

**DEPARTMENT OF CIVIL ENGINEERING  
INSTITUTE OF TECHNOLOGY  
BANARAS HINDU UNIVERSITY**

**M. Tech.**  
**in**  
**Civil Engineering**  
**(Transportation Engineering)**

**SYLLABUS**  
**(Effective From 2007-08)**

## **PROPOSAL FOR M.TECH IN CIVIL ENGINEERING (TRANSPORTATION ENGINEERING)**

Our country has a cherished goal of becoming a developed nation by the year 2020. The biggest impediment in this achievement is the lack of dependable system of transportation for freight and passengers. Realizing the need of the hour, the Govt. of India has already embarked upon ambitious plans to develop our highways and airports to the world standards. In highway sector alone, huge sums of money are being spent for construction of projects like the Golden Quadrilateral, National Highways Development Projects (NHDP), Expressways, Trans-Asian Highways and Pradhan Mantri Gram Sadak Yojana (PMGSY). Our airports await up-gradation that will require substantial amount of money. Such huge expenditure also requires matching number of engineers to handle these projects. The output of qualified transportation engineers from academic institutions is much below the demand and the industry is managing the works through engineers who are specialized for other disciplines. Construction works of such huge magnitude has potential for research, for developing cost effective products and processes.

Therefore, Transportation Engineering is emerging as one of the core sectors of our national development. There is a lack of any institute of repute in the geographical region of eastern part of Uttar Pradesh, Bihar and Northern Madhya Pradesh to educate and train technical manpower in Transportation sector to handle the challenges of the infrastructure industry. The objective of the course is to educate and train the young graduate engineers and employees of organizations to take up the challenges of the rapidly developing Transportation sector. Sufficient exposure will be given to the students on various aspects in Transportation Engineering to hone their talent and develop them as a good manpower for our national development. Research will be actively encouraged to develop cost effective and more durable products/ practices and principles. Needless to say, that this course holds a lot of promise for research and is a surging area of development in Civil Engineering.

### **Major aims of starting the course by the Department:**

Technical institutions offering M.Tech. Degree Programme in Civil Engineering (Transportation Engineering) are far and few in the country. The intake of students at IT, BHU is through the IIT-JEE system which has a proven quality standard, and, many of them are desirous of undertaking M.Tech. Programme in Transportation Engineering. Given the location of this Institute in the eastern part of UP and lying close to the borders of Bihar and Madhya Pradesh, it will be prudent on part of the University, to start this programme at the Department of Civil Engineering, Institute of Technology, Banaras Hindu University at an early date. The Department is well equipped to start this course at the present. The specific aims of starting the course by the Institute of Technology, Banaras Hindu University are:

- a) The course belongs to an emerging area of technical education, which is crucial to the infrastructure development of the country, and, it holds national priority.
- b) To bring innovation and excellence in teaching and research in Transportation Engineering.
- c) To seek solutions to the local/regional/global problems of Transportation Engineering sector through research and training.
- d) To impart Post Graduate education to students for employment opportunities Transportation Engineering sector.
- e) To serve the Industry, Govt. and other organizations which are possible beneficiaries of the proposed course by absorbing trained manpower in Transportation Engg. sector.
- f) Transportation projects create some measure of ecological / environmental / atmospheric imbalances. The course will attempt to actively monitor the levels of major transportation pollutants like air, noise and environment; and strive to work out its abatement measures/strategies.

- g) The course will add to societal education (usage procedures, signals, do's and donot's of transportation means), encourage and conduct research and teaching for application and popularization of the technology output.

**Contribution of the course to sustainable development:**

Transportation sector is a major infrastructure input. Its implications on the environment are well pronounced. Its unplanned growth will lead to poor life quality and ecological hazards. Our country is witnessing a phenomenal growth in Transportation sector at the moment, and therefore, the need for sustainable development in this sector hardly needs any emphasis. The course will seek to play an important role in this area with valued contribution to the “Environmental Impact Assessment” procedures.

**Details of the plan of the course as per the examination procedure of the UGC:**

**COURSE STRUCTURE OF M.TECH. IN CIVIL ENGINEERING (TRANSPORTATION ENGINEERING)**

***First Semester:***

Subjects	Contact Hours/Week		Credits
	L	P	
<i>Theory</i>			
1. AM-5103A : Mathematics	3		3
2. Elective I	3		3
3. Elective II	3		3
4. Elective III	3		3
5. Elective IV	3		3
Total of Theory	15		15
<i>Practical</i>			
6. CE – 5305 : Laboratory		3	2
Total of Practical		3	2
<b>TOTAL FOR SEMESTER</b>		<b>18</b>	<b>17</b>

List of Electives for First Semester:

1. CE – 5141 : Modelling, Analysis and Simulation
2. CE – 5142 : Pavement Materials
3. CE – 5143 : Geometric Design of Transportation Facilities
4. CE – 5144 : Traffic Flow Theory
5. CE – 5145 : Analysis of Transportation Systems
6. CE – 5146 : Transport and Environment
7. CE – 5147 : GIS Applications in Transportation Engineering
8. CE – 5112 : Advanced Soil Mechanics
9. CE – 5114 : Ground Improvement Techniques
10. AM – 5103B : Advanced Numerical Methods

**Second Semester:**

Subjects	Contact Hours/Week		Credits
	L	P	
<i>Theory</i>			
1. Open Elective (To be opted from other Departments)	3		3
2. Elective V	3		3
3. Elective VI	3		3
4. Elective VII	3		3
5. Elective VIII	3		3
Total of Theory	15		15
<i>Practical</i>			
6. CE – 5409 : Project work		6	4
7. CE – 5410 : Seminar		2	1
Total of Practical		8	5
<b>TOTAL FOR SEMESTER</b>		<b>23</b>	<b>20</b>

List of Electives for Second Semester:

1. CE – 5241 : Analysis and Design of Pavements
2. CE – 5242 : Urban Transportation Systems Planning
3. CE – 5243 : Highway Construction Practice
4. CE – 5244 : Mass and Multimodal Transportation Systems
5. CE – 5245 : Traffic Engineering and Management
6. CE – 5246 : Pavement Evaluation, Rehabilitation and Maintenance
7. CE – 5247 : Transport Economics
8. CE – 5211 : Advanced Foundation Engineering
8. CE – 5223 : Finite Element Method
9. CE – 5225 : Optimisation Methods
10. CE – 5236 : Environmental Impact Assessment and Auditing
11. CE – 5237 : Automobile Pollution Control

**Third Semester:**

Subjects	Contact Hours/Week	Credits
1. CE – 6309 : Seminar on dissertation	-----	5
2. CE – 6310 : Dissertation – Interim Evaluation	-----	5
<b>TOTAL FOR SEMESTER</b>	-----	<b>10</b>

**Fourth Semester:**

Subjects	Contact Hours/Week	Credits
1. CE – 6409 : Dissertation - Open Defence	-----	5
2. CE – 6410 : Dissertation - Evaluation	-----	10
<b>TOTAL FOR SEMESTER</b>	-----	<b>15</b>
<b>COURSE TOTAL</b>		<b>62</b>

# **DETAILED SYLLABUS**

**(As approved by the Faculty, Institute of Technology)**

**AM – 5103A : Mathematics**

Complex variables : Analytic functions, Cauchy-Reimann equations, Conformal mapping.

Cauchy's integral theorem, Cauchy's formula, Singularities, Taylor's theorem.

Laurent's series. Residues, Matrices : Eigen-values and Eigen-vectors, Cayley Hamilton theorem, Diagonalization of matrices.

Jordan Canonical form of matrices, Inner product, Unitary and Orthogonal matrices.

Calculus of variations : Functionals and their applications; Euler's equations; Applications to Engineering.

Applied Statistics : Analysis of variance.

Design of experiments.

Linear regression and Multiple regression. Reliability.

**CE – 5141 : Modeling, Analysis and Simulation**

Taxonomy of model types, steps in model building, Simulation, Algorithms and Heuristics, Simulation languages.

Relationships via physical laws, Relationships via Curve fitting, Parameter estimation problems, State transition models.

Collection and presentation of data, Measures of Central tendency, Elementary probability theory, Random events, Bay's theorem, Random variables and distributions, Derived distributions, Moments and Expectations, Common probabilistic models, Statistical inference, Estimation of parameters, Tests of hypotheses and significance, Goodness of fit tests, Regression and Correlation analysis, Multivariate analysis and applications, Time services.

Neighborhood and distances, Cluster analysis, Individual and group preference patterns.

Graphical models and matrix models, Input-Output type models, Decomposition of large systems, Routing problems.

Block diagram representation, State space models, Stability, System Control.

Discrete and continuous growths, Limits to growth, Competition among species, Growth process and integral equations, Discrete event approach, Population planning.

Monte Carlo methods, Stochastic simulation, System identification, Inverse problems, Virtual reality.

### **CE – 5142 : Pavement Materials**

Subgrade functions, Importance of subgrade soil properties on pavement performance. Identification and significance of soil characteristics, Soil classification, Effect of water on swelling and shrinkage, Cohesion and Plasticity.

Road making aggregates – Classification, Properties of aggregates, design of aggregate gradation, texture, polishing and skid resistance.

Bituminous road binders – Straight- run bitumen, emulsions, Cutback and modified binders. Rheology of bituminous binders, modified binders – adhesion and stripping, penetration index, viscosity, temperature susceptibility of viscosity. Additives and their suitability, Fillers.

Design of Bituminous mixes – Marshall method and super paves procedure. Design of emulsified mixes, Visco-elastic and fatigue properties of bituminous mixtures, resilient modulus of pavement materials. Requirements of paving concrete, design of mixes – IRC, absolute volume, Road Note No.4, Vibrated Concrete mix design, design of DLC and SFRC mixes, Soil stabilization techniques.

### **CE – 5143 : Geometric Design of Transportation Facilities**

Geometric design provisions for various transportation facilities as per AASHTO, IRC and other guidelines, Discussion of controls governing geometric design, route layout and selection.

Elements of design – sight distances, horizontal alignment, transition curves, super – elevation and side friction.

Vertical alignment – grades, crest and sag curves. Highway cross – sectional elements and their design for rural highways, Urban streets and hill roads.

At grade intersections – sight distance consideration and principles of design, Channelisation, mini round –abouts, layout of round –abouts, Inter – Changes – major and minor interchanges, entrance and exit ramps, acceleration and deceleration lanes, Bicycle and pedestrian facility design, Parking layout and design, Terminal layout and design.

**CE – 5144 : Traffic Flow Theory**

Component of Traffic Flow System, Traffic variables and parameters, Driver behaviour modeling, Simulation, Controlled – Access Concept, Freeway Concept, System performances, Measure of effectiveness.

Flow through transportation networks – various types of graphs, determination of link and chain flows, finding maximum flow values of capacitated networks. Capacity of a roadway, Botlenecks.

Approaches to traffic flow theory, Traffic flow relationships – flow at different densities, Shock wave phenomenon, time – Space diagram.

Mathematical modeling, Probabilistic and Stochastic models of traffic flow process, Discrete and Continuous modeling headways, Gaps and process of gap acceptance, Macroscopic models, Car – following model, Queuing models, fundamentals & developments of queuing process, Applications.

Indices of Level of Service (LOS) as offered to road users.

**CE – 5145 : Analysis of Transportation Systems**

Introduction to Transportation systems, Transportation innovations, Social and Economic impacts of Transportation, Decision makers and their options, Demand modeling and prediction, Supply and equilibrium flows, Modelling and transportation technology, Analysis of network flows, Transportation network, Network theory, Concepts in transportation models and location models, Analysis of utility maximizing systems such as entropy Concepts, Major transportation technologies, Cost functions and estimation, Urban transport economic policy, Models for selecting network investments and operation planning, Case Studies.

**CE – 5146 : Transport and Environment**

Modes of Transportation, Mixed traffic flow, Transport related pollution, Road transport related air pollution, Sources of air pollution, Effects of Weather Conditions, Vehicular emission parameters, Pollution standards, Measurement and analysis of vehicular emission, Mitigative Measures.

Urban and non-urban traffic noise sources, Noise level factors, Effects of traffic noise, Propagation and measurement of traffic noise, Prediction and control measures, Noise studies, Noise standards.

EIA requirements of highway projects, EIA procedures, guidelines, EIA practices in India.

**CE – 5147 : GIS Applications in Transportation Engineering**

Remote sensing : Physics of remote sensing, Ideal remote sensing system, Remote sensing satellites and their data products, Sensors and orbital characteristics, Spectral reflectance curves, resolution and multi-concept, FCC, Interpretation of remote sensing images.

Digital image processing : Satellite image – characteristics and formats, Image histogram, Introduction to image rectification, Image enhancement, Land use and land cover classification system.

Geographic information system (GIS) : Basic concept of geographic data, GIS and its components, Data acquisition, Raster and vector formats, Topography and data models, Spatial modeling, Data output, GIS applications.

Global positioning system (GPS) : Introduction, Satellite navigation system, GPS- space segment, Control segment, User segment, GPS satellite signals, Receivers; Static, Kinematic and Differential GPS.

Applications in Transportation Engineering : Intelligent Transport System, Urban Transport Planning, Accident Studies, Transport System Management, Road Network Planning, Collecting Road Inventory.

### **CE – 5112 : Advanced Foundation Engineering**

Water flow in soils, Steady state flow, Transient flow; One, two and three dimensional consolidation theories and applications; Stresses in soil mass under applied loads; Two dimensional and three dimensional problems; Shear strength characteristics of soils; Critical states of soils; Stability of slopes.

### **CE – 5114 : Ground Improvement Techniques**

Need of ground improvement; Shallow compaction, Deep compaction; Preloading, Drainage, Vibrofloatation, Sand drains and geosynthetic drains; Mechanical stabilization; Chemical stabilization; Thermal improvement methods; Stone columns; Grouting; Geosynthetics and other soil reinforcement methods; Soil nailing; Improvement by confinement; Effect of environment on soil properties; Case histories.

### **AM – 5103B : Advanced Numerical Methods**

Linear Algebra: Matrices, Matrices decomposition: LU decomposition, Cholesky decomposition, Spectral decomposition, Matrix Eigen-value problem, Gerchgorin's theorem, Eigen value by iteration, generalized inverse of a matrix, solution of linear system by decomposition method, Jacobi method. Nonlinear system of equations: Newton's method, Powel hybrid method.

Differential equations: Generalised characteristic value problems, phase plane and critical points, stability and phase plane methods in nonlinear equations. Boundary value problems, mixed boundary conditions, boundary conditions at infinity, nonlinear boundary value problems, linear eigen value problems.

Partial differential equations: Parabolic, elliptic and hyperbolic partial differential equations subjected to Dirichlet, Neumann (or flux) and mixed (or Robin or radiation) boundary conditions, Navier Stock's equation.

Approximate analytic methods: Variational methods, Weighted residual methods – Galerkin's method, collocation method, Functional, Quadratic convergence of solution. Finite element and Boundary element method. Software like MATHEMATICA and MATLAB in addition to programming languages C and C++. Application towards plane stress and plane strain two dimensional problems.

### **CE – 5241 : Analysis and Design of Pavements**

Philosophy of design of flexible and rigid pavements, Subsystem of pavement design, Basis of pavement design, Analysis of pavements using different analytical methods, Selection of pavement design input parameters – traffic loading and volume, Material characterization, Drainage failure criteria, Reliability pavement support condition, Properties of components and design tests, Design of flexible and rigid

pavements using different Methods for highway and airport pavements, Soil stabilization methods, Quality Control and Tolerance, Comparison of different pavement design approaches, Computer Programming for various pavement analysis and design methods.

Design of drainage system.

### **CE – 5242 : Urban Transportation Systems Planning**

Hierarchical levels of planning, Passenger and Good transportation, General concept and planning process, Urban Travel characteristics, Private and Public Travel Behaviour Analysis, Travel Demand Estimation and Forecasting, Trip Generation Method and their comparison, Trip Distribution, Modal Split Analysis and Trip Assignment, Behavioural Approach.

Trip Generation modeling – variables influencing trip generation, Regression Analysis and Category Analysis, Trip distribution Modeling – factors governing trip distribution, Growth factor Method, Gravity Model, Intervening opportunity and Competing opportunity Models, Modal Split Modeling – factors influencing Mode choice, Two stage Modal Split Models, Discrete choice Models, Entropy Maximizing and Linear Programming Methods, Transport behaviour of Individuals and Households, Network and Route Assignment, Capacity Restrain and Simultaneous Distribution, Direct Demand Models, Land – Use Transport Planning, Transport Related Land – use Models, Corridor Type Travel Planning, Statewide and Regional Transportation Planning, Introduction to Urban Freight Transportation.

### **CE – 5243 : Highway Construction Practice**

Embankment Construction: Formation cutting in Soil and hard rock, Preparation of Subgrade, Ground improvement, Retaining and Breast walls on hill roads, Granular and Stabilized, Sub – bases / bases, Water Bound Macadam (WBM), Wet Mix Macadam (WMM), Cement treated bases, Dry Lean Concrete (DLC).

Bituminous Constructions: Types of Bituminous Constructions, Interface Treatments, Bituminous Surfacing and wearing Courses for roads and bridge deck slabs, Selection of wearing Course under different Climatic and Traffic conditions, IRC specifications, Construction techniques and Quality Control.

Concrete road construction: Test on Concrete mixes, Construction equipments, Method of construction of joints in concrete pavements, Quality Control in Construction of Concrete pavements, Construction of Continuously reinforced, Prestressed, Steel Fibre Reinforced (SFRC) Pavements, IRC, MORT&H, ACI Specifications, AASHTO Specifications, Recycled pavements, Non – Conventional Pavements, Overlay Construction.

Hill Roads Construction: Stability of Slopes, Landslides – Causes and Control measures, Construction of Bituminous and Cement Concrete roads at high altitudes, Hill road drainage, Construction and maintenance problems and remedial measures.

### **CE – 5244 : Mass and Multimodal Transportation Systems**

Transportation scenario, Public Transportation, Demand characteristics, Spatial, Temporal and Behavioural Characteristics of Transportation Demand, Urban Mass Transportation Planning, Demand Surveys, Estimation and Demand Projection, Four stages of Planning, Performance Evaluation of Mass

Transport System, Structure of Decision Making, Evaluation and Selection Methods, Selection Procedures, Economic Evaluation Methods, Terminals and their Functions, Design, Typical Characteristics Scheduling, Service Analysis, Vehicle Despatch Policy, Vehicle Requirements, Spacing of Bus Stops, Route Spacing and Performance, Operational and Management Issues, Reserved Bus Lanes, Signal Preemption, Dial – a – Bus, Vehicle Monitoring and Control System, Modal Coordination, Underground Transportation, Rail Transit, Case Studies.

MRTS, LRT, Street Car, Sky Train and other Multiple modes, Behaviour Analysis, Multinomial and nested logit modals, Revealed and Stated Preference, Parking facilities, Operation Strategy.

### **CE – 5245 : Traffic Engineering and Management**

Traffic Characteristics – road user and Vehicle Characteristics, Traffic Studies – Volume, Speed, O – D and Parking studies.

Capacity and Level of Service (LOS) analysis, Statistical analysis of traffic flow variables, Traffic Control – principles, methodologies and devices, advance technologies.

Fundamentals of Traffic Management, Principles and Methodology, Traffic Systems Management, Technique of management, Exclusive Bus Lanes Traffic management Techniques, Speed control and Zoning, Parking Control, Traffic Segregation and Channelization, Principles and Design of Traffic Signs, Their Placement and Visibility, Transportation System Management, Route and Network Management, Area Traffic Management, City wide Traffic Control and Management, Centralized Data Processing and Monitoring.

Element of traffic flow theory, Characteristics of Uninterrupted traffic, Characteristics of interrupted traffic.

### **CE – 5246 : Pavement Evaluation, Rehabilitation and Maintenance**

Types of pavement distress, techniques for functional and structural evaluation of pavements, pavement rehabilitation techniques, Overlay design procedures, recycling of flexible and rigid pavements, maintenance of paved and unpaved roads.

### **CE – 5247 : Transportation Economics**

Economic significance of transport, Demand for transport – influencing factors, temporal and spatial variations, elasticity of demand, Supply of transport Costs – Long – term and short – term Costs, fixed and variable costs, and marginal costs, Pricing of services, Road User Costs, Evaluation of transport projects – Cost – benefit ratio, first year rate of return, net present value and internal – rate of return methods, Indirect Costs and benefits of transport projects, Project ownership and financing, Highway finance and Taxation.

**CE – 5211 : Advanced Foundation Engineering**

Bearing capacity: Shallow and deep foundations; Settlement analysis: Shallow and deep foundations; Different types of foundations and their designs: Raft, Piles, and Well foundation; Sheet pile walls: Cantilevered and anchored; Excavation and bracings; Design of retaining walls. Foundations subjected to dynamic loads; Design of machine foundations.

**CE – 5223 : Finite Element Method**

Introduction and basic concepts. Energy approach and variational principles in Finite Element Method. Various element shapes, Isoparametric elements, Axisymmetric elements, plate bending elements, introduction to 3-D elements, shell elements, interface elements, boundary elements, infinite elements. Direct and variational formulations of element stiffness and loads. Assemblage of elements, Boundary conditions and solution of overall problems. Techniques of nonlinear analysis. Mesh generation, graphic display and software packages. Organisation of FEM programs, efficient solutions, input/output, pre and post processors.

**CE – 5225 : Optimisation Methods**

Formulation of optimization problems, classical optimization methods.

Unconstrained and constrained minimization techniques. Penalty functions. Method of feasible directions and gradient projection. Linear programming. Applications to engineering problems.

**CE – 5236 : Environmental Impact Assessment and Auditing**

Environmental impact assessment (EIA): Environmental statement & target areas fixation, scoping, objectives, water & waste water quality assessment models related to EIA, Air pollutants transport models, noise propagation models, methods for carrying out EIA starting from feasibility studies; case studies of EIA with special emphasis on developmental projects like highways, dams, water supply & sewerage, power plants.

Preparation of environmental management plan (EMP) Procedure for obtaining environmental clearance, sitting guidelines for industries. Public participation in carrying out EIA and EMP. Environmental Auditing including resources auditing, water auditing, energy auditing, health auditing: advantages, procedure, case studies.

**CE – 5237 : Automobile Pollution Control**

Introduction to internal combustion engines: Spark ignition & Compression ignition engines, 4-stroke and 2-stroke engines, engine's performance parameters, principles of working, other types of engines.

Sources of emissions in an IC engine.

Mechanisms of formation of exhaust pollutants : CO, HC, NOX, SOX, Particulate Matters, Exhaust gas composition, analysis, important factors affecting exhaust composition, air fuel ratio. Overview of impact of air pollution due to automobiles. Control strategy: primary and secondary.

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