skid Resistance. Structural evaluation of pavements - non destructive testing, Benkelman beam and Falling Weight Deflectometer, Pavement strengthening based on deflection as per IRC.

Pavement Maintenance: Importance of maintenance – Types of Maintenance-Preventive maintenance. Repair of pavement defects, Preventive maintenance of road drainage system, pavements and other components of road. Preparation of existing pavement – patching, profile correction, Special measures to deal with reflection cracks in pavement layers, slipperiness of surface, etc. Recycling Techniques in Bituminous Pavements, Full Depth Reclamation.

References

1.	Kandhal, Veeraragavan, Rajan, *Bituminous Road Construction in India*, PHI Learning PVT, India, 2nd Edition, 2023.
2.	P. Purushothama Raj, *Ground Improvement Techniques*, Laxmi Publications (P) Ltd., New Delhi, 2016.
3.	Sandipan Goswami, *Pavement Engineering: Design, Construction, Maintenance*, PHI Publication, 2022.
4.	W.Ronald Hudson, Ralph Haas and Zeniswki, *Modern Pavement Management, Mc* Graw Hill and Co, 1994.
5.	Relevant IRC codes and Ministry Specifications.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	carry out the construction control and quality control checks of subgrade and stabilised layers.

CO2	carry out the construction of subbase, base and wearing courses in flexible pavements.
CO3	understand the construction of interlocking block pavements, quality control tests; construction of various types of joints.
CO4	understand various distresses and the evaluation of pavements
CO5	propose suitable maintenance and rehabilitation strategies for pavement failures.

Course Code	**:**	CE610
Course Title	**:**	**Computer Aided Design in Transportation Engineering**
Type of Course	**:**	Laboratory
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To be acquired with traffic analysis software, and the latest development such as GIS and Remote Sensing
CLO2	To learn the highway alignment software
CLO3	To get knowledge on transportation planning software
CLO4	To learn the development of models using MATLAB/Python/R Programs
CLO5	To get knowledge on pavement analysis and design software

Course Content

Traffic related Software – VISSIM, VISWALK, TRANSYT

Highway Alignment Software – OpenRoads, Civil 3D

Transportation Planning Software – NLOGIT, CUBE, CUBE VOYAGER, VISUM, SATURN

Pavement Engineering Software – KENPAVE, IITPAVE, HDM4, GAMS

GIS and Remote Sensing Packages – ArcGIS, ERDAS Imagine, QGIS

Spreadsheet concepts – Worksheet calculations in Civil Engg. - Regression & Matrix Inversion, Transportation Planning

Development of MATLAB/Python/R programs to solve problems using numerical techniques

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 (CO)

At the end of the course student will be able to

CO1	employ various traffic analysis software
CO2	operate various GIS and Remote Sensing packages
CO3	use various highway alignment and transportation planning software
CO4	develop programs for various numerical techniques
CO5	design the flexible and rigid pavements using different approaches

PROGRAMME ELECTIVES

Course Code	**:**	CE611
Course Title	**:**	**Traffic Flow Theory**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To be introduced to traffic flow theory
CLO2	To study macroscopic models
CLO3	To learn the fundamentals of queuing theory
CLO4	To study the car following models and intersection delay models
CLO5	To learn the simulation models and statistical analysis of simulation data

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 - Vehicle trajectories - Acceleration noise. Delay at Intersections - Type of delays - Saturated and oversaturated intersections – Steady state delay model, Time dependent delay model.

Fundamentals and concepts, components of traffic simulation- Simulation Model and Classification, Mathematical simulation model development, Software for simulation, calibration and validation of simulation model- Statistical analysis of simulation data.

References

1.	Lily Elefteriadou. *An Introduction to Traffic Flow Theory*, Springer New York, NY, 2014.
2.	Daiheng Ni, *Traffic Flow Theory- Characteristics*, Experimental Methods, and Numerical Techniques, Butterworth-Heinemann Inc, 2016.
3.	Drew, D.R., *Traffic Flow Theory and Control*, McGraw Hill., 1978.
4.	TRB, *Traffic Flow Theory - A Monograph*, SR, 165, 1975.
5.	Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
6.	Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	analyze the traffic stream parameters
CO2	apply macroscopic models in fluid flow analogy and shockwave approaches
CO3	apply the queuing theory for developing the microscopic models
CO4	analyze vehicle interactions in the form of car following concepts and apply the various delay models at intersections
CO5	simulate, calibrate and validate the traffic for the given stream with statistical analysis

Course Code	**:**	CE612
Course Title	**:**	**Introduction to Computational Techniques in Transportation**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts and importance of computational techniques in traffic and transportation engineering
CLO2	To understand the techniques for analyzing and optimizing transportation networks
CLO3	To be introduced to the fundamentals of Genetic Algorithm
CLO4	To understand the principles of fuzzy logic and its applications in transportation engineering
CLO5	To learn the application of Artificial Neural Networks

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

Transportation Network Analysis and Optimization - Graph Theory and Network representation - Shortest path Algorithms - Network flow optimization for maximum flow, minimum cost flow - Transportation network design problem

Genetic Algorithm - Terminology in GA – Strings, Structure, Parameter string - Data Structures – Operators - Algorithm – Application in Transportation - Calibration and validation of traffic flow models

Introduction to Fuzzy Logic - Fuzzy Sets and Membership Functions - Fuzzy Rules and Inference Systems - Fuzzy Logic Applications in Traffic Control - Fuzzy Logic in

Transportation Network Analysis - Integration of Fuzzy Logic with Other Computational Techniques - Software Tools for Fuzzy Logic Applications

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.	David E. Goldberg, G*enetic Algorithms in Search, Optimisation and Machine Learning*, Addison-Wesley, 1989.
3.	J.M. Zurada., *Introduction to artificial neural systems*., Jaico Publishers, 2006.
4.	George J. Klir, Bo Yuan. *Fuzzy Sets and Fuzzy Logic: Theory and Applications*. Prentice Hall PTR, 1995.
5.	Oliver Kramer. *Genetic Algorithm Essentials*. Springer, Technology & Engineering, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	explain the role and significance of computational methods in modern traffic and transportation systems
CO2	design and optimize transportation networks using computational algorithms
CO3	have a good understanding of GA applications
CO4	apply fuzzy logic techniques to model and solve complex transportation problems
CO5	apply ANN for solving transportation related problems

Course Code	**:**	CE613
Course Title	**:**	**Transportation Network Analysis and Optimization**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the fundamental definitions of networks
CLO2	To study the different Shortest Path Algorithms and network assignment techniques
CLO3	To understand the concept of network equilibrium and transportation system optimization
CLO4	To become familiar with formulation, analytical properties and algorithms of network models

CLO5	To understand the applications of shortest path algorithms and optimization techniques

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-cancelling 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.

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.
3.	Gendreau, M., and Marcotte, P., *Transportation and network analysis: Current trends: miscellanea in honor of Michael Florian* (Vol. 63). Springer Science & Business Media, 2013.
4.	Yosef Sheffi. *Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods*, Prentice Hall Publishers, 1985.
5.	Krylatov, A., Zakharov, V. and Tuovinen, T., *Optimization models and methods for equilibrium traffic assignment*, Springer, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	define and analyze different types of networks
CO2	characterize different types of networks based on network properties
CO3	apply the Shortest Path and Minimum cost algorithms
CO4	able to formulate, analyze and solve real-world transportation problems using the network analysis tools
CO5	understand the concepts of network equilibrium and optimization techniques

Course Code	**:**	CE614
Course Title	**:**	**Transportation Systems**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the functions and problems in the planning for a transportation system
CLO2	To learn the operation and maintenance of different modes of transport and their integration, interaction and impact on environment.
CLO3	To be aware of the development of transport, various road development plans and policies in India.
CLO4	To explain the factors influencing capacity and level of service for different transportation systems
CLO5	To study the terminal operational controls of urban transportation systems.

Course Content

Transportation and Society- Role of Transport in Society and Economy - Functions and Problems in Transportation Planning - Economic, Geographical, Political, Technological, Social and Cultural Factors in Planning of Transportation System. Transport Technology: System Classification and their Variation; Conventional Systems and Unconventional Systems - Air, Water and Ground Modes

Modes of Transport and their Characteristics, Propulsion Forces - Factors in Operation - Levels of Service and Performance Criteria - Quality of Service: Capacity and Levels of Service of different Transportation Systems; mobility and accessibility – Flexibility - Speed, Acceleration, Deceleration - Comfort and Environmental Effects - Time Spent and Cost – Integration of modes.

A Brief Historical Development of Transportation Systems in India: Growth of Transport - Road Development Plans - Imbalances in Transport System - National Transport Policy Recommendations - Optimum Inter Model Mix-Study - NHDP, PMGSY, Rural Roads Vision 2025 - IRC, CRRI etc. - Inland waterways in India

Planning of passenger and goods terminal facilities of Air, Water, Railway and Highway Transportation Systems – requirements and typical layouts - passenger facilities - parking configuration - terminal requirements – goods facilities and containerization

Operational Controls of Air, Water, Railway and Highway Transportation Systems: Functions of Control & Communications - Signals and Traffic Control Devices - Navigational Aids of the different Transportation Systems. Air Traffic Control; Navigational Control. Automatic Signaling Systems of Railway and Highway Movements.

References

1.	Paquette, R.J., Ashford, N.J. and Wright, P.H., *Transportation engineering: Planning and Design, 1982.*
2.	Horenjeff R., *The planning & Design of Airports*, McGraw Hill Book Co., 2007.
3.	Black Alan, *Urban Mass Transportation Planning*, McGraw- Hill,Inc., New York,1995.
4.	Vukan, R. Vuchic, *Urban Transit Systems and Technology*, John –Wiley & Sons, New Jersey, 2007.
5.	Chandra, S., and Agrawal M.M., *Railway Engineering*, 2nd Edition, Oxford University Press, 2013.
6.	Srinivasan, R., Harbour, *Dock and Tunnel Engineering*, Charotar Publishing House, Anand, India, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand different transport plans and policies
CO2	understand the traffic operations and maintenance
CO3	understand the concepts of capacity and level of service
CO4	characterize different modes of transport and their impact
CO5	controls and terminal facilities of transportation system

Course Code	**:**	CE615
Course Title	**:**	**Transportation Economics**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To be aware of the concepts in transportation decision making.
CLO2	To learn about transportation cost.
CLO3	To understand the vehicle operating cost
CLO4	To familiarize with the formulation of project alternatives and applying the economic analysis methods
CLO5	To understand the principles and procedure of financing of road projects.

Course Content

Introductory Concepts in Transportation Decision Making: Overall transportation project development, budgeting, financial planning, the process of transportation project development, models associated with transportation impact evaluation-professional ethics.

Transportation costs - Classification of transportation costs, transportation agency costs, transportation user costs, general structure and behavior of cost functions and road pricing. Estimating Transportation Demand and Supply - supply equilibration, dynamics of transportation demand and supply, elasticity of travel demand and supply, classification of elasticity.

Vehicle operating costs: Fuel costs - Maintenance and spares, Depreciation - Crew costs - Value of travel time savings - Accident costs. Economics of traffic congestion - Pricing policy.

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.
4.	David, H., and Brewer, A., *Transport: An Economics and Management Perspective*. Oxford University Press, UK, 2000.
5.	Sarkar, P. K., and Maitri, V., *Economics in Highway and Transportation Planning,* Standard Publisher, New Delhi, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the concepts of decision making
CO2	calculate transportation demand and supply
CO3	estimate vehicle operation cost and accident cost
CO4	perform economic analysis of a transportation project
CO5	apply various financing methods in road projects

Course Code	**:**	CE616
Course Title	**:**	**Waterway Transportation**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To know about water transport and harbour planning
CLO2	To learn about different docks and repair systems
CLO3	To understand the navigational aids
CLO4	To understand dredging and coastal protection
CLO5	To learn about port facilities

Course Content

Harbour Planning: Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

Docks and Repair Facilities: Design aspects and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, Harbour docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates.

Navigational Aids: Requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar.

Dredging and Coastal Protection: Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile, environmental impacts of port activities.

Port facilities: Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities. Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways.

References

1.	Bindra, S.P., *A Course in Docks and Harbour Engineering*, Dhanpat Rai & Sons, New Delhi, India, 1992.
2.	Seetharaman, S., *Dock and Harbour Engineering*, Umesh Publications, New Delhi, India, 1999.
3.	Srinivasan, R., Harbour, *Dock and Tunnel Engineering*, Charotar Publishing House, Anand, India, 2009.
4.	Wiegmans, B., and Konings, R., *Inland Water Transport: Challenges and prospects*, Routledge, 2019.
5.	Rodrigues, L., *Port Planning and Dredging,* Discovery Publishing House, 2024.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the concept of harbour planning

CO2	gain knowledge on various harbour infrastructures
CO3	understand the navigational aids
CO4	understand dredging and coastal protection
CO5	plan port and other facilities in the port

Course Code	**:**	CE617
Course Title	**:**	**Airport Planning and Design**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To be aware of aircraft characteristics
CLO2	To learn the concepts of airport planning and demand forecasting
CLO3	To understand the geometrics design of the airfield
CLO4	To know about planning and design of the terminal area
CLO5	To learn the importance of air traffic management

Course Content

Aircraft Characteristics: Aircraft characteristics related to airport design - Landing gear configurations, aircraft weight, engine types. Atmospheric conditions affecting aircraft performance: air pressure, temperature, wind speed and direction. Aircraft performance characteristics: speed, payload and range, runway performance, declared distances, wingtip vortices.

Airport planning and air travel demand forecasting: Airport system planning - Hierarchy of Planning - Airport Master Plan - Elements of Airport Master Plan - Airport Layout Plan - Forecasting methods: time series method, market share method, econometric modelling. Facilities requirements – Design alternatives - Financial plans- Land use planning – Environmental planning - Air Transport Planning in India – Airport Site Selection.

Geometric Design of the Airfield: Airport classification - Principles of Airport Layout - Airfield Configuration - Runway Orientation - Obstructions to Airspace - Runway and Taxiway design. Capacity of analysis - Taxiway and Gate Capacity - Holding Aprons - Terminal Aprons – Airport drainage.

Planning and Design of the Terminal Area: Components of airport terminal - Function of Airport Passenger and Cargo Terminal - Facilities Required at Passenger Terminal - Passenger and Baggage Flow - Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements Design of Air Freight Terminals - Airport access - Airport Landside planning – Capacity.

Air Traffic Management: Navigational aids: ground-based systems, satellite-based systems – Air traffic control and surveillance facilities – Weather reporting facilities –

Runway lighting, taxiway lighting. Runway and taxiway marking, airfield signage - Air traffic separation rules.

References

1.	Geoffrey D. Gosling., *Airport ground access mode choice models*, Transportation Research Board, Washington, D.C., 2008.
2.	Norman J. Ashford, Saleh Mumayiz, Paul H. Wright., *Airport Engineering Planning, Design, and Development of 21st century Airports*, John Wiley & Sons, Inc., 2011.
3.	Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B., *Planning and Design of Airports*, 5th Edition, McGraw-Hill, New York, USA, 2010.
4.	Young, S. B., and Wells, A. T., *Airport Planning and Management*, 6th Edition, McGraw-Hill, New York, USA, 2011.
5.	Khanna, S. K., Arora, M. G., and Jain, S. S., *Airport planning and Design*, 6th Edition, Nem Chand and Bros, Roorkee, India, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the various aircraft characteristics
CO2	apply the concept of airport planning and demand forecasting
CO3	design the runways, taxiways and aprons
CO4	design the components of airport terminal
CO5	plan air traffic management

Course Code	**:**	CE618
Course Title	**:**	**Advanced Highway Materials**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the properties and test on aggregate, bituminous materials, composites and recycled waste products
CLO2	To understand the properties of conventional and modified binders
CLO3	To introduce to the principles of bituminous pavement construction
CLO4	To learn the procedure of PQC mix design
CLO5	To study the use of composites and recycled waste products in road construction

Course Content

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

Bituminous Materials: conventional and modified binders – production – types and grade – physical and chemical properties and uses – Modified Bitumen- Type of Bitumen Modifiers- Specification Requirements for Modified Bitumen- tests on bituminous materials.

Bituminous Mixes: Design of bituminous mixes using Marshall method, and SUPERPAVE method. Types of bituminous mixes (HMA, WMA, SMA, etc.) and applications. Dynamic modulus, flow time, flow number, fatigue of bituminous mixes. Creep and stress relaxation. temperature susceptibility and performance.

Cement /concrete-based materials: Cement – properties – PQC mix design and properties – modified PQC – Mix Design – Behaviour – Performance – Special types of cement concrete: polymer concrete composites, sulphur concrete composites, fibre reinforced concrete, ferrocement, roller compacted concrete, and high strength concrete. Tests on Cement and Concrete mixes.

Reclaimed / Recycled Waste Products and other materials: 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. Composites, Plastics and Geosynthetics.

References

1.	Kandhal, P.S., Veeraragavan, A., Choudhary, R., *Bituminous Road Construction in India,* PHI Learning PVT, India, 2nd Edition, 2023.
2.	Islam, M. Rashed., and Tarefder, A. Rafiqul., *Pavement Deign, Materials, Analysis, and Highways*, McGraw-Hill Education, 2021.
3.	Barth, J. Edwin., *Asphalt: Science and Technology*, *2007.*
4.	Somayaji, S., *Civil Engineering Materials*, 2nd edition, Prentice Hall Inc., 2016.
5.	Sherwood, P. T., *Alternative Materials in Road Construction*, Thomas Telford Publication, London, 1995.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the properties and test procedures of aggregate
CO2	understand the properties of bituminous materials
CO3	perform bituminous mix design using various methods
CO4	perform PQC mix design and can conduct various tests on cement and concrete
CO5	use recycled and other materials in road construction

Course Code	**:**	CE619
Course Title	**:**	**Intelligent Transportation Systems**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the fundamentals of ITS
CLO2	To understand the different types of sensors
CLO3	To study the ITS functional areas
CLO4	To have an overview of ITS implementation in developed countries
CLO5	To learn the implantation, and advantages of ITS in field, with case studies from developed 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 – Roadside 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), Automatic Toll Management System.

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 Traffic Infrastructures – Integration of ITS on Microscopic and Macroscopic traffic assessment levels – V2X Communications – Connected and Autonomous Vehicles - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries, Case studies (AMAG, DFS, etc.).

References

1.	ITS Handbook 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).
4.	Chowdhary, M.A. and A Sadek, *Fundamentals of Intelligent Transportation systems planning*. Artech House Inc., US, 2003.
5.	Williams, B., *Intelligent Transportation Systems Standards*. Artech House, London, 2008.
6.	Ni, Daiheng. *Traffic Flow Theory*. Butterworth-Heinemann, Elsevier, 2016.
7.	Sarkar, P. K., and Jain, A.K., *Intelligent Transport Systems*. PHI Learning, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand the sensor technologies
CO2	understand the communication techniques
CO3	apply the various ITS methodologies
CO4	understand the user needs
CO5	define the significance of ITS from developed countries perspective and implications for Indian conditions

Course Code	**:**	CE620
Course Title	**:**	**Advanced Surveying and Cartography**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basics of advanced surveying and cartography
CLO2	To understand in detail the different types of maps, coordinate systems and coordinate transformation
CLO3	To understand about topographical surveying
CLO4	To be introduced to working principles of geodesy
CLO5	To understand the basics and surveying methods of GPS

Course Content

Advanced Surveying – Concepts and Principle of working - comparison with conventional surveying – Electromagnetic distance measurement (EDM) – Working principle - classification - electromagnetic distance measuring system – Total Station – Digital Level - application of Lasers in measurement

Cartography – Definition – Maps – Map Scale – Map Type - co-ordinate system - Thematic maps - map projections - classification - properties, uses and choice of projections - UTM system - projection used in SOI topographical sheets, map reproduction – Coordinate Transformation

Topographical Surveying - Introduction to topographical mapping, scale of topographical maps, Indian topographical series and their numbering system - topographical survey methods – Triangulation and precise leveling – Photogrammetry – Parameter Measurement using Photos

Geodesy – Figure of earth – Classification – Datums – Reference frames – Coordinate systems – computation of spherical coordinates – Space Geodesy – VLBI, SLR.

GPS Basics – system overview – working principle of GPS – Satellite ranging – calculating position – Ranging errors and its correction – GPS surveying Methods – RTK - DGPS – GNSS.

References

1.	Hoffman.B, H.Lichtenegga and J.Collins. *Global Positioning System - Theory and Practice*, Springer - Verlag Publishers, 2001.
2.	Borden D. Dent, Jeffrey Troguson, Thomas W. Hodler. *Cartography: Thematic map Design*, McGraw-Hill Higher Education, 2008.
3.	Wolfgang Torge. *Geodesy*, Berlin: de Gruyter, 2001
4.	Satheesh Gopi. *Advanced Surveying*, Pearson Education, 2007.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	describe the methods and applications of advanced surveying in the field of transportation engineering.
CO2	define the correct coordinate system and methods of transformation.
CO3	define the significance of topographical survey
CO4	describe in detail about geodesy
CO5	define the significance of GPS in transportation engineering

Course Code	**:**	CE621
Course Title	**:**	**Geospatial Techniques**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basics of advanced tools such as Remote sensing, GIS and GPS
CLO2	To highlight their applications in the field of Civil engineering
CLO3	To be introduced to various Remote Sensing/GIS/GPS equipment
CLO4	To understand various processing package in GIS and remote sensing

CLO5	To understand the application of remote sensing, GIS and GPS in smart city development

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 – Platform/Sensors - satellite system/sensor parameters – Data Acquisition –satellites for different applications.

GIS - Maps – Types of Maps - Projections & Datums – Map Accuracies - Components/Architecture of GIS – Spatial and Non–Spatial Data – Raster and Vector data structures – DBMS –GIS Data Models & design – Specifications & Standards – Data sharing – Data Transformation – WebGIS.

Geodesy - GPS different segments – Space Configuration – Satellite Geometry - working principle of GPS – Satellite ranging –calculating position – Ranging errors and its correction – GPS surveying Methods – RTK - DGPS – GNSS – GPS Data Processing – Output – Gagan – GNSS – LIDAR – Drones.

Digital Image Processing – Image Classification– Geo-rectification - Raster data analysis - Data handling in GIS – Representation of Spatial and Attribute Data - Geo-referencing - Data Extraction – Digitization - Vector spatial analysis – Overlay – Query – Buffers – DTM/DEM/DSM – Standard Remote Sensing/GIS/GPS Packages.

Integration of Remote Sensing/GIS/GPS – 3S Technology - Survey, mapping and monitoring –Transportation/Infrastructure planning – Environmental studies - Structural engineering/ Geotechnical Engineering - Shortest Path Analysis – Landuse/Urban Planning - Atmospheric studies - Mobile Mapping – Smart City Development – SDI – Unmanned vehicles – IoT – AI.

References

1.	Burrough, P.A., and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
2.	Lo, C.P., and Yeung K. W. Albert., *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 (CO)

At the end of the course student will be able to

CO1	describe the concept and application of remote sensing in civil engineering
CO2	define the importance of GIS and its use in civil engineering applications
CO3	describe the principle of GPS with more reference to positioning, method of measurement and satellite structure

CO4	describes the use of various software packages in Remote sensing, GIS, GPS in real time applications
CO5	summarize the application of Remote sensing, GIS and GPS in civil engineering

Course Code	**:**	CE622
Course Title	**:**	**Statistical Methods for Civil Engineers**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the concept of data, and various methods to represent and infer the data
CLO2	To understand the various sampling concepts, type, distribution and curve fitting of data
CLO3	To learn the concept and develop the correlation and regression equations
CLO4	To know the fundamentals of estimators and perform the time series analysis
CLO5	To understand the probability distributions

Course Content

Basic concepts of data – Tabulation of data – Frequency distribution – Cumulative Frequency Table - Measures of Central Tendency - Arithmetic Mean – Median – Mode - Geometric Mean - Harmonic Mean - Partition Values (Quartiles, Deciles, and Percentiles) - Measures of Dispersion – Range - Interquartile Range - Quartile Deviation - Mean Deviation - Standard Deviation - Hypothesis testing – Test of significance - Parametric tests - Non-parametric tests – Analysis of Variance - Case studies.

Introduction of Sampling – Population – Sample – Sampling - Random Sampling - Simple Random Sampling - Stratified Sampling - Systematic Sampling - Sample Size Determination - Sampling Distribution. Introduction to curve fitting - The Method of Least Squares - The Least-Squares Line - Fitting a Parabola by the Method of Least Squares - Fitting the exponential curve - case studies.

Introduction to Correlation - Coefficient of Correlation - Methods of Finding Coefficient of Correlation - Scatter Diagram- Spearman's Rank Correlation Coefficient - Calculation of r (Karl Pearson's Formula) – Regression - Curve of Regression - Types of Regression - Regression Equations (Linear Fit) - Angle between Two Lines of Regression - Coefficient of Determination - Multilinear Regression - case studies.

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency–Maximum Likelihood Estimation –Discrete choice model, applications in transportation

engineering, example in accident prediction model, Mode choice model. Purpose of Time Series Study - Editing of Data - Components of Time Series - Mathematical Model for a Time Series - Methods of Measuring Trend - Applications in civil engineering- case studies.

Introduction to probability and random variables, Normal distribution, Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Log-Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution, and Weibull distribution, Applications in civil engineering.

References

1.	Devore, J.L., *Probability and Statistics for Engineering and the Sciences*, Thomson and Duxbury, Singapore, 6th Edition, Boston, 2004.
2.	Gupta, S.C., and Kapoor, V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, 11th Edition, Reprint, New Delhi, 2019.
3.	Johnson, R. A. and Gupta, C. B., *Miller & Freund's Probability and Statistics for Engineers*, Pearson Education, Asia, 8th Edition, New Delhi, 2015.
4.	Johnson, R.A., and Wichern, D.W., *Applied Multivariate Statistical Analysis*, Pearson Education, 6th Edition, New Delhi, 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	apply the concepts of data and preliminary analysis with civil engineering data
CO2	perform the sampling, distribution and curve fitting for the large and small samples
CO3	determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data point
CO4	obtain the value of the point estimators using method of maximum likelihood and apply the time series approach
CO5	apply probability distributions to analyze civil engineering data

Course Code	**:**	CE623
Course Title	**:**	**Basics of Machine Learning and its Application in Civil Engineering**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts of Artificial Intelligence and Machine Learning
CLO2	To study the data pre-processing and post-processing aspects related to AI-ML
CLO3	To explore different ML-Algorithms applicable for transport engineering evaluation
CLO4	To explore and learn the fundamentals of applying machine learning algorithms for predictive analysis
CLO5	To gain a hands-on experience for running a ML model script to predict answers for Civil engineering problems

Course Content

Introduction to AI and ML: Importance and applications in Civil Engineering - Understanding datasets and features - Supervised vs. Unsupervised learning - Common algorithms in ML.

Data Preprocessing - Importance of data preprocessing - Techniques for handling missing data - Data normalisation and standardization - Removing outliers - Importance of balanced datasets - Techniques for handling imbalanced datasets - Introduction to SMOTE, ADASYN- Implementing data cleaning, normalization, and outlier removal.

Classification Algorithms - k-Nearest Neighbors, Decision Trees, Support Vector Machines, Binary Logistic Regression, Naive Bayes - Clustering Algorithms - Hierarchical clustering, Computer Vision and Object detection / Identification.

Model Evaluation and Validation- Random Splitting of Data, splitting data into training and testing sets, Importance of random seed, Cross-Validation Techniques, Introduction to k-fold cross-validation, Leave-one-out cross-validation - Performance and Evaluation Metrics – Variable Importance and SHAP values - Calculating and interpreting evaluation metrics.

Hyperparameter Tuning and Practical Implementation - Basic and general libraries in Python / R useful for ML - Introduction to hyperparameters and their importance - Techniques for hyperparameter tuning - Case Studies and Applications -Real-world examples and projects.

References

1.	John D. Kelleher, Brian Mac Namee and Aoife D'Arcy. *Fundamentals of Machine Learning for Predictive Data Analytics Algorithms, Worked Examples, and Case Studies*. MIT Press, 2015.
2.	Aman Kharwal. *Machine Learning Algorithms: Handbook*. Clever Fox Publishing, 2023.
3.	Giuseppe Bonaccorso. *Machine Learning Algorithms, 2nd* Edition. Packt Publishing, 2018.
4.	Shai Shalev-Shwartz, Shai Ben-David. *Understanding Machine Learning: From Theory to Algorithms.* Cambridge University Press, 2014.
5.	Handouts shall be provided in the class as required.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	understand and explain the fundamental concepts of Machine learning algorithms
CO2	deploy ML-Algorithms to predict binary and multiclass responses
CO3	learn data handling and pre-processing options for successful application and running of ML-algorithms
CO4	compare the performances of different ML algorithms to find the best-performing/applicable option.
CO5	get exposure to the Shapely Additive explanation Values used for interpreting each parameter's effect on the ML algorithm's predictive performance.

Course Code	**:**	CE624
Course Title	**:**	**Urban Planning Techniques and Practices**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the key characteristics of urban areas
CLO2	To understand the different types of plans
CLO3	To get acquainted with various surveys and steps in urban planning process
CLO4	To understand the various concepts in town planning
CLO5	To understand the significance of urban renewal

Course Content

Urban Areas – characteristics, categories of a town, Classification of settlement-based on form, use, scale etc., densities of a town. New Towns. Concepts of Smart City.

Plans – Regional Plan, Master Plan, Structure Plan, and Detailed Development Plans.

Planning Process and Surveys – Planning process. Various stages of the planning process with relevant examples. Delineation of planning areas/regions, Type of planning surveys, and data identification for various plan preparations. aerial photo and remote sensing techniques in planning. Formulation of standards for various urban functions. Land use models.

Concepts in Town Planning – Role and contribution of the following towards contemporary town planning thought - Patrick Geddes, Patric Abercrombie, Daniel Burnham, Soria Y Mata, Frederick Olmstead, Henry Wright, Ebenezer Howard, Clarence Perry, Clearance Stein, CA Doxiadis, Le Corbusier, Frank Lloyd Wright.

Urban Renewal – Urban Decay - Causes and Impacts, Urban Renewal - significance, scope and limitations, identification of renewal areas, Renewal strategies. National Urban Renewal Schemes and Policies. Development control and planning guidelines.

References

1.	Lichfield, N., Barbanente, A., Borri, D., Khakee, A., Prat, A., *Evaluation in Planning: Facing the Challenge of Complexity*, Kluwer Academic publications, Dordrecht, 1998.
2.	Knox, P. L., and Taylor, P, J., *World Cities in a World-System*, Cambridge University Press, Cambridge, 2009.
3.	Edward, J.K., David, R.G., Stuart, F., *Urban Land use Planning,* 4th edition, Urbana, University of Illinois Press, 1995.
4.	Paul R. Wolf, *Elements of Photogrammetry*, McGraw Hill Books Co., London, 1986.
5.	Hall, P., *Cities of tomorrow: An intellectual history of urban planning and design in the twentieth century*, Blackwell, London, 2001.
6.	Peter, G.H. and Tewdwr-Jones, M., *Urban and Regional Planning, Routledge*, London. 5th Edition, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	identify and describe the key characteristics of urban areas
CO2	differentiate various types of plans
CO3	identify different types of planning surveys and demonstrate how to collect, analyze, and use survey data for the preparation of various urban plans
CO4	compare the different town planning theories
CO5	apply development control measures and planning guidelines to urban renewal projects

Course Code	**:**	CE625
Course Title	**:**	**Design and Construction of Low Volume Rural Roads**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concept of low-volume roads (LVRs)
CLO2	To design geometric features of low-volume roads
CLO3	To identify and evaluate suitable materials and cost-effective technologies for the construction and maintenance of low-volume roads

CLO4	To analyse and design both flexible and rigid pavements for low-volume roads
CLO5	To select appropriate pavement construction techniques for low-volume roads

Course Content

Introduction of Low Volume Road: Significance, definition, characteristics of LVRs, terminology used in LVRs, PMGSY, development of LVRs in India, rural roads vision 2025, international scenario of LVRs developments, Master plan and core network concepts, network planning of LVRs and models, detailed project report preparation, environmental issues, and GIS-based rural road network planning.

Geometric Design of LVRs: Topography and physical features, traffic, geometric design standards for LVRs with reference to PMGSY, Hill Road standards, design concepts and criteria, cross-sectional elements, CD works, horizontal alignment, vertical alignment, and traffic engineering requirements, international recommendations, experience, and various countries standards on LVRs geometric designs and case studies.

New Materials: Overview of conventional materials, waste materials, source of marginal materials, guidelines, subgrade stabilization, dealing with poor subgrades, framework for appropriate use of marginal materials, new technologies and their design aspects, Geosynthetic applications, functions, and design methods.

Pavement Design of LVRs: LVR design principles, vehicle classifications, traffic volumes, ESALs per vehicle class, design traffic classes, pavement design methods for LVRs, empirical approaches, AUSTROADS pavement, AASHTO, US MEPDG, flexible and rigid pavement using IRC methods, and gravel road design in the Indian context.

Construction and Specifications of LVRs: Conventional construction methods, specifications, new technologies, construction methods and benefits, case studies, low-cost construction techniques, quality control and assurance mechanism, and MoRD specifications.

References

1.	Robert A., Douglas, *Low Volume Road Engineering: Design, Construction and Maintenance*, CRC Publishers, 2018, 9th Edition.
2.	Gordon Keller and James Sherar, *Low-Volume Roads Engineering: Best Management Practices Field Guide*, USDA Forest Service / USAID, 2003.
3.	Guidelines for Geometric Design of Low Volume Roads, American Association of State Highway and Transport Officials, Washington, DC, 2019, 2nd Edition.
4.	Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads, Indian Road Congress, IRC: SP 72, New Delhi, 2015, First Revision.
5.	Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads, IRC: SP62, Indian Road Congress, New Delhi, 2014, First Revision.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	plan low-volume road network
CO2	design low volume road geometrics
CO3	identify appropriate materials and cost-effective technologies for LVRs
CO4	analyse and design flexible and rigid pavements for LVRs
CO5	select an appropriate pavement construction technique and perform quality control tests

Course Code	**:**	CE626
Course Title	**:**	**Pavement Evaluation and Management**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the pavement performance evaluation
CLO2	To know about the pavement structure evaluation and field tests
CLO3	To be aware of basic concepts of pavement management system
CLO4	To develop the performance prediction models
CLO5	To learn pavement life cycle cost analysis and optimization of pavement maintenance and rehabilitation

Course Content

Pavement Performance Evaluation: serviceability-performance concept, characterization of pavement roughness, equipment for evaluating roughness, a universal roughness to standard, relating roughness to serviceability, and applications of roughness data. Pavement distresses Evaluation: – General concepts – functional evaluation, condition surveys, Evaluation of structural capacity – safety evaluation-application of GIS in pavement evaluation-case study.

Pavement Structure Evaluation and Field Tests: Factors affecting Structural Condition of Flexible and Rigid Pavements- Effects of Subgrade Soil, Moisture, Pavement Layers, Temperature, Environment and Traffic on Structural Stability, Pavement Deterioration- Evaluation by Non-Destructive Tests such as FWD, Benkelman Beam Rebound Deflection, Plate Load Test - Evaluation by Destructive Test Methods, and Specimen Testing.

Introduction to Pavement Management: Pavement Management Levels and Functions- The ideal Pavement Management System (PMS), the network and project levels of pavement management, influence levels of PMS components, pavement management at three levels, PMS function, key consideration in the application of a total pavement management system concept, the function of pavement evaluation.

Performance Prediction Models: Pavement performance prediction - concepts, Techniques for developing prediction models– structural conditional deterioration models, mechanistic & and empirical models, functional condition deterioration models, unevenness deterioration models and other models, ranking and optimization methodologies- CRRI, AASHO, and HDM-IV models – computer applications – Identification of alternatives –deterioration modelling.

Pavement Maintenance Management: expert system for pavement evaluation and rehabilitation, Pavement Life Cycle Cost Analysis, Components of Maintenance Management and Related Activities, Priority Programming: Basic Approaches - Program Period - Functions - Methods - Budget Level Evaluation - Final Program Selection; Formulation of Maintenance Strategies, optimization of pavement maintenance and rehabilitation. Evaluating Alternative Strategies and Decision Criteria Using HDM Package.

References

1.	R Srinivasa Kumar, *Pavement Evaluation and Maintenance Management System*, Universities Press (India) Pvt. Ltd, 2014.
2.	Rajib B. Mallick,Tahar El-Korchi, *Pavement Engineering: Principles and Practice*, 2nd Edition, CRC Press.
3.	Haas, Hudson and Zaniewski, *Modern Pavement Management*, Krieger Publishing Company. McGraw- Hill, 1994.
4.	Derek Pearson, *Deterioration and Maintenance of Pavements*, ICE Publishing, 211.
5.	Relevant IRC codes, CRRI and HDM 4 Manuals.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	comprehend principles for evaluating pavement performance and assessing pavement distresses.
CO2	gain knowledge of pavement structure evaluation techniques and field tests
CO3	learn to develop and utilize performance prediction models for pavement management
CO4	utilize performance prediction models for pavement management
CO5	conduct life cycle cost analysis and optimize maintenance and rehabilitation strategies

Course Code	**:**	CE627
Course Title	**:**	**Behavioral Travel Modeling**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36

Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the foundations of behavioral travel modeling
CLO2	To master survey design and analysis for travel behavior research
CLO3	To develop proficiency in individual choice theory and discrete choice models
CLO4	To explore advanced concepts in behavioral travel modeling
CLO5	To apply discrete choice models to integrated land use and transport planning

Course Content

Introduction to behavioral travel modeling - Overview of behavioral travel modeling, its significance, and applications, Key concepts: behavior theory, decision-making processes, Attitudes, perceptions, and behavior change theories.

Survey design and analysis: travel surveys and their role in transport planning, survey methods, precision and accuracy in travel surveys, sample design, sampling procedures, survey format, pilot surveys, survey administration, collection of stated and revealed preference data, survey data processing.

Individual choice theory: binary choice models, multinomial and multi-dimensional choice models, methods and statistics of model estimation with emphasis on maximum-likelihood estimation, aggregation and forecasting with discrete choice models, validation and transferability aspects, ordered multinomial models, nested logit models.

Introduction to advanced concepts - accommodating unobserved population heterogeneity in choice behavior, mixed logit models, joint stated preference and revealed preference modeling, and longitudinal choice analysis.

Discrete choice models for integrated land use and transport modelling, review of state-of-the-art and future directions.

References

1.	Ortuzar, J. D. and Willumsen, L.G., *Modelling Transport*, John Wiley & Sons, New York, 3rd edition, 2001.
2.	Domencich, T.A. and McFadden, D., *Urban Travel Demand: A Behavioral Analysis*, North-Holland, 1975.
3.	Ben-Akiva, M. and Lerman, S, *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, 1985.
4.	Oppenheim, N., *Urban Travel Demand Modeling: From Individual Choices to General Equilibrium*, John Wiley, 1995.
5.	Profillidis, V.A., and Botzoris, G. N., *Modeling of Transport Demand*, Elsevier, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	demonstrate comprehensive knowledge on behavioral travel modeling
CO2	design and implement travel surveys
CO3	perform discrete choice modelling
CO4	understand advanced modelling techniques
CO5	understand integrated land use and transport modeling

Course Code	**:**	CE628
Course Title	**:**	**Sustainable Transportation**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concept of sustainable transportation planning
CLO2	To learn the various evaluation techniques of non-motorized transportation
CLO3	To be introduced to the fundamentals of planning for pedestrians
CLO4	To be introduced to the fundamentals of planning for bicyclists
CLO5	To understand the sustainable policies and technologies

Course Content

Problem of Sustainability in Transport – Energy use in transport sector; Transport and climate change; Greenhouse gas emissions, urban air quality, Congestion and sustainability. Planning for Sustainability- Urban form, Indicator based planning, landuse transportation integration, Compact City, Public Transit, TOD, NMT, First and Last Mile Connectivity.

Evaluation of non-motorized transportation-Surveys, Demand Estimation and Analysis; Crash Data, Barrier Effect; Cycling Condition, Evaluation Techniques; Pedestrian Condition Evaluation Techniques; Prioritizing Improvements and Selecting Preferred Options

Planning for pedestrians- Types of pedestrians and Characteristics; Pedestrian facilities and planning; Pedestrian standards and improvements; Pedestrian facility Design, LOS; Pedestrian safety programs.

Planning for bicyclists: Types of cyclists and Bikeways; Integrating cycling into roadway planning; Bicycle network planning; Accommodating cyclists on rural roads; Design of Bicycle boulevards/bike paths; Bicycle Parking/storage Facilities; Roadway maintenance for cyclists.

Sustainable policies and technology: Continuum of Policies, speed and speed limit policies, national policies, sustainable travel demand management; public awareness;

pricing transportation, Alternative Cleaner Fuels, vehicle technologies, nationally appropriate mitigation actions.

References

1.	Black, W. R., *Sustainable Transport: Definitions and Responses*, In Transportation Research Board, Integrating Sustainability into the Transportation Planning Process, Conference Proceedings 37. Washington, D.C., National Research Council, 2005.
2.	Black, W.R., *Sustainable transport: Problems and Solutions*. Gulford Press, New York, 2010.
3.	Cervero, R. *Accessible Cities and Regions: A Framework for Sustainable Transport and Urbanism in the 21st Century*. Center for Future Urban Transport, Institute of Transportation Studies, University of California, Berkeley, 2005.
4.	Mehrdad, Ehsani, Fei-Yue, Wang and Gary, L. Brosch., *Transportation technologies for sustainability*, Springer, 2013.
5.	Preston, L. Schiller, Eric, C. Brunn and Jeffrey, R. Kenworthy. *An Introduction to Sustainable Transportation: Policy, Planning and Implementation*, Earthscan, 2010.
6.	Tolley, R., *Sustainable Transport: Planning for Walking and Cycling in Urban Environments*, CRC Press, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	explain effect of transport sector on sustainability and specify transport planning strategies for sustainable development
CO2	evaluate strategies for development of non-motorised transport
CO3	specify actions for planning for pedestrian facilities
CO4	specify actions for planning for bicyclists' facilities
CO5	elaborate on sustainable policies and technologies

Course Code	**:**	CE629
Course Title	**:**	**Logistics In Transportation Engineering**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To know the concepts of logistics and freight transport and their association
CLO2	To understand the trip generation, trip distribution, mode share, and hybrid models for freight
CLO3	To learn the supply chain variables and freight facility

CLO4	To understand various logistics management and application of IT services on it
CLO5	To gain the knowledge on ITS application in freight transport

Course Content

Logistics and freight transport- Introduction to Logistics, sustainable logistics. Introduction to freight transports- Stakeholder- Importance-Planning process- Planning process - The issues associated with urban freight and policy initiatives in Indian Cities Freight data collection - Survey Methodologies.

Freight modelling- Freight Demand Models - Freight travel demand forecasting and models; Freight Trip Generation Models: Trip Distribution; Modal share for Regional and Urban Freight - Tour Based Model Approach, Hybrid Model Approach.

Distribution management- Supply Chain – freight facility planning types location, layout, Warehouse types – Planning Vehicle Routing and Scheduling- freight distribution, freight regulation.

Logistics management - Logistics- Introduction, outsourcing, types – IT Application in Logistics – IT Application in Freight Management- IOT in Logistics Management – Intermodal Transportation.

ITS application in freight transport - E tailing- E commerce, City logistics, Toll Plaza Analysis – Types – Influencing factors - Challenges – ITS applications for driver safety and vehicle monitoring - Overview of Software and Algorithms - Case studies in worldwide.

References

1.	Blanchard, S. Benjamen, *Logistics Engineering and Management*, Prentice Hall, Inc, Eaglewood Cliffs, New Jersey 07632,1986.
2.	Ministry of Commerce and Industry, National Logistics Policy, Govt. of India, 2022.
3.	Edwin, Bacht J.A., *Geography of Transportation and Business Logistics*, WmC Brown Company Publishers, Dubuque, IOWA,1970
4.	Khanna, K.K., *Physical Distribution Management*, Logistical Approach, Himalaya Publishing House, Bombay,1985
5.	Planning Commission, Government of India, Total Transport System Study – Report on Commodity Flows, Railways, Highways and Coastal Shipping, (Interim) by RITES, New Delhi.
6.	Shapiro, D. Roy and Heskett, L. James, *Logistics Strategy-Cases and Concepts*, Wesg Publishing Company, New York,1985.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	apply the concepts of logistics and freight transport
CO2	develop the various freight models in small and large scaling
CO3	apply the concepts of supply chain in design of freight facility and distribution management

CO4	apply the IT and IoT facilities in logistics management
CO5	develop the various ITS solutions in freight transport and movement

Course Code	**:**	CE630
Course Title	**:**	**Road Safety System**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To know the basic of road accidents and influencing factors
CLO2	To learn the details of accident investigations and analysis
CLO3	To understand the accident costing and road safety audit procedure
CLO4	To introduce the big data in road safety system and management
CLO5	To learn the advanced techniques in accident analysis

Course Content

Accident Scenarios – Global, National, Regional and Mega City Levels -Causes of accidents – Human factors – Vehicles – Road and its condition – Environmental Factors- Conventional methods and Inadequacies- Case studies –Intersection safety, Work zone safety

Accident investigations and analysis- Accident Data Collection - Interpreting accident data, identifying and prioritizing hazardous location, condition and collision diagram, crash reconstruction- statistical Analysis of Accidents - Accident Prediction Models – Empirical Bayes Approach – Before and After methods in accident analysis, Block spot identification and investigations, Hot spot analysis– Case Studies

Accident costing and road safety audit- Cost of Road Accidents –methods of accident costing - Economic Analysis of Road Accident Cost in India. Key Elements of road safety audit, Road safety audit & Investigations, Planning stage, Design stage, construction stage, work zone safety audit- Post Construction stage

Introduction to big data in road safety- Evolution of Big data - Best Practices for Big data Analytics - Big data characteristics - Validating - The Promotion of the Value of Big Data - Big Data Use Cases- Characteristics of Big Data Applications - Perception and Quantification of Value -Understanding Big Data Storage - A General Overview of High-Performance Architecture – Case studies with accident data

Advanced techniques in accident analysis-Introduction – Decisions making techniques - Delphi - TOPSIS – AHP – Random Forest - AdaBoost – Artificial Neural Network – Genetic Algorithms – Fuzzy Logic - Support vector machine – Clustering techniques – Case studies with accident data

References

1.	Martin Belchar, *Practical Road Safety Auditing*, ICE Publishing, 2015.
2.	Ministry of Surface Transport, Accident Investigation and Prevention Manual for Highway Engineers in India, Government of India, 2001.
3.	Indian Roads Congress -IRC (2013), Ministry of Road Transport & Highways (MORTH) Road Safety Audit Manual (IRC: SP-88).
4.	Geetam Tiwari, Dinesh Mohan, *Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safety,* 1st Edition, CRC Press Publication, USA, 2016.
5.	Dhillon B.S, *Transportation Systems Reliability and Safety,* 1st Edition, CRC Press Publication, USA, 2011.
6.	Martin Belcher, Steve Proctor and Phil Cook, *Practical Road Safety Auditing,* 3rd Edition, ICE Publication, Scotland, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	apply the knowledge of science and engineering fundamentals in developing an efficient road safety system & conduct research pertinent to road safety and management
CO2	explain concepts and analysis of accident data collection and analysis techniques with various advanced methods
CO3	conduct research pertinent to road accident costing and road safety audit and management system with case studies
CO4	apply the big data analytics in road safety system and management
CO5	perform advanced techniques in accident analysis

Course Code	**:**	CE631
Course Title	**:**	**Railways Infrastructure Planning and Design**
Type of Course	**:**	Programme Elective
Prerequisites	**:**	-
Contact Hours	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To know the basics of planning of railway lines network and components of railway track
CLO2	To study the geometric design of railway track
CLO3	To introduce with track construction and maintenance practices
CLO4	To know about signalling and interlocking
CLO5	To learn about modernization of railways

Course Content

Planning of railway lines networks - Historical background of Indian railways, plans and developments, policy and standards, traffic forecast and surveys, railway

alignment, project appraisal, and organization setup; Component of tracks - Permanent way, forces acting, rails, the function of rails, rail fixtures and fastenings, sleepers and ballast, rail joints, elements of junctions and layouts.

Geometric design of railway track- Right of way and formation, field investigation, geometric design elements, safe speed on curves, speeds computation, string lining of curves, gradients, grade compensation, railway cant and cant deficiency, tractive effort of a locomotive, hauling power of a locomotive.

Track construction – Special considerations and construction practices, track laying; Introduction of the maintenance programme - monsoon, pre-monsoon & post-monsoon maintenance, routine maintenance; tools for railway track maintenance & their functions, off-track tampers, shovel packing, ballast confinement and directed track maintenance, bridge maintenance, renewal, classification of renewal works, through sleeper renewals, mechanized relaying, track renewal trains.

Signaling and interlocking - Objectives, classification, fixed signals, stop signals, signaling systems, mechanical signaling systems, electrical signaling systems, systems for controlling train movement, interlocking, and modern signaling installations; Train accidents, collision and derailments and their causes, restoration of traffic, safety measures, disaster management, classification of level crossings, accidents at level crossings, remedial measures, and maintenance of level crossings.

Modernization of railways, the effect of high-speed track, vehicle performance on track, high-speed ground transportation system, ballastless track, track requirement for bullet trains, elevated railways, underground and tube railways, dedicated freight corridor; Integration of IoT and AI in railway operations.

References

1.	Chandra, S., and Agrawal M.M., *Railway Engineering*, 2nd Edition, Oxford University Press, 2013.
2.	Mundrey, J.S., *Railway Track Engineering*, McGraw-Hill Education (Australia) Pty Limited, 2009.
3.	Gupta, B.L., and Gupta, A., *Railway Engineering*, Standard Publishers, 2005.
4.	Rangwala, S.C., *Railway Engineering*, Charotar Publishing House Pvt. Limited, 2008.
5.	Saxena, S.C., and Arora, S.P., *Textbook of Railway engineering*, DhanpatRai, 2001.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	explain railway line network planning concepts and components of railway tracks
CO2	perform geometric design of railway track
CO3	understand various track construction and maintenance practices
CO4	comprehend railway signalling and interlocking
CO5	elaborate on modernization of railways