VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examinations and Syllabus
M.Tech Transportation Engineering(CTE)
(Effective from Academic year 2020 - 21)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

Scheme of Teaching and Examinations – 2020 - 21

M.Tech., TRANSPORTATION ENGINEERING

(CTE)

Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CTE11	Applied Statistics for Highway Engineering	03	--	02	03	40	60	100	4
2	PCC	20CTE12	Traffic Engineering	03	--	02	03	40	60	100	4
3	PCC	20CTE13	Pavement Materials	03	--	02	03	40	60	100	4
4	PCC	20CTE14	APPLIED SOIL MECHANICS FOR HIGHWAY ENGINEERS	03	--	02	03	40	60	100	4
5	PCC	20CTE15	Urban Transport Planning	03	--	02	03	40	60	100	4
6	PCC	20CTEL16	Pavement Materials Testing Lab I	--	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	02	--	--	03	40	60	100	2
			TOTAL	**17**	**04**	**10**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core.

Skill development activities:

Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills.

The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem.

The students shall

(1) Gain confidence in modelling of systems and algorithms.

(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.

(3) Handle advanced instruments to enhance technical talent.

(4) Involve in case studies and field visits/ field work.

(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process.

(ii) Three credit courses are designed for 40 hours Teaching – Learning process.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.TechTRANSPORTATION ENGINEERING (CTE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ seminar	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CTE21	Pavement Design and Analysis	03	--	02	03	40	60	100	4
2	PCC	20CTE22	Public Transportation Systems	03	--	02	03	40	60	100	4
3	PCC	20CTE23	Geometric Design Of Transportation facilities	03	--	02	03	40	60	100	4
4	PEC	20CTE24X	Professional elective 1	04	--	--	03	40	60	100	4
5	PEC	20CTE25X	Professional elective 2	04	--	--	03	40	60	100	4
6	PCC	20CTEL26	Pavement evaluation and software Laboratory	--	04	--	03	40	60	100	2
7	PCC	20CTE27	Technical Seminar	--	02	--	--	100	--	100	2
TOTAL				**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		Professional Elective 2	
Course Code under 20CTE24X	**Course title**	**Course Code under 20CTE25X**	**Course title**
20CTE241	Theories of traffic flow	20CTE251	Pavement Management System
20CTE242	Transport Economics and Project Appraisal	20CTE252	Transportation Structures
20CTE243	Transportation Systems	20CTE253	Remote Sensing and GIS in Transport Planning
20CTE244		20CTE254	Advanced Travel Demand Modelling.

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.TechTRANSPORTATION ENGINEERING (CTE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini –Project/ Internship	Skill Development activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CTE31	Pavement Construction Technology	03	--	02	03	40	60	100	4
2	PEC	20CTE32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20CTE33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20CTE34	Project Work phase -1	--	02	--	--	100	--	100	2
5	PCC	20CTE35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20CTEI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
TOTAL				**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		Professional elective 4	
Course Code under 20CTE32X	**Course title**	**Course Code under 20CTE33X**	**Course title**
20CTE321	Road Safety and Management	20CTE331	Rural Roads
20CTE322	Intelligent Transportation Systems	20CTE332	Environmental Impact Assessment of Transportation Projects
20CTE323	Road Asset Management	20CTE333	Pavement Evaluation And Management
20CTE324	Railway Infrastructure Planning and Design	20CTE334	Transportation Networks and Optimization

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the Universitynorms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as fail in internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
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M.Tech TRANSPORTATION ENGINEERING (CTE)
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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Project	20CTE41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

APPLIED STATISTICS FOR HIGHWAY ENGINEERING

[As per Choice Based Credit System (CBCS) scheme] Semester I

Subject Code	**20CTE11**	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the use of statistical tools to express the traffic data for better interpretation.
2. Apply probability concept to understand the vehicular flow behavior helping the planners to predict traffic flow.
3. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.
4. Test the hypothesis and assess the error involved in the data analysis.
5. Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.

Module -1

Introduction to statistical methods, scope aim and limitations, sample, attribute and types of data sources and collection of data. Accuracy of data. Representation and summarizing data. Frequency distribution, histogram and frequency curves. Ogive curve,Measure of central tendency–arithmetic mean, median and mode dispersion-range, standard deviation, variance and co-efficient of variation, skewness and kurtosis.

Module -2

Introduction to probability & statistics for Traffic Engineering Design– Introduction, Random variables and statistical measures: arithmeticmean, measures of dispersion, basic laws of probability, probability laws of discrete random variables: binomial and Poisson distribution, probability laws for continuous random variables: normal distribution, Poisson distribution.

Module -3

Sampling Techniques– objective, basics of sampling, advantages of sampling, sampling techniques, sampling distributions –sampling distribution of the sample mean, central limit theorem, chisquare, and F-distributions. Sampling error, sample size and design.

Module -4

Statisticaldecisions–point estimation, properties of parameters, Testing of Hypothesis – Type I and II errors.

Tests of significance–tests for mean and variance. Tests for proportions.

Module -5

Chi-square test of goodness of fit, student's test, Confidence interval.

Curve fitting by the method of least squares, Linear correlation & regression, multiple linearre gression. Analysis of variance.

Use of soft-ware sin statistical analysis–MATLAB,MINITAB

Course outcomes:

After studying this course, students will be able to:

1. Use statistical tools to express the traffic data for better interpretation.
2. Apply probability concept to understand the vehicular flow behavior helping the planners to predict traffic flow.
3. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.
4. Test the hypothesis and assess the error involved in the data analysis.
5. Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.

Graduate Attributes (as per NBA)

- *Scholarship of Knowledge.*
- *Problem Analysis.*
- *Critical thinking*
- *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Johnson R and G Bhattacharya, "Statistics–Principles and methods"- JohnWiley&sons,Newyork,1985
2. L.R Kadiyali,"Traffic Engineering"-Khanna Publishers New Delhi

Reference Books:

1. Medhi,"Introduction to statistics"-NewAgePub,NewDelhi
2. Benjamin Jack R and Cornell C Allin, "Probability Statistics & Decisions for Civil Engineers"- Mc-Graw Hill Co.
3. Agarwal,B.L, "Basic Statistics"-3rd edition, New Age Publication New Delhi.
4. Martin Wohl, Brian V Martin, "Traffic System Analysis"-Mc-Graw Hill Series

COURSE TITLE: TRAFFIC ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	20CTE12	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Analyse the factors affecting performance of road traffic and the various traffic studies needed for the analysis of traffic flow.
2. Evaluate level of service and capacity of roadways and intersections using traffic data.
3. Propose and design suitable traffic regulatory system based on traffic requirements such as signs, signals, markings, etc.
4. Analyse and design intersections at-grade and grade separated types for smooth and safe movement of vehicles.
5. Propose parking facilities, pedestrian facilities and general safety measures required for highways and expressways.

Modules	Teaching Hours
Module -1	
TrafficCharacteristics,roadusercharacteristics– humanfactorsincludingreactiontimeandvehicularcharacteristics affectingroaddesign andtrafficflow **Trafficstudies-** datacollection,analysisandinterpretationofresultsofclassifiedtrafficvolume,spotspeed,speedanddelay, originanddestination.Samplingintrafficstudies– samplingtechniques,samplingtheory,accuracyandsamplesize.	**10 Hours**
Module -2	
Accident characteristics,causes,studies,investigationsandanalysisofindividualaccidents,statisticalanalysis,measurestoimprove roadsafety. Problemsonabove. **Trafficflowcharacteristics,trafficflowvariables,speed**–flow–densityrelationship,PCUvalues,levelofservice,factors influencingroadwaycapacity,capacityofroadsatvariouslevels ofservice,capacityofintersections	**10 Hours**
Module -3	
Trafficforecast- trafficgrowthestimationfrompasttrends,econometricmodels.Commonmethodsoftrafficforecast **Trafficregulationsandcontrol-** Regulationonvehicles,driversandtrafficflow,Trafficcontroldevices– Types&objectivesofmarkings,signs,signalsandislands,delineators.	**10 Hours**
Module -4	
DesignofsignalizedintersectionsincludingsignaltimingsasperIRCguidelines.Signalsystem,useofsoftware.Problems. Designofothertypesofintersectionsatgradesuchasintersectionswithmarkings,channelizedintersectionsandtrafficrotary. Trafficdesignofgradeseparatedintersectionsandinterchangefacilities.	**10 Hours**
Module -5	
Designofon-streetandoff-streetparkingfacilities,pedestrianfacilities,busbays,safetydevices. DesignfeaturesofexpresswaysanddifferenttypesofUrbanRoads	**10 Hours**
Course outcomes: After studying this course, students will be able to:	

1. Gets the knowledge of factors affecting performance of road traffic and also the traffic studies needed for the analysis.
2. Evaluate level of service and capacity of roadways and intersections.
3. Propose and design suitable traffic regulatory system such as signs, signals, markings, etc.
4. Analyse and design intersections at-grade and grade separated types for smooth and safe movement of vehicles.
5. Propose parking facilities, pedestrian facilities and general safety measures required for highways and expressways.

Graduate Attributes (as per NBA)

1. *Engineering Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. KadiyaliL.R.“TrafficEngineeringandTransportationPlanning”-KhannaPublication,NewDelhi
2. Nicholas J.Garber, Lester A. Hoel, “Traffic and Highway Engineering”, Third Edition Thompson Learning

Reference Books

1. SalterRJandHounsellNB,“Highway,TrafficAnalysisandDesign”-MacmillanPressLtd.,London.
2. MatsonTM,SmithWS,HurdFW,“Traffic Engineering,McgrawHillBookCo,NY,USA.
3. DrewDR,”TrafficFlowTheoryandControl”,McGrawHillBookCo,NY,USA.
4. WohlandMartin,“TrafficSystemAnalysisofEngineersandPlanners”-McgrawHillBookCo,NewYork,USA.
5. Pignataro,“TrafficEngineering”,Johnwiley&sons.NicholasJGarber,LesterAHoel, “Traffic&HighwayEngineering”-Thirdedition,
6. IRC:SP:41-1994,IRCSP:31-1992,IRC43-1994,IndianRoadsCongress
7. MoRTH“TypeDesignsforIntersectionsonNationalHighways”-IndianRoadsCongress
8. MORTH“ManualforRoadSafetyinRoadDesign”-IndianRoadsCongress
9. IRC3-1983,9-1972,62-1976,64-1990,65-1976, 66-1976,67-2001,69-1977,70-1977,73-1980,79-1981,80-1981,86-1983,92-1985,93-1985,99-1988,102-1988,103-1988,106-1990,110-1996IndianRoadsCongress
10. KhannaandJusto,“HighwayEngineering”-NemChandandBros.,Roorkee
11. Indian Highway Capacity Manual (Indo-HCM) CSIR, New Delhi, 2012-2017

COURSE TITLE: PAVEMWNT MATERIALS

[As per Choice Based Credit System (CBCS) scheme]

Semester I

Subject Code	20CTE13	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the aggregates with respect to their shape, size and gradationrequirement which are most important in the construction of different pavement layers.
2. Understand the different types of bituminous binders and apply the knowledge inSuggesting suitable binder for road construction.
3. Understand the use of various binder materials that can be used for interface treatment during construction and repair works carried out on roads.
4. Analyse the properties and design the bituminous and cement concrete mixes for road construction.
5. Analyse the effect of weather on the properties and to understand the various tests that are to be conducted to check the adhesion failure in bituminous materials and mixes.

Modules	Teaching Hours
Module -1	
Basicroadconstructionmaterials –types, source,functional, requirements andproperties,testsandspecificationsforuseinvariouscomponentsofroad. Basic soil properties, methods to determine strength of soil, Soil compactionforuseinfillandsubgradeofroads,compactionstudiesinlaboratoryandfield,properties ofcompactedsoils.	**10 Hours**
Module -2	
Aggregates–Origin, classification,equipments,properties.Testsandspecificationsonroadaggregatesforflexible andrigid pavements.Importanceofaggregategradationproblemson Rothfutch's andCriticalsievemethodsandShapefactorinmix design.	**10 Hours**
Module -3	
Bituminousbinders– differenttypes,propertiesanduses,physicaltestsonbitumen,Rheologicalandpavementperfo rmance relatedproperties,Modifiedbinders,idealpavementbinders,characteristicsandapplicationsi nroadconstruction,criteriafor selectionofdifferentbinders. Bituminousmixes,types,requirements,properties,tests,MarshallMethodofmixdesign,Crite riaandsuperpavemixdesign, Additives&ModifiersinBituminousmixes,problemsonmixdesign.	**10 Hours**
Module -4	
Portlandcementandcementconcreteforuseinroadworks– requirements,designofmixforCCpavement,useof additives,IRCspecifications&Tests,jointfillerandsealermaterials.	**10 Hours**
Module -5	
Soilstabilization– principle,methodsandtests,proportioningofmaterialsandmixdesign,applicationofRothfutc h'smethod. Marginalandwastematerialsinroadconstruction,theirpropertiesandscopeinroadconstruction. UseofFly-ashinroad embankmentandcementconcretemixes,useofchemicalstabilizersinroadconstruction.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Identify and select based on their characteristics the basic construction materials for road construction.
2. Design aggregate gradation for construction of pavement layers keeping in mind the density and strength parameters.
3. Characterize the binder material for bituminous roads and provide an optimum bituminous mix design.
4. Provide mix design procedure and the base layer for a CC pavement.
5. Propose soil stabilisation techniques for highway construction using locally available materials.

Graduate Attributes (as per NBA)

- *Scholarship of Knowledge.*
- *Problem Analysis.*
- *Usage of modern tools*
- *Ethical practices and social responsibility*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. KhannaandJusto,"HighwayEngineering"-NemChandandBros.,Roorkee
2. FreddyLRoberts,PrithviSKandhaletal,"HotMixAsphaltMaterials,mixturedesignandconstruction"-(2nd Edition),NationalAsphaltPavementAssociationResearchandEducationFoundation, Maryland,USA
3. "BituminousmaterialsinRoadConstruction"-HMSOPublication.

Reference Books:

1. MoRTH'SpecificationsforRoadsandBridgesWorks'-IndianRoadsCongressIS73,revised2006,IS2720,IS2386,IS1201to1220,IS8887-1995,IS217-1986
2. Stateofart,specialreport3–"compactionofearthworkandsubrade"-IRC,HRB,1999
3. IRC:51-1992,63-1976,74–1979,88-1984,"IndianRoadsCongress".
4. IRCSP:53–2002,IRCSP:58– 2000,"IndianRoadsCongress".
5. "GuidelinesforuseofGeotextilesinRoadPavementsandAssociatedworks"-2002,IndianRoadsCongress
6. KhannaandJusto,"HighwayMaterialsTesting"-NemChandandBros.,Roorkee.
7. "Soil Mechanics for Road Engineers"- HMSO Publication
8. Highway Hand Book by FAW, Publication from NUS, Singapore.
9. StandardDataBookonHighwayTechnologyissuedbytheUniversitymaybereferredintheP.GExaminationofVTU.

APPLIED SOIL MECHANICS FOR HIGHWAY ENGINEERS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	20CTE14	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the properties and behavior as a highway material under the application of wheel loads.
2. Understand and compare the shear strength of soil and stability of slopes when used as subgrade soil and embankment fills or cut slopes
3. Understand the permeability characteristics of soils to design proper drainage system and various investigations required to assess the soil properties.
4. Understand the type and soil composition affecting the surface runoff and sub-surface water flow in order to design proper drainage system.
5. Analyse lack of strength or instability problems in soils due to soil formation or any other reasons and propose suitable strengthening methods for the same.

Modules	**Teaching Hours**
Module -1	
IntroductiontoSoilandtheirEngineering Properties: Functions of Subgrade soil, Influence of soil properties on designand erformance of pavement, embankments and foundations. Laboratory and field tests for the soil classification,methods of soil classification useful for highway,Importanceofcohesion,plasticity andvolumechangeofsoils. Frost actioninsoils-factors,mechanics,depthoffrostpenetration,measurestodecrease the damagingeffects.	**10 Hours**
Module -2	
Strengthof Soils: Stress-strainrelationshipsunder differenttypesofloadings-incremental, sustainedand repeated loading, time dependent deformations. **SoilWater:**Movementof water insoil,gravitationalwater, heldwater,soilmoisture movements,soilsuctionand soil vapour. **SoilCompaction:**Introduction,LabTests,Factorsaffecting,Structure&Enggbehaviorofcompactedcohesivesoil,Fieldcompactionspecifications,Fieldcompactioncontrol,Differenttypesof Equipmentsusedforcompaction,theirchoice.	**10 Hours**
Module -3	
SoilInvestigations: Soilsurveysinhighway projects.Methodsofsoilexploration–boring,geophysicalmethods, disturbed andundisturbed sampling.Investigations on detrimental matters -organic matters, sulphatesand carbonates. **Permeabilityofsoil:**Darcy'sLaw,Validity,Soil-watersystem,Types,Determinationofpermeability,problems.	**10 Hours**
Module -4	
HighwayDrainage: Introduction,Importance,Surfacedrainage,Sub-surfacedrainage,methods,Designofsubsurface drainagesystem,Roadconstructioninwaterloggedareas,Landslides–definition,classifies,factorsproducing.	**10 Hours**
Module -5	
Stabilityofslopes:Introduction,Types,Differentmethodsofanalysisofslopesfor$\emptyset_u$+0&C-$\emptyset$soil,Locationofmostcriticalcircle,Earthdamslopesstability,Taylor'sstabilitynumber.Effect	**10 Hou**

ofEarthquakeForce,problemsonabove. **ReinforcedEarthstructures**Introduction,Components,Advantages,Typesofstability–external,Internal,(Noproblems), Geotextiles–types,Functions,theirusesinroadembankmentsandrailwayworks,otheruses.	**rs**

Course outcomes:

After studying this course, students will be able to:

1. Analyse the wheel load effects on pavement materials
2. Evaluate and compare the shear strength of soil and stability of slopes when used as pavement component.
3. Design proper drainage system by knowing the permeability characteristics of soils.
4. Design surface runoff and sub-surface drainage system as per field conditions
5. Propose suitable strengthening methods for soil from the knowledge of lack of strength or instability in soils.

Graduate Attributes (as per NBA)

- *Scholarship of Knowledge.*
- *Problem Analysis.*
- *Design / development of solutions (partly).*
- *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. "BasicandAppliedsoilMechanics",GopalRanjan,ASRRao,NewAgeInternationalPublishers.
2. "SoilMechanics&FoundationEngg",Dr.B.C.Punmia,AshokKumarJain,ArunKumarJain,LaxmiPublications(P)Ltd,16th edition.
3. "HighwayEngg",S.K.Khanna,C.E.G.Justo,5th edition.

Reference Books:

1. "SoilMechanics&FoundationEngg"–K.R.AroraStandardPublishersDistributors.
2. "SoilMechanicsforroadEngineers"–HMSO,London.
3. IRC–RelevantCodes.

COURSE TITLE: URBAN TRANSPORT PLANNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	20CTE15	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Identifyurbantransportationproblems.
2. Estimateurbantraveldemand.
3. Planurbantransportnetworks.
4. Identifyurbantransportcorridors.
5. Prepareurbantransportationplans.

Modules	Teaching Hours
Module -1	
Urban Transportation Problems & Policy: Urban transportation Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach; NUTP, Recommendations of 12th FYP and NTDP **Travel Demand Modelling**: Trends, Overall Planning process, Long term - Short term planning, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques, Tour based models, and Activity based models.	**10 Hours**
Module -2	
Data Collection and Inventories: Collection of data – Organization of surveys and Analysis, Study Area, Zoning,TypesandSourcesofData,RoadSide Interviews,HomeInterview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors,AccuracyChecks,UseofSecondarySources,Economicdata – Income– Population– Employment– Vehicle Ownership **Trip Generation Models:** UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis. Household Models, Trip Attraction models, Commercial Trip Rates.	**10 Hours**
Module -3	
Trip Distribution Models: Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models,Time FunctionIterationModels. **Mode SplitAnalysis:** ModeChoiceBehavior,CompetingModes,ModeSplitCurves,Modelsand Probabilistic Approaches–LogitModel	**10 Hours**
Module -4	
TrafficAssignmentTechniques: DiversionCurves,BasicElementsofTransportNetworks,Coding,Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes,EquilibriumAssignment,Multipath Assignment Technique.	**10 Hours**
Module -5	
CorridorIdentification-Plan preparation and evaluation: Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis; TOD; Travel Forecasts to Evaluate Alternative Improvements,ImpactsofNew Development onTransportationFacilities; PivotPointAnalysis,EnvironmentalandEnergyAnalysis.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. ~~Identify theurbantransportationproblems.~~
2. ~~Estimateurbantraveldemand.~~
3. ~~Planurbantransportnetworks.~~
4. ~~Identifyurbantransportcorridors.~~
5. ~~Prepareurbantransportationplans~~.

Graduate Attributes (as per NBA)

1. *Engineering Knowledge.*
2. *Problem Analysis.*
3. *Design / development of solutions (partly).*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. C. JotinKhisty and B. Kent Lall, Transportation Engineering: An Introduction, 3rd Edition, Pearson, 2016.
2. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Third Edition, Prentice Hall of India Pvt. Ltd., 2015

Reference Books:

1. Hutchinson, B.G., Principles of Urban Transport Systems Planning, McGraw Hill, 1974.
2. Juan de Dios Ortuzar and Luis G. Willumsen, Modelling Transport, 4th Edition, JohnWiley and Sons, 2011.
3. Michael D. Meyer, Transportation Planning Handbook, Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
4. Michael D. Meyor and Eric J. Miller, Urban Transportation Planning: A decision oriented Approach, Second Edition, McGraw Hill, 2001.
5. Michael J. Bruton, Introduction to Transportation Planning, UCL Press, London, UK,2000.

E-Learning and Web References:

1. http://www.nptelvideos.in/2012/11/urban-transportation-planning.html
2. https://nptel.ac.in/courses/105107067/
3. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-252j-urban-transportation-planning-fall-2016/
4. https://olc.worldbank.org/content/integrated-urban-transport-planning-self-paced

Pavement Materials Testing Lab I

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	20CTEL16	CIE Marks	40
Practical /field work/Assignment	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 02

Course objectives: The objective of this course is to make students learn

- The procedure and test the basic properties of soil, aggregates, cement and concrete

Modules

Tests on soil

1. Grain size analysis - Wet sieve analysis
2. Liquid limit, plastic limit & Shrinkage limit
3. Compaction test
4. California bearing ratio test and
5. Unconfined Compression Strength Test
6. Field density by sand replacement & Core cutter method

Tests on aggregates

1. Shape tests - Elongation, Flakiness Index & Combined Index, Angularity Number
2. Aggregate impact value test
3. Los angeles abrasion value test
4. Specific gravity & Water absorption test
5. Stripping value test

Penetration Test

1. Softening Point Test
2. Ductility Test
3. Rolling Thin film oven Test
4. Marshall Method of Bituminous Mix Design

Tests on cement& concrete

1. Tests on cement
2. Compressive strength
3. Concrete Mix design

Concrete

1. Concrete Mix design
2. Compressive Strength
3. Flexural strength

Course outcomes:

After the completion of the course students should have

- Acquired the expertise to conduct various tests on soil, aggregates, cement and concrete

Text Books:

1. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A., `Highway Materials and Pavement Testing', NemChand and Bros, Roorkee
2. Gambhir, M. L., 'Concrete Manual', DhanpatRai and sons New Delhi

Reference Books:

1. Relevant IS and IRC codes

RESEARCH METHODOLOGY AND IPR			
Course Code	20RMI17	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	1:0:2	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. ■

Module-2

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. ■

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. ■

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.

Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests. ■

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO. ■

Course outcomes:

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

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.■

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbooks

(1) Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg,New Age International,4th Edition, 2018.

(2) Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2), RanjitKumar,SAGE Publications,3rd Edition, 2011.

(3) Study Material (For the topic Intellectual Property under module 5),
Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.

Reference Books

(1) Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.
(2) Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.

COURSE TITLE: PAVEMENT DESIGN AND ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CTE21	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the factors affecting pavement design and performance
2. Evaluate the strength of soil subgrade soil and factors that affect the behavior of soil.
3. Compute the stresses and deflections in flexible pavement layers under the action of wheel loads.
4. Design the thickness of flexible pavements by different methods under different exposure conditions and materials.
5. Design the thickness of concrete pavements and joints associated with CC pavements in addition to the computation of stresses in CC pavements.

Modules	Teaching Hours
Module -1	
RoadPavementsandpavementlayers- types,functions,choiceFactorsaffectingdesignandperformanceofflexibleandrigidpavements –Pavementdesignfactors,loads–axleload distribution,ESWL,EWL, VDFduetovaryingloadsandCSA.	**10 Hours**
Module -2	
Subgradesupport-CBRandplatebearingtests,Resilient Modulus,fatiguetests,permanentdeformationPavementmaterial Characteristics,climatic,drainageandenvironmental factors,theireffectsandevaluation.Factorsaffectingdesignandperformanceofairportpavements.	**10 Hours**
Module -3	
StressesandDeflection/straininflexiblepavements: Applicationofelastictheory, stresses,deflections/strainsinsingle, twoandthreelayersystem,Applicationsinpavementdesign. problems	**10 Hours**
Module -4	
Flexible pavement design: Emperical, semi- empirical and theoretical design approaches, principle, advantages and application. Design steps by CBR method as per IRC, outline of other common design methods such as AASHTO and Asphalt Institute methods, Problems.	**10 Hours**
Module -5	
Rigidpavementdesign: DeterminationofESWL,EWLfordualanddualtandemwheelloadsinRigidpavements,General designprinciple,Stressesinrigidpavements,stressesduetowheelloadsandtemperaturevariations,designofcementconcrete pavements(jointsandslabthickness)asperIRCguidelines.DesignfeaturesofCRCP,SFRCandICBP,Problems.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Get the knowledge of factors affecting pavement design and performance
2. Evaluate the strength of soil subgrade soil and identify the factors that affect the behavior of soil.
3. Compute the stresses and deflections in flexible pavement layers under the action of wheel loads.
4. Design the thickness of flexible pavements by different methods under different exposure conditions and materials.
5. Design the thickness of concrete pavements and joints associated with CC pavements in addition to the computation of stresses in CC pavements.

Graduate Attributes (as per NBA)

1. Engineering Knowledge.
2. Problem Analysis.
3. Design / development of solutions (partly).
4. Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. YoderandWitczak,"PrinciplesofPavementDesign"-JohnWileyandsonsInc(secondedition)1975
2. Yang,"Designoffunctionalpavements"-McGrawHillBookCo.

Reference Books:

1. Huang,"PavementAnalysis"-ElsevierPublications
2. DavidCroney,PaulCroney,"Design&PerformanceofRoad Pavements"-McGrawhill BookCo.
3. W.RonaldHudson,RalphHaasandZeniswki"ModernPavementManagement"-McGrawHillandCo
4. IRC37-2001,IRC81-1997,IRC58–2002,IRC59–1976,IRC101-1988,IndianRoadsCongress
5. KhannaandJusto"HighwayEngineering"-Nemchand&Bros,Roorkee

COURSE TITLE: PUBLIC TRANSPORTATION SYSTEMS.

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CTE22	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Differentiate different transit systems
2. *Estimate transit demand*
3. *Plan bus route network and prepare bus schedules*
4. Identify mass transit corridors
5. Evaluate transit performance
6. Plan and Design transit terminals

Modules	Teaching Hours
Module -1	
Transit Systems: Role of Transit - Types of Transit Modes - Buses - LRT, RTS - Air cushionedand Maglev System – S-Bahn Dual Mode Busses, Para Transit - Dial - a-Ride-Taxi- Jitney and Ridesharing – PRT Networks - DRTS TechnologicalCharacteristics – Resistances, acceleration & velocity Profiles – Operationalcharacteristics speed, capacity & payloads – Route capacity – Comfortconditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport.	**10 Hours**
Module -2	
Estimation of Transit Demand: Data requirements & Collection techniques, Conventional Methods Destination Survey - Bus Stop Surveys and Analysis - Mode Split Models - Captive and Choice Riders - Attitudes of Travelers -Patronage Determination.	**10 Hours**
Module -3	
Bus Route Network Planning: Route Systems -Route Location,Route Structure,RouteCoding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Integration with UTPS. **Bus Scheduling:** Patterns of Bus Services - Frequency of Services - Special Services – SingleRoute Bus Scheduling - Fleet Requirement, Marginal Ridership Concept - Use of Optimisation Technique - Load Factor - Depot Location - Spacing of Bus Stops	**10 Hours**
Module -4	
Mass Transit Corridor Identification & Planning: Corridor identification - Network Compression Method - Planning of RapidTransit System - System Selection - Supporting and Enclosing Structures -System Evaluation - Track Structures - Signal System - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.	**10 Hours**
Module -5	
Public Transport Management Measures: RTC Act - ASRTU System Efficiency and Effectiveness Measures - Performance Indicators – LOPTS - Preferential Treatment to HOV: Exclusive Bus Lanes - Bus Streets - Contra Flows - Reversible	**10 Hours**

Lanes - Bus Bypass -Bus Pre-emption Signals for Bus Operations	

Course outcomes:

After studying this course, students will be able to:

1. ~~Differentiate different transit systems~~
2. ~~*Estimate transit demand*~~
3. ~~*Plan bus route network and prepare bus schedules*~~
4. ~~Identify mass transit corridors~~
5. ~~Evaluate transit performance~~
6. ~~Plan and Design transit terminals~~

Graduate Attributes (as per NBA)

- *Scholarship of Knowledge.*
- *Critical thinking.*
- *Ethical practices and social responsibility*
- *Use of modern tools*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Alan Black, Urban Mass Transportation Planning, McGraw-Hill International Enterprises, Inc. 1995.
2. David A. Hensher, Bus Transport: Economics, Policy and Planning. Research in Transportation Economics Volume 18. Elsevier Publications, 2007.

Reference Books:

Readings and References:

1. George E. Gray and Lester A. Hoel: Public Transportation: Planning, Operation andManagement, 2nd Edition, Prentice Hall; 1992
2. Michael D.Meyer, Transportation Planning Handbook,Fourth Edition, Institute of Transportation Engineers, John Wiley & Sons Inc., 2016
3. Nick Tyler, Accessibility and the Bus System: from Concepts to Practice, ThomasTelford, 2002.
4. P.R. White, Public Transport: Its Planning, Management and Operation, Fifth Edition, London New York, 2008.
5. Simpson, Barry J., Urban Public Transport Today. Taylor & Francis RoutledgePublisher, 2003
6. Tiwari G., Urban Transport for Growing Cities: High Capacity Bus System, MacMillanIndia Ltd., 2002
7. Vukan R. Vuchic, Urban Transit: Operations, Planning and Economics, Wiley, 2005.

COURSE TITLE: GEOMETRIC DESIGNOF TRANSPORTATION FACILITIES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CTE23	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Analysistodetermine thesightdistance considerations.
2. AnalysistoDesign of horizontal and vertical alignment,
3. AnalysistoDetermine Superelevation required forsafetravel.
4. AnalysistoDetermine Level ofService.
5. AnalysistoDesign of GradeSeparators and Interchanges.

Modules	Teaching Hours
Module -1	
Introduction: Classification ofrural highways and urban roads. Objectives and requirements of highway geometric design **DesignControls:**Topography,vehicle characteristicsanddesignvehicle,driver characteristics, speed,traffic flow andcapacity,levelsof service,pedestrianandother facilities, environmentalfactors	**10 Hours**
Module -2:	
DesignElements: Sightdistances-types,analysis,factorsaffecting,measurements, **Horizontalalignment**-designconsiderations,stability atcurves,superelevation, widening, transitioncurves;curvatureatintersections,verticalalignment-grades, ramps,designofsummitandvalley curves,combinationofverticalandhorizontal alignment, expressways,IRC standards andguidelines fordesign problems	**10 Hours**
Module -3	
CrossSectionElements: Rightofwayandwidthconsiderations,roadway,shoulders, kerbs,traffic barriers,medians, Pavementsurfacecharacteristics-types,crossslope, skid resistance, unevenness.	**10 Hours**
Module -4:	
DesignConsiderations:Designconsiderationsforruralandurbanarterials,freeways, andother ruralandurbanroads-designspeeds,volumes,levelsof service andother design considerations.	**10 Hours**
Module -5:	
DesignOfIntersections&Parkinglots:Characteristicsanddesignconsiderationsof at-grade intersections;Differenttypesof islands,channelization;medianopenings; Rotary intersections; Grade separations and interchanges - types, warrants, adaptabilityanddesigndetails; ramps.Computerapplicationsforintersectionand interchangedesign.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. *DesignofGradient,visibilityonverticalcurves,designofsummitandvalley curves.*
2. *Determinethesightdistance,horizontalcurvature,superelevation,grades, visibilityon vertical curves, cross section elements.*
3. *Justify thegeometricdesign standards adopted forROW*
4. *Perform safetyauditat different stages of road construction.*
5. *Design of gradeseparators and interchanges*

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Khanna S.K.and Justo,C.E.G. Justo,`Highway Engineering',NemChandand Bros.
2. Jack ELeishand Associates, `Planning and Design Guide: At-Grade Intersections'. Illinios.

Reference Books:

1. AASHTO, `A Policy on Geometric Design of Highways and Streets', American Association of State Highway and Transportation Officials, Washington D.C.
2. DSIR,`Roads in UrbanAreas', HMSO,London.
3. RelevantIRC publications

COURSE TITLE: THEORIES OF TRAFFIC FLOW

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 241	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Learn the relationships and the types of flow theories.
2. Learn the concept of Macroscopic and Microscopic traffic flow models.
3. Learn the application of probabilistic aspects of vehicle arrivals, ueuing theory.
4. Learn the principles of application of GIS in traffic flow theory.

Modules	Teaching Hours
Module -1	
Traffic Stream Parameters - Fundamental diagram of volume-speed-density surface. Discreteandcontinuous probability distributions. Merging manoeuvres - critical gaps and their distribution.	**10 Hours**
Module -2:	
Macroscopic Models - Heat flow and fluid flow analogies - Shock waves and bottleneck controlapproach.	**10 Hours**
Module -3	
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.	**10 Hours**
Module -4:	
Linear And Non-Linear Car Following Models - Determination of car following variables -Acceleration noise.	**10 Hours**
Module -5:	
Geographical Information System – Global Positioning System – Intelligent TransportationSystems - Area Traffic Control – Automatic Toll Col lection – Smart Cards – Collision DetectionSystem.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Ableto applytheflowtheories tofieldsituationssuchas tollbooths, diversion measuresetc.
2. Ableto understand variouscarfollowingtheories
3. Abletoapplytheconceptsofvehiclearrivalstofieldsituationssuchasexitramps,entryramps etc.byqueuingtheory
4. Ableto appreciatetheapplication ofGIS techniquesintrafficengineering.

Graduate Attributes (as per NBA)

1. Scholarship of Knowledge.
2. Problem Analysis.
3. Critical thinking
4. Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.
Text Books:
Reference Books: Drew, D.R.,TrafficFlowTheoryand Control,McGrawHill.,1978TRB, TrafficFlowTheory-AMonograph, SR165,1975. BurroughP.A.andRachelA.McDonell,PrinciplesofGeographicalInformation Systems,Oxford Publication,2004

COURSE TITLE: TRANSPORT ECONOMICS AND PROJECT APPRAISAL

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 242	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Differentiate macro and micro economic principles
2. Quantify benefits and costs of transport projects and carryout economic analysis
3. Evaluate transport projects
4. Analyse life cycle cost of a transport projects
5. Appreciate private sector participation in transportation industry

Modules	Teaching Hours
Module -1:	
Transport Economics: Review of Engineering Economics and Microeconomics, Welfare Theory and Equilibrium Conditions, Goals and Objectives, Principles of Economic Analysis	**8 Hours**
Module -2:	
Methods of Economic Analysis: Discounted Cash Flows: Analysis of User Costs and Benefits, RUCS Models for Costs and Benefits, Methods of Economic Analysis; Suitability, Analysis for Null Alternative	**10 Hours**
Module -3	
System Selection and Evaluation: Framework of Evaluation, Transport Planning Evaluation at Urban and Regional levels, Other Evaluation Procedures - Traditional Economic Analysis, Achievement Matrices, Factor Profiles, Plan Ranking, Introductionto Mathematical Programming, Bidding Games, Delhi Technique, Multi-Criteria Evaluation, Case Studies.	**12 Hours**
Module -4:	
Life Cycle Cost Analysis: Factors consider for Life Cycle Cost Analysis; Data requirements for highwayproject feasibility analysis, establishment of Technical/ Economic/ Financialfeasibility of a highway project, Social Benefits, Role of HDM in feasibility studies.	**10 Hours**
Module -5:	
Project Appraisal – Private Sector Participation: BOT, BOOT, BOLT Projects – Case history– Project Planning – ProjectSystem Management – Project Implementation – Funds Planning –Budgetary and Control – Tendering and Contract – Value Analysis,Information System - Impact assessment, Project Report Preparation.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Slove the problems of macro and micro economic principles
2. Analyse the benefits and costs of transport projects and carryout economic analysis
3. Analyse and Evaluate transport projects
4. Calculate the life cycle cost of a transport projects
5. Analyse private sector participation in transportation industry

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. C.G. Swaminathan and L.R. Kadiyali, Road User Cost Study in India, Central Road Research Institute, New Delhi, 1983.
2. CRRI, Updation of Road User Study Data and Road User Costs, CRRI, 2012

Reference Books:

1. Highway investment in Developing countries; Commission of the European Communities, Institute of Civil Engineers, Thomas Telford Ltd 1983.
2. John W. Dickey and Leon H. Miller, Road Project Appraisal for Developing countries, John Wiley and Sons., 1984.
3. L.R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, 2012.
4. Michael J Markow, Engineering Economic Analysis Practices for Highway Investment, NCHRP Synthesis 424, TRB, 2012
5. Robley Winfrey, Economic Analysis for Highways - International Text Book Co., Pennsylvania, 1969.
6. VinayMaitri and P.K Sarkar, Thory and Applications of Economics in Highway and Transport Planning, Standard Publishers Distributors, First Edition 2010.

COURSE TITLE: TRANSPORTATION SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 243	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Explain the various modes of transportation with their relative merits and demerits.
2. List the various types of roads and road patterns; explain the importance of 20 year road development plans and current road projects in the country.
3. Explain the factors affecting development of harbours and ports and elements in harbour and port planning.
4. Categorize various the national waterways in the country with their important characteristics. Explain the need of urban mass transportation in developing countries and compare the various modes of urban mass transportation systems.

Modules	Teaching Hours
Module -1:	
Introduction– Importance of transportation systems, Different modes, characteristics, theirintegration and comparison Highway systems – Road type and classification, road patterns, phasing road development inIndia, salient features of 3rd and 4th twenty year road development plans, Present scenario ofroad development in India and in Karnataka.	**10 Hours**
Module -2:	
Railways systems– Role of railways in transportation, Advantages of railways, Indian railways, classification, present scenarioof railway development in India, Modernizationof railways, development of high and super high speed railways.	**10 Hours**
Module -3	
Airports - .Overview of air transportation, Role of FAA and ICAO, air transport in India, typesof airports, Heliports, STOL ports, complexities in airport planning, elements of airport planning, airport master plan, environmental impact.	**10 Hours**
Module -4:	
Harbours and Ports –Development of harbours and ports in India , characteristics, factors constraining development, elements of harbour and port planning, role of harbours and ports in transportation, National waterways, characteristics.	**10 Hours**
Module -5:	
Urban transportation systems – Importance of collective transportation v/s individualtransportation, freight transportation, Physical system components of urban transportation, Overview of Mass rapid transit, Light rail transit, Personal rapid transit, guided way systems, Para transit systems, Mono rail, bus rapid transit systems	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. List, explain and compare the various modes of transportation with their relative merits and demerits.
2. Classify the various types of roads and road patterns, list the salient features of 20 year road development plans and discuss on current road projects in the country.
3. List and discuss on factors affecting development of harbours and ports and explain o n elements in harbour and port planning.
4. List the various the national waterways in the country and explain their important characteristics.
5. Explain the need of urban mass transportation in developing countries and

compare the various modes of urban mass transportation systems.

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A., `Highway Engineering', NemChandandBros, Roorkee
2. S.C.Saxena and S.P.Arora "A text book of Railway Engineering", DhanpatRai publications

Reference Books:

1. Vukan R. Vuchic, Urban Transit Systems and Technology, Wiley and Son, New York, 2005
2. Alan Black, Urban Mass Transportation Planning, McGraw-Hill, 1995.

COURSE TITLE: XXXXXXXXXXX

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 244	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the structural and functional requirements of pavements and also to carry out the structural and functional evaluation of both flexible and rigid pavements
2. To evaluate new pavement materials through various approaches such as model pavement studies, test track studies etc.

Modules	Teaching Hours
Module -1:	
	10 Hours
Module -2:	
	10 Hours
Module -3	
	10 Hours
Module -4:	
	10 Hours
Module -5:	
	10 Hours

Course outcomes:

After studying this course, students will be able to:

- Understand the failure mechanism in pavements and suggest suitable corrective measures.
- Analyse and evaluate structural and functional adequacy of pavements

Graduate Attributes (as per NBA)

5. *Scholarship of Knowledge.*
6. *Problem Analysis.*
7. *Critical thinking*
8. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1.

Reference Books:

1.

COURSE TITLE: PAVEMENT MANAGEMENT SYSTEM

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	20CHT 251	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Discuss the need of PMS in planning and maintaining the flexible pavements.
2. Discuss the performance of pavements, causes of failure, rating methods.
3. Formulate the development and application of models for pavement management.
4. Discuss the need of application of methods of prioritization and application of innovative methods
5. Discuss the application of Road Asset Management

Modules	Teaching Hours
Module -1:	
Introduction: Definition -Components of Pavement Management Systems, Essential features. Pavement Management Levels and functions: Ideal PMS- Network and Project levels of PMS- Influence Levels- PMS Functions- Function of Pavement evaluation.	**10 Hours**
Module -2:	
Pavement Performance: Serviceability Concept- Development of Serviceability Index-PSI-RCI- Roughness- Roughness Components- Evaluation-Equipment- Universal Roughness standard-Techniques-IRI Application of Roughness Data in Network level and Project Level. **Evaluation of Pavement Structural capacity:-** Basics- NDT and Analysis - Condition SurveysDistress- Destructive Structural Analysis- Application in Network and Project Levels-Methodsand Equipment- Combined Measures of Pavement Quality-Concept-Methods of developing a combined index-limitations.	**10 Hours**
Module -3	
Evaluation of Pavement Distress and Functional Aspects – Principles-Condition survey- Survey Methodology-Types of Distress-Examples-Equipment-Indexes-Applications of Distressdata- Pavement Safety-Components –Evaluation-Basic Concepts of Skid resistance-Methods of measuring skid resistance- Effect of Time ,Traffic and Climate on Skid resistance. Establishing Criteria - Rehabilitation and Maintenance.	**10 Hours**
Module -4:	
Expert Systems and Pavement Management - Implementation of Pavement ManagementSystems	**10 Hours**
Module -5:	
Road Asset Management: Management, Data and Modeling, Planning Application	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Identify the factors influencing performance of pavement.
2. Carry out structural and functional evaluation of pavements
3. Explain the use of models for pavement management.
4. Develop a framework for efficient pavement management system
5. To apply Road Asset Management

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ralph Haas and Ronald W. Hudson, 'Pavement Management System', McGraw Hill Book Co.1978.
2. Ralph Haas, Ronald Hudson Zanieswki. 'Modern Pavement Management, KreigerPublications, New York, 1992.

Reference Books:

1. PIARC Guidelines
2. Proceedings of North American Conference on Managing Pavement, USA, 2004.
3. Proceedings of International Conference on Structural Design of Asphalt Pavements NCHRP, TRR and TRB Special Reports, USA, 2006.

COURSE TITLE: TRANSPORTATION STRUCTURES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 252	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Classify the various transportation structures,
2. Explain the principles of design methods and list the steps involved in the design of various transportation structures.
3. Identify the input parameters required for design of transportation structures
4. Design and evaluate a transportation structures based on the data given.

Modules	Teaching Hours
Module -1: Introduction to pavement evaluation	
Introduction: Principles of Planning of Elevated Rail Transit System, grade separationstructures, pedestrian crossing and sub- ways.	**10 Hours**
Module -2:	
Loads on Bridges: Dead loads, live loads, dynamic effects of vehicles, longitudinal forces, centrifugal forces, wind loads, earth quake forces, stream flow pressure, load combinations, design examples.	**10 Hours**
Module -3	
Design of Bridge Slabs: Longitudinally reinforced deck slabs, transversely reinforced bridge slabs.	**10 Hours**
Module -4:	
Design of Reinforced Concrete Bridges: Design procedures for T- beam, box girder bridges design examples.	**10 Hours**
Module -5:	
Design of Pre-stressed Concrete Bridges: Complete design with case study.Design code, design examples.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Understand and classify the various transportation structures,
2. Use the principles of design methods and list the steps involved in the design of various transportation structures.
3. Identify the input parameters required for design of transportation structures
4. Evaluate and design transportation structures based on the data given.

Graduate Attributes (as per NBA)

1. Scholarship of Knowledge.
2. Problem Analysis.
3. Critical thinking
4. Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Raina,R.K, 'Principles of Design of RCC Bridges, Tata McGraw Hill,1999.
2. Krishnaraju ‘Bridge Engineering‘, UPD Publishers, New Delhi,2000.

Reference Books:

1. Conrad P. Heins and Richard A. Lawrie, `Design of Modern Concrete Highway Bridges, John Wiley and Sons, 1999.
2. BaiderBakhtand Leslie, G.Jaeger,` Bridge Analysis Simplified, McGrawHill Book Co,1998.
3. Johnson Victor, `Bridge Engineering', Oxford IBH, NewDelhi, 2000.

COURSE TITLE: REMOTE SENSING AND GIS IN TRANSPORT PLANNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 253	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Explain the purpose of accurate mapping of all features under different spatial and temporal scales of all kinds of terrain and land under water bodies.
2. Discuss on the advantages of remote sensing compared to traditional surveying techniques in terms of time, accuracy and output.
3. Explain the purpose and methods of obtaining abstract data both spatial and temporally.
4. Illustrate the application of GIS and remote sensing in solving real world transportationproblems.

Modules	Teaching Hours
Module -1:	
Introduction to remote sensing : Definition – Components of Remote Sensing – Energy, Sensor, Interacting Body –Active and Passive Remote Sensing – Platforms– Aerial and Space Platforms – Balloons, Helicopters, Aircraft and Satellites – Electromagnetic Radiation– EMR Spectrum.	**10 Hours**
Module -2:	
Introduction to GIS : Basic Concept and Components – Hardware, Software –Data Spatial and non- spatial – Geo-referencing – Map Projection – Types of Projection – Simple Analysis – Data retrieval and querying.	**10 Hours**
Module -3	
Data structures and analysis: Database – Raster and Vector data structures – Datastorage – Run length, Chain and Block coding – Vector data storage – Topology – GIS Modeling - Raster and Vector data analysis – Buffering and overlaying techniques – Network Analysis – Spatial Analysis	**10 Hours**
Module -4:	
Basic applications in transportation: Highway and Railway Alignment, location of transport terminals and roadside facilities, bus stops – Route optimization – Bus route rationalization – Accident analysis – Applications of Aerial Photography and Satellite Imageries.	**10 Hours**
Module -5:	
Advanced applications: GIS as an integration technology – Integration of GIS, GPS and Remote Sensing Techniques – Advanced Traveller Information System (ATIS) – Automatic Vehicle Location System (AVLS)	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Choose the remote sensing image from different sensors, resolutions, spatial and temporal scales.
2. Explain and to comprehend large tracks of earth surface with less time and cost but more accuracy.
3. Communicate to the common man his analysis of different problems developments, benefits by preparing different thematic maps.
4. Apply GIS and remote sensing techniques in solving real world transportation problems.

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*

2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Anji Reddy, Remote Sensing and Image Interpretation, John Wiley and Sons Inc. New York,1987.
2. M.G.Srinivas, Remote Sensing Applications, Narosa Publishing House, 2001

Reference Books:

1. Burrough P.A, Principles of GIS for Land ResourcesAssessment, Oxford Publication, 1994.
2. Jeffrey Star and John Ester, Geographical Information System – An Introduction, Prentice Hall Inc., Englewood Cliffe, 1990.
3. Marble, D.F, Calkins, H.W and Penquest, Basic Readings in GIS, Speed System Ltd., New York, 1984

COURSE TITLE: ADVANCED TRAVEL DEMAND MODELLING.

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	20CHT 254	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Develop discrete choice models.
2. Develop travel demand models using Stated Preference data.
3. Estimate Travel Demand using activity based analysis.
4. Assess Qualitative Variables.
5. Test model aggregation and transferability.
6. Develop Travel Demand Models for small cities using Quick response

Modules	Teaching Hours
Module -1:	
Discrete Choice Analysis: Utility Concept; Mode choice; Logit Models; Dogit Model; Nested Logit Model; Probit Model; Route Choice Modelling; Combined Travel Demand Modelling; Model Parameter Estimation – Maximum Likelihood and Maximum Entropy Estimates. **Stated Preference Methods** Stated preference vs. Revealed Preferences; Design Issues; Survey Methods, Conjoint Analysis; Functional Measurement; Trade off Analysis, Transfer Price Method	**10 Hours**
Module -2:	
Activity Based Travel Demand Models Activity patterns; Activity scheduling; Activity Time Allocation studies; Activity Episode Analysis; Travel Duration Analysis	**10 Hours**
Module -3	
Qualitative Variables: Role of Soft variables in Travel Demand Forecasting; Attitudes; Psychometric scaling Techniques – One-dimensional Scaling – Multidimensional Scaling; Basic Rating Scales: Comparative Rating Scales, Non – Comparative Rating scale, Itemised rating scale, graphic rating scale; Specific Attitude scales; Successive Categories; Principal Components Factor Analysis; Attitudinal Models	**10 Hours**
Module -4:	
Model Aggregation and Model Transferability: Aggregation bias and forecasting; Aggregation Methods; Temporal Stability and geographical stability of Models; Transfer Model Updating Procedures –Transferring with Aggregate and Disaggregate sample data; Transferability Measures. **Simplified Travel Demand Models:** Sketch planning Methods; Incremental Demand Models; Model estimation from traffic Counts; IVF Models, Marginal and Corridor Models; Gaming Simulation, Quick Response Techniques.	**10 Hours**
Module -5:	
Introduction to Advanced Modeling Techniques: GO Models; Entropy Models; Equilibrium Assignment Techniques, MultipathAssignment – Dial's Algorithm, Knowledge Based Expert System; Neuro – Fuzzy Application; ANN Techniques; Genetic Algorithms; Object OrientedProgramming; Decision Support Systems; Goal Programming.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Alan Geoffrey Wilson. Optimisation in Location and Transport Analysis, John Wiley & Sons, 1981 (Digitized: 31 March 2011).
2. Harry Timmermans, *Progress in Activity Based Analysis*, Elsevier Science, 2005

Reference Books:

1. Joe Castiglione, Mark Bradley and John Gliebe, Activity-Based Travel Demand Models: A Primer, TRB, Washington, D.C., 2015
2. Juan de Dios Ortuzar and Luis G. Willumsen, *Modelling Transport, 4th Edition*, John Wiley and Sons, 2011.
3. Laurie A. Garrow, Discrete Choice Modelling and Air Travel Demand: Theory and Applications, Routledge, 2010
4. Moshe Ben-Akiva, and Steven R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand*, The MIT Press, Paperback 2018.
5. Norbert Oppenheim, *Urban Travel Demand Modelling: From Individual Choices to general Equilibrium*, John Wiley and Sons, Inc., 1995 (Digitized 29 June 2011).
6. Time use Analysis, Special Issue, Transportation, 26, Kluwer Academic Publishers, 1999.

E-Learning and Web References:

1. https://professional.mit.edu/programs/short-programs/discrete-choice-analysis
2. http://support.sas.com/techsup/technote/mr2010f.pdf
3. https://eml.berkeley.edu/books/train1201.pdf
4. https://ocw.tudelft.nl/courses/transportation-and-spatial-modelling/

COURSE TITLE: PAVEMENT EVALUATION AND SOFTWARE LABORATORY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	20CTEL26	CIE Marks	40
Practical /field work/Assignment	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 02

Course objectives: The objective of this course is to make students learn

1. Illustrate the application of software for analyzing traffic survey data.
2. Evaluation of Pavement functional and structural condition
3. Explain and illustrate generation of models for transportation planning
4. Introduce the methods of designing geometry of highways using computer software

Modules

PART - A: LAB Components

Module 1: ANALYSIS OF TRAFFIC SURVEYS

Classified volume count survey Highway capacity Estimation. Moving car method LoS study, Origin and destination studies

Environmental impact – Noise studies and vehicular emission measurement

Lighting studies, Delay studies, Headway and Gap-acceptance studies. Pedestrian Survey.Parking studies, Road Safety Audit.

Module 2: PAVMENT EVALUATION LAB

Road inventory, Pavement Condition Studies, Skid Resistance Studies,Stone Polishing Value Studies Road Roughness Measurement

Benkelman Beam Deflection Studies

PART B: Demonstration and Assignment

Module 3: HIGHWAY GEOMETRY

Design of horizontal alignment, vertical alignment, generating cross section and design ofintersections.

Module 4: TRANSPORTATION PLANNING:

(Data will be provided to compute the following) Trip generation modeling

Mode choice/modal split problems

Trip assignment problems

Module 5: Introduction to Use of Software Related to Transportation Engineering

PAVEMENT EVALUATION & ECONOMIC ANALYSIS PACKAGES:

DAMA Package

Ken layer & Ken slab Economic Analysis Package HDM – IV

IIT PAVE

TRAFFIC ENGINEERING PACKAGES:

Signal Design TRANSIT SYNCRO

ACCIDENT ANALYSIS PACKAGE TIME SERIES PACKAGE

Course outcomes:

After the completion of the course students should have

1. Examine and arrive at required output from traffic surveys
2. Identify the adequacy of the pavement performance- functional and structural.
3. Analyse and generate models for transportation planning.
4. Design the geometry of highways.

Text Books:

1. User Manuals of various packages
2. Relevant IRC publications
3. C.S.Papacostas and P.D.Prevedouros “Transportation engineering & Planning”, PHI learning
4. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A., `Highway Engineering’, NemChandandBros, Roorkee

Reference Books:

1. Relevant IS and IRC codes

THIRD SEM III

COURSE TITLE: PAVEMENT CONSTRUCTION TECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CTE31	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Explain conceptof locationsurveys, procedureofpreparingprojectreport,documentation ofcontract.
2. Explain features, functioning and uses of different types of equipmentsused in road construction and construction specification fordifferentlayersof road
3. Provideinformationonspecificationsofconstruction ofdifferenttypesofgranularsubbase,baseand surfacecourseand constructionofspecialpavement
4. Provide information on application of CPM and PERT in construction planning
5. Explain the maintenance activities for road and road furniture

Modules	Teaching Hours
Module -1:	
Importance of surveys and investigations, Guidelines foralignmentandroute location, Use ofaerial photographsand remotesensing technology,Conventionalgroundsurvey techniques, Typesofdrawings, Estimates,Projectreports,ProjectCostForecasting,CostOptimizationandResourcesPlanning,Tendering and Contracting, LawsofContracts, Subcontracts, PotentialProblems, PostContractProblems, Documents, Conditions, Arbitration, Special Features of International Contracts. ; HumanResource Management, ResourceManagementandInventory:Basicconcepts,laborrequirementsandproductivity.	**10 Hours**
Module -2:	
Roadconstructionequipment– different typesofex cavators,graders, soilcompactors/ rollers,paversand otherequipmentforconstructionofdifferentpavementlayers– theirusesandchoice.Problem onequipment usagecharges;Pre-constructionsurveysandmarking onground-Specificationsandstepsfor theconstruction of road formationinembankmentand cut, constructionsteps forgranular sub-base, qualitycontroltests.	**10 Hours**
Module -3	
Differenttypesofgranularbasecourse– WMM,CRM,WBM;specifications,constructionmethodand qualitycontroltests.Differenttypesofbituminouslayersforbinderandsurfacecourses;theirspecifications (asperIRCand MORTH);construction method and qualitycontroltests.	**10 Hours**
Module -4:	
Differenttypesofsub-baseandbasecourse forcementconcrete	**10 Hours**

(CC)pavementandconstructionmethod. Construction ofcementconcrete (PQC)pavements jointsquality controlduring construction.Construction detailsofinterlockingconcreteblockpavements	
Module -5:	
Principleofconstructionplanning,applicationofCPMandPERT,Problems,Roadmaintenanceworks–day to dayand periodicmaintenanceworksofvariouscomponentsof road worksandroadfurniture	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Able to gain knowledge of location surveys, procedure of preparing project report, documentation of contract.
2. Able to understand functioning and uses of different types of equipments used in road construction.
3. Gain knowledge of application of CPM and PERT in construction planning

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Peurifoy.R.L., 'Construction Planning, Equipment and Methods', McGraw Hill Publishers, New York, 2000
2. S.C.Sharma, ' Construction Equipment and its Management', Khanna Publishers, New Delhi, 1988
3. Asphalt Technology and Construction Practices, The Asphalt Institute, Maryland, USA, 1997
4. Relevant IS, IRC, AASHTO and MoRTH Publications.

Reference Books:

2.

COURSE TITLE:ROAD SAFETY AND MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CTE321	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Explain the causes of accidents, statistical measures of accident data analysis and computer application indataanalysis.
2. Explain differentparameters responsibleforprovidingroadsafetyintheconstruction ofnewroads. Explain road reconstructionprincipleandimprovementofroad consideringthedifferentcomponents of road and intersections.
3. Explainroadsafetyandmaintenancemeasuresforroadinoperationconsideringpedestrian,cyclists and road furniture.
4. Explainroadsafetyauditprincipleandprocedure,varioustrafficmanagementtechniquesandtheir effectiveness.

Modules	Teaching Hours
Module -1:	
Road accidents, Causes, Scientific Investigations and Data Collection: Analysis of Individual accidents to arrive at Real Causes, Statistical Methods of Analysis of Accident Data,Application of Computer Analysis of Accident Data.	**10 Hours**
Module -2:	
Ensuring TrafficSafety in Designing NewRoads:MeteorologicalConditions, StructureofTrafficStreams, Orientation ofaDriverontheDirection ofa RoadbeyondtheLimits ofActualVisibility andRoadway Cross Section & ObjectsontheRight-of-Way.	**10 Hours**
Module -3	
Ensuring TrafficSafety inRoadReconstruction:RoadReconstruction and TrafficSafety,Reconstruction Principles,PlottingofSpeedDiagram forWorkingout Reconstruction Projects, Use of Accident Data in Planning Reconstruction of Roads, Examples ofReconstruction ofSelected RoadSections forImproving Traffic Safety, Improving Traffic Conditions onGrades, Sharp Curves, Redesign ofIntersections, Channelized At-GradeIntersections, BusStops, Parking& RestAreasand EffectivenessofMinorRoad Improvements.	**10 Hours**
Module -4:	
Ensuring TrafficSafety inRoadOperation :Ensuring Traffic Safety during Repair and Maintenance, Prevention of Slipperiness and Influence ofPavementSmoothness,Restriction speedsonRoads,Safety of	**10 Hours**

Pedestrians,CyclePaths,Informing DriversonRoad ConditionswithAidofSigns, TrafficControlLines&GuidePosts,Guardrails& BarriersandRoad Lighting.	
Module -5:	
RoadSafetyAuditandTrafficManagementTechniques:Principles-ProceduresandPractice,CodeofGood PracticeandChecklists.Roadsafety issuesand engineering,education,enforcementmeasures forimproving roadsafety.Localareamanagement,Varioustypesoflong term trafficmanagementmeasuresandtheiruses. Evaluation of theeffectivenessand benefitsofdifferenttrafficmanagementmeasures, managementand safety practicesduringroad works.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Able to acquire knowledge statistical methods and computer application of accident analysis.
2. Capable of analyzing the factors affecting the construction of new roads.
3. Capable of analyzing the factors affecting the reconstruction of existing roads.
4. Capable of analyzing the factors affecting the operation condition of road.
5. Able to remember the process of road safety audit and the measures of improving road safety.
6. Qualified to evaluate the effectiveness of various management techniques adopted in reducing road accident.

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. BABKOV, V.F. `Road conditions and Traffic Safety', MIR, publications,Mascow - 1975.
2. K.W. Ogden, `Safer Roads – A Guide to Road Safety Engg.' Averbury Technical, Ashgate Publishing Ltd., Aldershot, England, 1996.

Reference Books:

1. Kadiyali, L.R., `Traffic Engineering and Transport Planning', Khanna Publications, New Delhi, 2009.
2. C. JotinKishty& B. Kent Lall, "Transportation Engineering-An Introduction" , Thrid Edition, Prentice Hall of India Private Limited, New Delhi, 2006
3. Latest Editions of Relevant Indian Roads Congress (IRC) Publications for Design of Roads and Road Safety.
4. Khanna and Justo, 'Text book of Highway Engineering', Nemchand Brothers, Roorkee,2001.

Course Title: INTELLIGENT TRANSPORTATION SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CTE322	CIE Marks	40
Number of Lecture Hours/Week	03	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Have an awareness and scope of transport issues, such as, traffic safety, public transport, advanced vehicle management and control.
2. Learn how Intelligent transport systems (ITS) involve the application of information technology and telecommunications to control traffic, inform travelers and drivers, operate public transport, automating payments, handle emergencies and incidents, operate commercial fleets and freight exchange, and automate driving and safety.

Modules	Teaching Hours
Module -1	
Basic elements of intelligent transportation systems (ITS), focusing on technological, systems and institutional aspects. Benefits of ITS -ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.	**10 Hours**
Module -2	
Advanced traveler information systems; transportation network operations; commercial vehicle operations and intermodal freight;	**10 Hours**
Module -3	
Public transportation applications, ITS and regional strategic transportation planning, including regional architectures	**10 Hours**
Module -4	
ITS and changing transportation institutions, ITS and safety, ITS and security, ITS as a technology deployment program, research, development and business models, ITS and sustainable mobility,	**10 Hours**
Module -5	
Travel demand management, electronic toll collection, and ITS and road-pricing. Automated Highway Systems- Vehicles in Platoons –ITS in World – Overview of ITS implementations in developed countries, ITS in developing countries.	**10 Hours**

Course outcomes:

After studying this course, students would be able to suggest the appropriate system/s in various functional areas of transportation.

Would be able to amalgamate the various systems, plan and implement the applications of ITS. Would have learnt the application of information technology and telecommunication to control traffic and also provide advance information to the travelers, automatic handling of emergencies and to improve safety.

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Critical thinking.*
3. *Ethical practices and social responsibility*
4. *Use of modern tools*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

1. Choudury M A and Sadek A, "Fundamentals of Intelligent Transportation Systems Planning" Artech House.

Reference Books:

1. Kan Paul Chen, John Miles, "Recommendations for World Road Association (PIARC)" ITS HandBook 2000.
2. Sussman, J. M., "Perspective on ITS", Artech House Publishers, 2005.
3. US Department of Transportation, "National ITS Architecture Documentation", 2007 (CDROM).
4. Turban. E and Aronson. J. E, "Decision Support Sys tems and Intelligent Systems", Prentice Hall

COURSE TITLE: ROAD ASSET MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CHT323	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Value the principles and concepts of asset management.
2. Develop Highway Inventory systems.
3. Develop Financial Management and workforce management systems
4. Develop Construction Management and Safety Management Systems.
5. Develop Bridge Management System.
6. Develop Pavement Management & Highway Maintenance Management Systems

Modules	Teaching Hours
Module -1:	
Highway Asset Management: Principles, types of asset management definition, structure, historical background, elements of highway asset management, asset Inventory, activity and cost model development, public assets versus private assets, motivation for asset management, benefits of road asset, management system, financial management systems, roads billing, roads payment and cost accounting and tools for asset management.	**10 Hours**
Module -2:	
Highway Asset Valuation and Frame Work: Asset Valuation approaches, guidelines, overview of highway asset valuationprocedure, valuation principles, basis and rules, depreciation, highwaylighting and high mast lighting, land associated with the highways	**10 Hours**
Module -3	
Construction Management Systems: Preconstruction scheduling, utility management, ROW management, user occupancy permits, project control, agreement monitoring and contractormanagement.	**10 Hours**
Module -4:	
Roadway Operations Management Systems **Joint operations center, district operations center, traveler information systems.**	**10 Hours**
Module -5:	
Road Asset Management Modules: Bridge inventory and rating, bridge management, Workforce Management Systems, Payroll detail, personal information and employee accident.Safety Management SystemsAccident records, hazardous location and highway safety informationEquipment Management SystemsEquipment management information, fleet management	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

- Understand the failure mechanism in pavements and suggest suitable corrective measures.
- Analyse and evaluate structural and functional adequacy of pavements

Graduate Attributes (as per NBA)

1. Scholarship of Knowledge.
2. Problem Analysis.
3. Critical thinking

4. Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. AASHTO Transportation Asset Management Guide: A Focus on Implementation, AASHTO, 2011.
2. Hamilton, W.E. Transportation: Asset Management, House Fiscal Agency, 2001.
3. NCHRP Report 551. Performance Measures and Targets for Transportation AssetManagement, TRB, 2006.

Reference Books:

1. NCHRP Report 632. An Asset-Management Framework for the Inter State Highways, TRB, 2009.
2. NCHRP Synthesis 439. Use of Transportation Asset Management Principles in StateHighway Agencies, TRB, 2013.
3. NHS. Transportation Asset Management, Federal Highway Administration, NationalHighway Institute, USA, 2003.
4. OECD. Asset Management for the Roads Sector, Organization for Economic Co-operation and Development, France, 2001.
5. Thompson, P.D. AASHTO Transportation Asset Management Guide: A Focus onImplementation, USA, 2011.
6. Transportation Association of Canada, "Pavement Asset Design and ManagementGuide, December, 2013.
7. https://www.youtube.com/watch?v=ep3j7f_LuM

COURSE TITLE: RAILWAY INFRASTRUCTURE PLANNING AND DESIGNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CHT224	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Describe the procedure of railway infrastructure planning.
2. Examine the factors governing planning and design of railway infrastructures.
3. Design the railway track system and signaling system.
4. Carryout railway tracks maintenance by advanced methods and apply remedial measures to ensure safety.

Modules	Teaching Hours
Module -1:	
Planning of railway network: Operational system, historical background, plans and developments, policyand standards, traffic forecasts and surveys, railway alignment, projectappraisal and organization setups	**10 Hours**
Module -2:	
Component of railway track and rolling stock: Permanent way, forces acting on rails, function of rails, rail fixtures andfastenings, sleepers and ballast, rail joints, elements of junctions and layouts,types of traction, locomotives and other rolling stock, tractive effort and hauling power of locomotives.	**10 Hours**
Module -3	
Geometric design of railway track, construction and maintenance: Field investigation, right of way and formation, geometric design elements and standards, speeds computation, string lining of curves, grade compensation, railway cant and cant deficiency, traction, practice with examples. Special considerations and practices, track laying, inspection and maintenance, maintenance tools, maintenance of rail surface, track drainage, track circuited lengths, track tolerances, ballast confinement and track maintenance, renewal works.	**10 Hours**
Module -4:	
Signalling and interlocking: Objectives, classifications, signaling systems, mechanical and electrical signaling systems, systems for controlling train movement, interlocking, and modern signaling. **Railway accidents and safety:** Cause of train accidents, types of collision and derailment, restoration of traffic, safety measures, disaster management, level crossing and related accidents, remedial measures.	**10 Hours**
Module -5:	
Railway Station and Yards: Site selection, facilities, classification, platforms, building areas, types of yards, sidings, foot over bridges and subways, loading gauge, end loading ramps, locomotive sheds, triangles, buffer stop, scotch block, derailing switch, sand hump, fouling mark. **High Speed Railways:** Modernization of railways, effect of high speed track, vehicle performance on track, high speed ground transportation system, ballastless track, elevated railways, underground, and tube railways.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1.

Graduate Attributes (as per NBA)

1. *Scholarship of Knowledge.*
2. *Problem Analysis.*
3. *Critical thinking*
4. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Agarwal, M.M. Indian Railway Track, Prabha& Co., New Delhi, India, 1988.
2. Chandra S. and M. Agrawal, Railway Engineering, Second Edition, Oxford University Press, 2013.

Reference Books:

1. Clifford F. Bonnett, Practical Railway Engineering, 2nd edition, imperial college press, London, 2005.
2. Gupta, B.L. Text Book of Railway Engineering, Standard Publishers, New Delhi, India, 1982.
3. Mundrey, J. S., Railway Track Engineering, Fourth Edition, TATA McGraw- Hill, New Delhi, 2009
4. Rangwala, S.C. Principles of Railway Engineering, Charotar Publishing House, Anand, India, 2009.
5. Saxena S.C. and S.P. Arora, A text book of Railway Engineering, DhanpatRai, 2010
6. https://nptel.ac.in/courses/105107123/
7. https://www.edx.org/course/railway-engineering-an-integral-approach-2

COURSE TITLE: RURAL ROADS

[As per Choice Based Credit System (CBCS) scheme]

Semester -III

Subject Code	20CTE331	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. To understand the factors affecting pavement design and performance of Rural Roads.
2. To relate the concepts of Highway Geometric design to that of Rural roads
3. To design the Special pavements which form alternatives for Rural Roads.
4. To understand the concepts of design of drainage, CD works and small bridges which form essential structures of Rural roads

Modules	Teaching Hours
Module -1	
Planning of rural road, planning data base, concept of network planning Rural roads plan, guidelines laid down in recent 20 year plans and in PMGSY Road alignment and surveys, governing factors for route selection Factors controlling alignment; obligatory points, traffic , geometric designs, economy, special considerations in hilly areas	**10 Hours**
Module -2	
Geometric design standards: classification of rural roads, terrain classification, design speed, basic principles of geometric design cross sectional elements, camber, sight distances Horizontal alignment: general guidelines, super elevation, transition curve, widening and set back distances, vertical alignment: gradient, grade compensation at curves, valley curves, alignment compatibility, lateral and vertical clearances	**10 Hours**
Module -3	
Location Surveys and Geometrics Design : Location surveys, geometric design standards for rural roads, special considerations for rural roads in hilly area.	**10 Hours**
Module -4	
Materials: Stabilized soils, Design of soil-lime, soil-cement, soil-bitumen and soil-lime-fly ash mixes, Use of soft aggregates. Construction, Operation and Plants: Surveying and setting, excavation, hauling, Shaping and compaction, Stabilized soils-spreading, mixing and compaction. Appropriate technology, tools, plants and equipment for construction as per IRC practices.	**10 Hours**
Module -5	
Road Drainage and Maintenance : Drainage of road surface, pavement layers and cross drainage works. Various low cost drainage alternatives. Short term routine maintenance, long term maintenance, organizational and financial aspects of maintenance works.	**10 Hours**

Course outcomes:

1. Get the knowledge of factors affecting pavement design and performance of rural roads
2. The student will be able to differentiate the design and construction of Low volume rural roads with that of the Highways.
3. The students will be able to infer and review the DPRs prepared for construction of Rural Roads such under PMGSY

Graduate Attributes (as per NBA)

- *Critical thinking.*
- *Problem Analysis.*

- *Use of modern tools*
- *Project management and finance*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A.,`Highway Materials and PavementTesting', NemChand and Bros, Roorkee

Reference Books:

1. IRC SP 20 Rural Roads ManualMinistry of Rural Road Development
2. HMSO, "Soil Mechanics for Road Engineers", Her Majesty's Stationary Office, London.
3. IRC, Manual for Rural Roads, Indian Road Congress, 2002.
4. Relevant IRC Codes & Publications.
5. PIARC, International Road Maintenance Hand Book –Maintenance of Paved Roads, France.
6. PIARC, International Road Maintenance hand Book –Maintenance of Unpaved Roads, France.

COURSE TITLE: ENVIRONMENTAL IMPACT ASSESSMENT OF TRANSPORTATION PROJECTS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CHT332	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Explain theconceptsofenvironmental impactassessmentand applyintheprojects.
2. List a n d define variousindicatorssuchasterrestrialsubsystems, Indicatorsaquaticsubsystems, Socio-economicand abletoSelectvariousindicatorsforEIAstudies.
3. Explain theimpactsoftransportationrelated componentsonenvironment
4. Explain and illustratethemethodologies forenvironmental impactassessment

Modules	Teaching Hours
Module -1:	
Introduction: Environment and its interaction with human activities - Environmental imbalances - Attributes, Impacts, Indicators and Measurements - Concept of Environmental Impact Assessment (EIA), Environmental Impact Statement, Objectives of EIA, Advantages and Limitations of EIA	**10 Hours**
Module -2:	
Environmental Indicators - Indicators for climate - Indicators for terrestrial subsystems - Indicators for aquatic subsystems - Selection of indicators - Socio-economic indicators - Basic information - Indicators for economy - Social indicators - Indicators for health and nutrition - Cultural indicators - Selection of indicators.	**10 Hours**
Module -3	
Environmental Impact Assessment For TransportationProjects: Basic Concepts, Objectives, Transportation Related Environmental Impacts – Vehicular Impacts – Safety & Capacity Impacts– Roadway Impacts – Construction Impacts, Environmental Impact Assessment – EnvironmentalImpact Statement, Environment Audit, Typical case studies	**10 Hours**
Module -4:	
Environmental Issues in Industrial Development: On-site and Off-site impacts during various stages of industrial development, Long term climatic changes, Green house effect, Industrialeffluents and their impact on natural cycle, Environmental impact of Highways, Mining andEnergy development	**10 Hours**
Module -5:	
Methodologies for Carrying Environmental Impact Assessment: Overview of Methodologies,AdhocChecklist, Matrix, Network, Overlays, Benefit Cost Analysis, Choosing a Methodology, Review Criteria.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

- Understand the failure mechanism in pavements and suggest suitable corrective measures.
- Analyse and evaluate structural and functional adequacy of pavements

Graduate Attributes (as per NBA)

1. Scholarship of Knowledge.
2. Problem Analysis.
3. Critical thinking
4. Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Jain, R.K., Urban, L.V., Stracy, G.S., (1991), "Environmental Impact Analysis", Van Nostrand Reinhold Co., New York
2. Rau, J.G. and Wooten, D.C., (1996), "Environmental Impact Assessment", McGraw Hill Pub.Co., New York.

Reference Books:

1. Canter, L.W., (1997), "Environmental Impact Assessment", McGraw Hill Pub. Co., NewYork
2. Grand Jean, E. Gilgen A., “Environmental Factors in Urban Planning”, Taylor and FrancisLimited, London, 1976.
3. UNESCO, (1987), "Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development", UNESCO/UNEP, Paris

COURSE TITLE: PAVEMENT EVALUATION AND MANEGMENT

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CTE333	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the structural and functional requirements of pavements and also to carry out the structural and functional evaluation of both flexible and rigid pavements
2. To evaluate new pavement materials through various approaches such as model pavement studies, test track studies etc.

Modules	Teaching Hours
Module -1:	
Introduction to pavement evaluation:Structuralandfunctionalrequirementsofflexibleandrigidpavements.Distressanddifferenttypesoffailuresin pavements.Functionalandstructuraldeteriorationofflexibleandrigidpavements,Deteriorationmodels.	**10 Hours**
Module -2:	
Structuraland functional evaluation of pavements-Structural deterioration of pavements, causes, effects, methods of treatment. Structuralevaluationofflexiblepavementsby Rebounddeflectionmethod,Analysisofdata,interpretationandapplications,designofoverlay." UseofFWDandother methodsforevaluation offlexibleandrigidpavementsandtheirapplication.Problems. Ratingmethods.Useofmodernequipmentforpavementsurface conditionmeasurements.	**10 Hours**
Module -3	
Functional deterioration of pavements, causes, effects, methods of treatment. **Pavement surface condition** - Causes, effects, methods of measurement. Functional evaluation and treatment of: a) Pavement slipperiness b) Riding quality and unevenness c) Rutting d) Cracking e) Potholes f) Edge breaking etc. Rating methods. Use of modern equipment for pavement surface condition measurements. Analysis of data, interpretation and application.	**10 Hours**
Module -4:	
Evaluation of Pavement Structural Condition & Overlay Design: Evaluation by non- destructive tests such as FWD, Benkelman Beam rebound deflection, Plate load test, wave propagation and other methods; evaluation by destructive test methods, and specimen testing. **Overlay Design:** Design of Flexible overlay over flexible pavement, choice of overlays on existing flexible& rigid pavement.	**10 Hours**
Module -5:	
Model Pavements & Instrumentation in Pavement Testing: Testing of new pavementmaterials and model pavements under controlled conditions, test set up and instrumentation. **Instrumentation in Pavement Testing:** Details, applications and limitations of various equipment/ instrument/accessories, for, in-situ measurement of strain, pressure, moisture and pavement temperature.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

- Understand the failure mechanism in pavements and suggest suitable corrective measures.

- Analyse and evaluate structural and functional adequacy of pavements

Graduate Attributes (as per NBA)

5. *Scholarship of Knowledge.*
6. *Problem Analysis.*
7. *Critical thinking*
8. *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

3. HassR.,Hudson.W.R.,Zaniewisti.J."ModernPavementManagement"– KriegerPublishingCompany,Florida, 1994.
4. DavidandPaulCroney,"Designandperformanceofroadpavements"- thirdedition,McGrawhill,1998.

Reference Books:

1. PerUlitz"PavementAnalysis"-ElsevierAmsterdam.
2. Highway Hand Book by FAW, Publication from NUS, Singapore.
3. Nicholas J.Garber, Lester A. Hoel, "Traffic and Highway Engineering", Third Edition Thompson Learning
4. IRC 81, 1997, GUIDELINES FOR STRENGTHENING OF FLEXIBLE ROAD PAVEMENTS USING BENKELMAN BEAM DEFLECTION TECHNIQUE
5. IRC SP 16, 2004 Guidelines for Surface Evenness of Highway Pavements
6. IRC SP 17, Recommendation about Overlays on Cement concrete Pavements

Course Title: TRANSPORTATION NETWORKS AND OPTIMISATION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	20CTE334	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

1. Apply different traffic assignment techniques.
2. Estimate Trip tables.
3. Determine network reliability.
4. Design transportation networks

Modules	Teaching Hours
Module -1	
Transport Network Characteristics: Networks representation, Network equilibrium, Link and Cost Functions, Incidence matrices, Network capacity, Shortest path algorithm.	**10 Hours**
Module -2	
Optimality and Cost Functions: Matrix operations, Objective functions, Traffic representation, Junctions costs, Priority junctions, Signal controlled junctions.	**10 Hours**
Module -3	
Assignment Techniques: User Equilibrium – Existence and Uniqueness, Deterministic user equilibrium assignment, Most Likely paths, Elastic demand, Time Dependent Networks, stochastic user equilibrium assignment, User Equilibrium with variable demand models, Space-time networks, Case Studies.	**10 Hours**
Module -4	
Trip Table Estimation: Maximum entropy, Generalized least squares, Linear path-flow estimations,Log-linear path-flow estimations, Time-dependent methods, Case Studies. **Network Reliability:** Connectivity, Structure functions and reliability value, Heuristic methods, Travel time reliability; Considerations of sample size; experiment design for demand forecasting and transportation operations analysis.	**10 Hours**
Module -5	
Network Design: Bi-level programming-Iterative design, Sensitivity based algorithm, Sensitivities of user equilibrium and stochastic user equilibrium methods. Combined trip distribution and assignment, Combined mode choice and assignment, discrete choice models, Application to route choice, Estimating OD matrices, Estimating demand functions, Theory of congestion pricing, Path flows and link flows, Path-based and origin-based methods.	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Use the different traffic assignment techniques.
2. Estimate Trip tables.
3. Analyse the network reliability.
4. Development of transportation networks

Graduate Attributes (as per NBA)

- *Scholarship of Knowledge.*
- *Problem Analysis.*
- *Design / development of solutions (partly).*
- *Interpretation of data.*

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 12 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ahuja R., T. Magnanti, and J. Orlin. Network Flows; Prentice Hall, 1993.

Reference Books:

1. Michael Alexander Florian, Michel Gendreau, Patrice Marcotte. Transportation and network analysis: current trends: miscellanea in honor of Michael Florian; Springer Publisher, 2002.
2. Michael G.H. Bell andYasunoriLida. Transportation Network Analysis, J. WileyPublishers, 1997.
3. YosefSheffi. Urban Transportation Networks: Equilibrium Analysis with MathematicalProgramming Methods, Prentice Hall Publishers, 1985. (http://web.mit.edu/sheffi/www/selectedMedia/sheffi_urban_trans_networks.pdf)

E-Learning and Web References:

1. https://transportgeography.org/?page_id=623
2. https://www.e-education.psu.edu/geog597i_02/node/823