

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: APPLIED STATISTICS IN TRANSPORTATION ENGINEERING</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16 CHT 11	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the use of statistical tools to express the traffic data for better interpretation.</li> <li>2. Apply probability concept to understand the vehicular flow behavior helping the planners to predict traffic flow.</li> <li>3. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.</li> <li>4. Test the hypothesis and assess the error involved in the data analysis.</li> <li>5. Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<p><b>Introduction to statistical methods</b>, 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.</p>			<b>10 Hours</b>
<b>Module -2</b>			
<p><b>Introduction to probability &amp; statistics for Traffic Engineering Design</b> – Introduction, Random variables and statistical measures: arithmetic mean, measures of dispersion, basic laws of probability, probability laws for discrete random variables: binomial and Poisson distribution, probability laws for continuous random variables: normal distribution, Poisson distribution.</p>			<b>10 Hours</b>

<b>Module -3</b>	
<b>Sampling Techniques</b> – objective, basics of sampling, advantages of sampling, sampling techniques, sampling distributions – sampling distribution of the sample mean, central limit theorem, chi square, t and F – distributions. Sampling error, sample size and design.	<b>10 Hours</b>
<b>Module -4</b>	
<b>Statistical decisions</b> – point estimation, properties of parameters, Testing of Hypothesis – Type I and II errors. <b>Tests of significance</b> – tests for mean and variance. Tests for proportions.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Chi-square test of goodness of fit, student's t test, Confidence interval.</b> Curve fitting by the method of least squares, Linear correlation & regression, multiple linear regression. Analysis of variance <b>Use of soft-wares in statistical analysis</b> – MATLAB, MINITAB	<b>10 Hours</b>
<p><b>Course outcomes:</b> After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Use statistical tools to express the traffic data for better interpretation.</li> <li>2. Apply probability concept to understand the vehicular flow behavior helping the planners to predict traffic flow.</li> <li>3. Use appropriate statistical testing tools to check the degree of accuracy in the traffic data analysis.</li> <li>4. Test the hypothesis and assess the error involved in the data analysis.</li> <li>5. Use software tools like MATLAB, MINITAB etc., for analysis of traffic data and also use curve fitting techniques for predicting the performance trends.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>o <i>Scholarship of Knowledge.</i></li> <li>o <i>Problem Analysis.</i></li> <li>o <i>Critical thinking</i></li> <li>o <i>Interpretation of data.</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> <li>• The students will have to answer 5 full questions, selecting one full question from each module.</li> </ul>	

**Reference Books:**

1. Martin Wohl, Brian V Martin, "Traffic System Analysis"- Mc Graw Hill Series
2. Johnson R and G Bhattacharya, "Statistics – Principles and methods"- John Wiley & sons, New york, 1985
3. Medhi, "Introduction to statistics"- New Age Pub, New Delhi
4. Benjamin Jack R and Cornell C Allin, "Probability Statistics & Decisions for Civil Engineers"- McGraw Hill Co.
5. Agarwal, B.L, "Basic Statistics"- 3<sup>rd</sup> edition, New Age Pub. New Delhi.
6. L.R Kadiyali, "Traffic Engineering"- Khanna Publishers New Delhi

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: HIGHWAY MATERIALS</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16 CHT 12	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the basic construction materials and their suitability as road materials.</li> <li>2. Analyse the aggregates and design aggregate gradation for construction of pavement layers.</li> <li>3. Characterize the binder material for bituminous roads and provide an optimum bituminous mix design.</li> <li>4. understand mix design using different materials for various components of a CC pavement.</li> <li>5. Understand and propose soil stabilization techniques for highway construction using locally available materials.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<p><b>Basic road construction materials</b> – types, source, functions, requirements, properties, tests and specifications for use in various components of road. Soil compaction for use in fill and subgrade of roads, compaction studies in laboratory and field, properties of compacted soils.</p>			<b>10 Hours</b>
<b>Module -2</b>			
<p><b>Aggregates</b>–Origin, classification, equipments, properties. Tests and specifications on road aggregates for flexible and rigid pavements. Importance of aggregate gradation problems on Rothfutch’s and Critical sieve methods and Shape factor in mix design.</p>			<b>10 Hours</b>

<b>Module -3</b>	
<p><b>Bituminous binders</b> – different types, properties and uses, physical tests on bitumen, Rheological and pavement performance related properties, Modified binders, ideal pavement binders, characteristics and applications in road construction, criteria for selection of different binders.</p> <p>Bituminous mixes, types, requirements, properties, tests, Marshall Method of mix design, Criteria and super pave mix design, Additives &amp; Modifiers in Bituminous mixes, problems on mix design.</p>	<b>10 Hours</b>
<b>Module -4</b>	
<p><b>Portland cement and cement concrete for use in road works</b> – requirements, design of mix for CC pavement, use of additives, IRC specifications &amp; Tests, joint filler and sealer materials.</p>	<b>10 Hours</b>
<b>Module -5</b>	
<p><b>Soil stabilization</b> – principle, methods and tests, proportioning of materials and mix design, application of Rothfutch’s method. Marginal and waste materials in road construction, their properties and scope in road construction. Use of Fly-ash in road embankment and cement concrete mixes, use of chemical stabilizers like RBI -81, soil fix etc in road construction.</p>	<b>10 Hours</b>
<b>Note: All Relevant Laboratory &amp; Field Test will be conducted in Batches</b>	
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Identify and select based on their characteristics the basic construction materials for road construction.</li> <li>2. Design aggregate gradation for construction of pavement layers keeping in mind the density and strength parameters.</li> <li>3. Characterize the binder material for bituminous roads and provide an optimum bituminous mix design.</li> <li>4. Provide mix design procedure and the base layer for a CC pavement.</li> <li>5. Propose soil stabilisation techniques for highway construction using locally available materials.</li> </ol>	

**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 16 marks.
- There will be 2 full 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. MoRTH 'Specifications for Roads and Bridges Works'- Indian Roads Congress
2. IS 73, revised 2006, IS 2720, IS 2386, IS 1201 to 1220, IS 8887- 1995, IS 217- 1986
3. State of art, special report 3 – “compaction of earthwork and subgrade”- IRC, HRB, 1999
4. Freddy L Roberts, Prithvi S Kandhal et al, “Hot Mix Asphalt Materials, mixture design and construction”- (2<sup>nd</sup> Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA.
5. IRC: 51-1992, 63-1976, 74 –1979, 88-1984, “Indian Roads Congress”.
6. IRC SP: 53 – 2002, IRC SP: 58 – 2000, “Indian Roads Congress”.
7. “Guidelines for use of Geotextiles in Road Pavements and Associated works”- 2002, Indian Roads Congress
8. Khanna and Justo, “Highway Engineering”- Nem Chand and Bros., Roorkee
9. Khanna and Justo, “Highway Materials Testing”- Nem Chand and Bros., Roorkee.
10. “Soil Mechanics for Road Engineers”- HMSO Publication
11. “Bituminous materials in Road Construction”- HMSO Publication.
12. Highway Hand Book by FAW, Publication from NUS, Singapore.

**Reference Books:**

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: PAVEMENT DESIGN AND ANALYSIS</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16 CHT 13	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the factors affecting pavement design and performance</li> <li>2. Evaluate the strength of soil subgrade soil and factors that affect the behavior of soil.</li> <li>3. Compute the stresses and deflections in flexible pavement layers under the action of wheel loads.</li> <li>4. Design the thickness of flexible pavements by different methods under different exposure conditions and materials.</li> <li>5. Design the thickness of concrete pavements and joints associated with CC pavements in addition to the computation of stresses in CC pavements.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<b>Road Pavements and pavement layers</b> - types, functions, choice Factors affecting design and performance of flexible and rigid pavements – Pavement design factors, loads – axle load distribution, ESWL, EWL,VDF due to varying loads and CSA.			<b>10 Hours</b>
<b>Module -2</b>			
Subgrade support - CBR and plate bearing tests, Resilient Modulus, fatigue tests, permanent deformation Pavement material Characteristics, climatic, drainage and environmental factors, their effects and evaluation. Factors affecting design and performance of airport pavements.			<b>10 Hours</b>
<b>Module -3</b>			
<b>Stresses and Deflection / strain in flexible pavements:</b> Application of elastic theory, stresses, deflections / strains in single, two and three layer system, Applications in pavement design. Problems			<b>10 Hours</b>

<b>Module -4</b>	
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.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Rigid pavement design:</b> Determination of ESWL, EWL for dual and dual tandem wheel loads in Rigid pavements, General design principle, Stresses in rigid pavements, stresses due to wheel loads and temperature variations, design of cement concrete pavements (joints and slab thickness) as per IRC guidelines. Design features of CRCP, SFRC and ICBP, Problems.	<b>10 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Get the knowledge of factors affecting pavement design and performance</li> <li>2. Evaluate the strength of soil subgrade soil and identify the factors that affect the behavior of soil.</li> <li>3. Compute the stresses and deflections in flexible pavement layers under the action of wheel loads.</li> <li>4. Design the thickness of flexible pavements by different methods under different exposure conditions and materials.</li> <li>5. Design the thickness of concrete pavements and joints associated with CC pavements in addition to the computation of stresses in CC pavements.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Engineering Knowledge.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Design / development of solutions (partly).</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	



**Text Books:**

1. Yoder and Witczak, "Principles of Pavement Design"- John Wiley and sons Inc(second edition) 1975
2. Yang, "Design of functional pavements"- Mc Graw Hill Book Co.
3. Huang, "Pavement Analysis"- Elsevier Publications
4. David Croney, Paul Croney, "Design & Performance of Road Pavements"- Mc Graw hill Book Co.
5. W.Ronald Hudson, Ralph Haas and Zeniswki "Modern Pavement Management"- Mc Graw Hill and Co
6. IRC 37-2001, IRC 81-1997, IRC 58 – 2002, IRC 59 – 1976, IRC 101-1988, Indian Roads Congress
7. Khanna and Justo "Highway Engineering"- Nemchand & Bros, Roorkee

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: HIGHWAY CONSTRUCTION AND MAINTENANCE</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Subject Code	16 CHT 14	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the various equipment used for road construction and difficulties associated with highway drainage.</li> <li>2. Select suitable equipment for preparation of subgrade in cutting or filling and also the preparation steps for base and sub base layers.</li> <li>3. Characteristics of different types of bituminous layers and design of bituminous surfacing along with safety aspects needed for roads.</li> <li>4. Design the base course thickness and selection of materials as base layer for CC pavements.</li> <li>5. Analyse the defects in road construction and general pavement failures with remedies.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>		<b>10 Hours</b>	
<p>Components of road and pavement structure including subgrade, drainage system, functions, requirements and sequence of construction operations</p> <p><b>Plants and equipment for production of materials</b> - crushers, mixers, bituminous mixing plants, cement concrete mixers – various types, advantages and choice.</p> <p><b>Drainage</b> – Assessment of drainage requirements for the road and design of various components, drainage materials, Construction of surface and subsurface drainage system and design of filter materials for roads. Drainage of urban roads, problems.</p>			
<b>Module -2</b>		<b>10 Hours</b>	
<p><b>Road construction equipment</b> – different types of excavators, graders, soil compactors / rollers, pavers and other equipment for construction of different pavement layers – their uses and choice Problem on equipment usage charges.</p> <p><b>Pre-construction surveys and marking on ground</b> - Specifications and steps for the</p>			

<p>construction of road formation in embankment and cut, construction steps for subgrade (preparation of subgrade) in cutting, filling and at grade. Construction of subgrade in marshy areas and weak / expansive soils and water-logged - areas. Construction steps for granular sub-base, quality control tests.</p>	
<p><b>Module -3</b></p>	
<p><b>Different types of granular base course</b> – WMM, CRM, WBM, specifications, construction method and quality control tests.</p> <p>Different types of bituminous layers for binder and surface courses, their specifications (as per IRC and MORTH), construction method and quality control tests. Special structural courses like stone matrix asphalt and mastic asphalt and construction of porous asphalt.</p>	<p><b>10 Hours</b></p>
<p><b>Module -4</b></p>	
<p><b>Different types of sub-base and base course for cement concrete (CC) pavement and construction method.</b> Construction of cement concrete (PQC) pavements and joints, quality control during construction. Construction of special Cement concrete pavements like interlocking concrete block pavements (ICBP), Continuously reinforced cement concrete pavements (CRCP), Fibre reinforced cement concrete pavements (FRCP), white topping, Ultra thin white topping etc.</p> <p><b>General Aspects:</b> Quality assurance, statistical approach, quality system for road construction. Safety aspects during road construction and maintenance works. Installation of various traffic safety devices and information system Principle of construction planning, application of CPM and PERT( Problems not included)</p>	<p><b>10 Hours</b></p>
<p><b>Module -5</b></p>	
<p><b>Road maintenance works</b> – day to day and periodic maintenance works of various components of road works and road furniture. Preventive maintenance of road drainage system, pavements and other components of road. Preparation of existing pavement – patching, profile correction, Special measures to deal with reflection cracks in pavement layers, slipperiness of surface, etc. Requirements for rehabilitation, recycling and re-construction.</p> <p><b>Special problems</b> in construction &amp; maintenance of hill roads, land slide, causes, investigation, and preventive and remedial measures, protection of embankment and cut slopes.</p>	<p><b>10 Hours</b></p>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Gain the knowledge on the equipment used for road construction and difficulties associated with highway drainage.</li> <li>2. Select suitable equipment for preparation of subgrade and preparation stages for base and sub base layers.</li> </ol>	

3. Design bituminous surfacing and other layers along with safety aspects needed during construction.
4. Design the base course thickness and select materials for base layer in CC pavements.
5. Analyse the defects in road construction and general pavement failures and propose suitable remedies.

**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 16 marks.
- There will be 2 full 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., and Clifford, JS “Construction Planning Equipment and Method”- McGraw Hill Book Co. Inc.
2. Sharma S.C., “Construction Equipment and its Management”- Khanna Publishers

**Reference Books:**

1. Freddy L Roberts, Prithvi S Kandhal et al, “Hot Mix Asphalt Materials, mixture design and construction”- (2nd Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA
2. National Asphalt Pavement Association “Hot Mix Asphalt Paving Hand book”- 5100 Forbes Boulevard, Lanham, Maryland, USA
3. “Hand Book on Cement Concrete Roads”- Cement Manufacturers Association, New Delhi
4. MoRTH “Specifications for Roads and Bridge Works”- 2001, fourth revision, Indian Roads Congress
5. MoRTH “Manual for Construction and Supervision of Bituminous Works”- 2001, Indian Roads Congress
6. MoRTH “Manual for Maintenance of Roads”- 1989, Indian Roads Congress
7. IRC: 42-1994, IRC:15-2002, IRC SP :11-1988, , 55-2001, 57-2001,58-2001, IRC 19-1977, 27-1967, 29-1988, 34- 1970, 36-1970,48-1972,61-1976, 63-1976, 68-1976, 81-1997,82-1982, 84-1983,93-1985, 94-1986, 95-1987, 98-1997, 105-1988.

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: ROAD PROJECTS</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I			
Subject Code	16 CHT 151	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Prepare project report for new and up-gradation type road works by conducting necessary feasibility/detailed studies.</li> <li>2. Conduct the soil and material investigations to understand their behavior and performance.</li> <li>3. Perform various traffic related studies helping to finalise the project preparations and methods of forecasting traffic data.</li> <li>4. Analyse the social impact of road projects and also determine the economic feasibility analysis for justification of investments.</li> <li>5. Prepare DPR on road projects with relevant drawings and get the knowledge of tendering process for the construction.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1: Introduction</b>		<b>8 Hours</b>	
<p><b>Introduction:</b> Various steps of preparation and execution of road projects, Investigations for preparation of project reports for new and up-gradation of roads. Objects and scope of pre – feasibility, feasibility and detailed studies for project preparation. Typical HR structure for preparations and implementation of road projects.</p> <p><b>Topographic surveys and investigations</b> for finalisation of horizontal alignment and vertical profile of roads, Application of GIS. Geometric Design elements, standards and specifications for road projects</p>			
<b>Module -2:</b>			

<p><b>Soil investigations</b> for assessing the design details of road embankments and cuts, drainage requirements and foundation of cross drainage structures</p> <p><b>Material surveys and investigations</b> for availability and choice of basic and alternate materials for road construction and for soil stabilization.</p>	<b>8 Hours</b>
<b>Module -3</b>	
<p><b>Traffic studies</b> – classified traffic volume, growth rate, projected traffic for assessing road way requirements, origin- destination characteristics and studies, Axle load / wheel load studies using weigh bridges and analysis of data for pavement design</p> <p><b>Traffic forecast</b> - traffic growth estimation from past trends, econometric models. Common methods of traffic forecas</p>	<b>8 Hours</b>
<b>Module -4:</b>	
<p><b>Environmental and social impact studies</b> and assessment relevant to road up-gradation / new projects, Mitigation measures, Road safety audit. Collection of relevant data, analysis and interpretation for pre-feasibility and feasibility study reports of the proposed road project. Economic evaluation of different possible alternatives. Preparation of drawings and project reports. Use of software</p>	<b>8 Hours</b>
<b>Module -5: Methodologies for Carrying Environmental Impact Assessment</b>	
<p><b>Preparation of DPR</b> design details, estimates, BOQ, drawings and detailed project report, use of software</p> <p><b>Tendering process</b> - Preparation of tender documents for different types of road projects, tender evaluation.</p>	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Prepare project report for new and up-gradation type road works by conducting necessary feasibility/detailed studies.</li> <li>2. Conduct the soil and material investigations to understand their behavior and performance.</li> <li>3. Perform various traffic related studies helping to finalize the project preparations and methods of forecasting traffic data.</li> <li>4. Analyse the social impact of road projects and also determine the economic feasibility analysis for justification of investments.</li> <li>5. Prepare DPR on road projects with relevant drawings and get the knowledge of tendering process for the construction.</li> </ol>	

**Graduate Attributes (as per NBA)**

- *Engineering 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 16 marks.
- There will be 2 full 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. IRC: SP:19 - 2001, Manual for Survey, "Investigation and Preparation of Road Projects"- (first revision), Indian Roads Congress
2. IRC: SP: 30 - 1993, "Manual on Economic Evaluation of Highway"- Projects in India (first revision), Indian Roads Congress
3. IRC SP - 38, "Manual for Road Investment Decision Model"-1992, Indian Roads Congress
4. IRC : 9-1972, 35 - 1997, 38-1988, 39-1986, 52-2001, 54-974, 62-1976, 64-1990, 66-1976, 67-2001, 69-1977, 73-1980, 79-1981, 80-1981, 86-1983, 98-1997, 99-1988, 103-1988, 104-1988, 110-1996
5. MoRTH "Specifications for Road Bridge Works"- 2001, fourth revision, Indian Roads Congress
6. MoRTH "Standard and Bidding Document Procurement of Civil Works"- Part I and II, 2000, Indian Roads Congress MoRTH "Model Concession Agreement for Small Road Projects"-2000, Indian Roads Congress

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: SOIL MECHANICS FOR HIGHWAY ENGINEERS</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I			
Subject Code	16 CHT 152	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the properties and behavior as a highway material under the application of wheel loads.</li> <li>2. Understand and compare the shear strength of soil and stability of slopes when used as subgrade soil and embankment fills or cut slopes</li> <li>3. Understand the permeability characteristics of soils to design proper drainage system and various investigations required to assess the soil properties.</li> <li>4. Understand the type and soil composition affecting the surface runoff and sub-surface water flow in order to design proper drainage system.</li> <li>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.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>		<b>8 Hours</b>	
<p><b>Introduction:</b> Soil Mechanics applications to Highway Engineering. Soil formations, Types, Regional Soil deposits of India, Index properties, their determination, importance, various soil classification systems, HRB classification, problems on these.</p> <p>Soil Compaction: Introduction, Lab Tests, Factors affecting, Structure &amp; Engg behavior of compacted cohesive soil, Field compaction specifications, Field compaction control, Different types of Equipments used for compaction, their choice.</p>			



<b>Module -2</b>	
<p><b>Shear strength of soil:</b> Introduction, Importance, Measurements, shear strength of clay, Sand, Elastic properties of soil – Tangent, Secant modulus, Stress – Strain curves, Poisson’s ratio, Shear Modulus.</p> <p><b>Stability of slopes:</b> Introduction, Types, Different methods of analysis of slopes for <math>\phi</math>-<math>c</math> &amp; <math>c</math>-<math>\phi</math> soil, Location of most critical circle, Earth dam slopes stability, Taylor’s stability number. Effect of Earthquake Force, problems on above.</p>	<b>8 Hours</b>
<b>Module -3</b>	
<p><b>Permeability of soil:</b> Darcy’s Law, Validity, Soil-water system, Types, Determination of permeability, problems.</p> <p><b>Site Investigation:</b> Introduction, Planning exploration programmes, Methods, Samplers, SPT, Subsoil investigation Report, Geophysical methods.</p>	<b>8 Hours</b>
<b>Module -4</b>	
<p><b>Highway Drainage:</b> Introduction, Importance, Surface drainage, Sub-surface drainage, methods, Design of subsurface drainage system, Road construction in water logged areas, Landslides – definition, classifies, factors producing.</p>	<b>8 Hours</b>
<b>Module -5</b>	
<p><b>Reinforced Earth structures</b> Introduction, Components, Advantages, Types of stability – external, Internal, (No problems), Geo textiles – types, Functions, their uses in road embankments and railway works, other uses.</p>	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Analyse the wheel load effects on pavement materials</li> <li>2. Evaluate and compare the shear strength of soil and stability of slopes when used as pavement component.</li> <li>3. Design proper drainage system by knowing the permeability characteristics of soils.</li> <li>4. Design surface runoff and sub-surface drainage system as per field conditions</li> <li>5. Propose suitable strengthening methods for soil from the knowledge of lack of strength or instability in soils.</li> </ol>	

**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 16 marks.
- There will be 2 full 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.

**Reference Books:**

1. "Basic and Applied soil Mechanics", Gopal Ranjan, ASR Rao, New Age International Publishers.
2. "Soil Mechanics & Foundation Engg", Dr.B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Laxmi Publications (P) Ltd, 16<sup>th</sup> edition.
3. "Highway Engg", S.K. Khanna, C.E.G. Justo, 5<sup>th</sup> edition.
4. "Soil Mechanics & Foundation Engg" – K.R. Arora Standard Publishers Distributors.
5. "Soil Mechanics for road Engineers" – HMSO, London.
6. IRC – Relevant Codes.

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title:</b> PLANNING AND DESIGN OF LOW VOLUME ROADS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16 CHT 153	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<b>Course objectives:</b> This course will enable students to 1 Plan the rural road network. 2 Determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements.			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1:</b>			
<b>Planning of Low volume roads:</b> Introduction to planning of low volume roads, concepts of network planning, selection of roadway alignment, factors affecting route selection, engineering surveys for new road location.			<b>8 Hours</b>
<b>Module -2:</b>			
<b>Geometric design parameters:</b> basic principles of geometric design, design of horizontal alignment, curves, super elevation, design of vertical alignment, summit curve, and valley curve standard of design of low volume road.			<b>8 Hours</b>
<b>Module -3:</b>			
<b>Materials:</b> Road materials for pavement construction, soil-subgrade, road aggregate, binder, test on soil, test on aggregates and test on bitumen, bituminous mix design, Marshall stability method for mix design.			<b>8 Hours</b>
<b>Module -4:</b>			
<b>Design of pavement:</b> Factors affecting pavement design function of pavement components, design of flexible pavement by GI method, CBR method, Burmister layer. Design of rigid pavement by using IRC method.			<b>8 Hours</b>

<b>Module -5:</b>	
<b>Road construction:</b> Specifications of material and construction of sub grade, subbase, base and surface layer, construction of non bituminous road, construction of bituminous roads, equipment required for construction, maintenance of low volume roads	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1 Plan the rural road network.</li> <li>2 Determine the sight distance, horizontal curvature, super elevation, grades, visibility on vertical curves, cross section elements.</li> <li>3 Justify the geometric design standards adopted for low volume roads.</li> <li>4 Plan surveys, and prepare survey forms.</li> <li>5 Perform safety audit at different stages of road construction.</li> <li>6 Design both flexible and rigid pavements for low volume roads.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Critical thinking.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Use of modern tools</i></li> <li>○ <i>Project management and finance</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	

**Reference Books:**

1. A. Veeraragavan, S.K Khanna and C.E.G. Justo, Highway Engineering, Nem Chand & Brothers, 2014.
2. Bruton, M. J., Introduction to Transportation Planning, UCL press, London, UK, 1992.
3. Ethiopian Roads Authority, Design Manual for Low Volume Roads, Parts A-G:  
<http://www.icafrica.org/knowledge-publications/article/design-manual-for-low-volume-roadsparts-a-g-116/>
4. Gordon Keller & James Sherar, Low-Volume Roads Engineering: Best Management Practices – Field Guide, USDA Forest Service/USAID, 2003. 27  
<http://www4.worldbank.org/afr/ssatp/Resources/HTML/LVSR/English/Added-2007/2003-LVR-Engineering-FieldGuide-USA-by-GKeller.pdf>
5. IRC SP 20: Rural road manual, Indian road congress, New Delhi, 2002 6. Yan H. Huang, Pavement Analysis and design, Second Edition, prentice hall inc, 2004

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: URBAN PUBLIC TRANSPORT</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16 CHT 154	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the various options for urban public transportation and recommend suitable mode for the given situation.</li> <li>2. Conduct economic analysis between different transport modes and suggest most economical and efficient mode under the given set of conditions.</li> <li>3. Understand the management of public transport system and developing strategies for efficient functioning of the system.</li> <li>4. Carry out the evaluation of capacities of the system parameters such as routes, junctions, stations etc, to know the performance of the system.</li> <li>5. Forecast the future transportation needs and variations in system components so as to plan for the transportation system requirements.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<b>System and Technologies:</b> Urban passenger transportation modes, transit classifications and definitions, theory of urban passenger transport modes, rail transit, bus transit, Metro and Mono Rail, Para transit and ride sharing, designing for pedestrians, trends in transit rider ship and use of different modes.			<b>8 Hours</b>
<b>Module -2</b>			
<b>Comparing Alternatives:</b> Comparing costs, comparative analysis, operational and technological characteristics of different rapid transit modes, evaluating rapid transit, Problems.			<b>8 Hours</b>
<b>Module -3</b>			

<b>Planning:</b> Transportation system management, system and service planning, financing public transportation, management of public transportation, public transportation marketing.	<b>8 Hours</b>
<b>Module -4</b>	
<b>Transit System Evaluation:</b> Definition of quantitative performance attributes, transit lane capacity, way capacity, station capacity, theoretical and practical capacities of major transit modes, quantification of performance, Problems.	<b>8 Hours</b>
<b>Module -5</b>	
<b>Urban traffic:</b> Classification of transportation systems, conventional transportation systems, non-conventional transportation systems, prototypes and tomorrow's solutions, analysis and interpretation of information on transportation systems, perspectives of future transportation.	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the various options for urban public transportation and recommend suitable mode for the given situation.</li> <li>2. Conduct economic analysis between different transport modes and suggest most economical and efficient mode under the given set of conditions.</li> <li>3. Understand the management of public transport system and developing strategies for efficient functioning of the system.</li> <li>4. Carry out the evaluation of capacities of the system parameters such as routes, junctions, stations etc, to know the performance of the system.</li> <li>5. Forecast the future transportation needs and variations in system components so as to plan for the transportation system requirements.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Scholarship of Knowledge.</i></li> <li>○ <i>Problem solving.</i></li> <li>○ <i>Critical thinking</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> </ul>	

- 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.

**Reference Books:**

1. George E. Gray and Lester A. Hoel, 'Public Transportation', Prentice Hall, New Jersey.
2. Vukan R. Vuchic, 'Urban Public Transportation Systems and Technology', Prentice Hall Inc., New Jersey.
3. Horst R. Weigelt, Rainer E. Gotz, Helmut H. Weiss, 'City Traffic - A Systems Digest', Van Nostrand Reinhold Company, New York
4. John W. Dickey, 'Metropolitan Transportation Planning', Tata McGraw-Hill Publishing Co.. New Delhi



**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b><u>Course Title: Highway Materials Lab -1</u></b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I			
Subject Code	16 CHT L16	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	42	Exam Hours	03
<b>CREDITS – 02</b>			
<b>Course objectives:</b>			
<p>The objective of this course is to make students learn</p> <ul style="list-style-type: none"> <li>• The procedure and test the basic properties of soil, aggregates, cement and concrete</li> </ul>			
<b>Modules</b>			
<b>Tests on soil</b>			
<ol style="list-style-type: none"> <li>1. Grain size analysis - Wet sieve analysis</li> <li>2. Liquid limit, plastic limit &amp; Shrinkage limit</li> <li>3. Compaction test</li> <li>4. California bearing ratio test</li> </ol>			
<b>Tests on aggregates</b>			
<ol style="list-style-type: none"> <li>1. Shape tests - Elongation, Flakiness Index &amp; Combined Index</li> <li>2. Aggregate impact value test</li> <li>3. Los angeles abrasion value test</li> <li>4. Specific gravity &amp; Water absorption test</li> <li>5. Stripping value test</li> </ol>			
<b>Tests on cement&amp; concrete</b>			
<ol style="list-style-type: none"> <li>1. Fineness</li> <li>2. Std consistency &amp; setting time of cement</li> <li>3. Soundness</li> <li>4. Compressive strength</li> </ol>			

**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

**Reference Books:**

1. Relevant IS and IRC codes
2. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A., 'Highway Materials and Pavement Testing', Nem Chand and Bros, Roorkee
3. Gambhir, M. L., 'Concrete Manual', Dhanpat Rai and sons New Delhi

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: Pavement Evaluation and Management</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16 CHT 21	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>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</li> <li>2. To evaluate new pavement materials through various approaches such as model pavement studies , test track studies etc.</li> <li>3. To develop the pavement performance prediction models ,ranking &amp; optimization methodologies</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1: Introduction to pavement evaluation</b>			
Structural and functional requirements of flexible and rigid pavements. Distress and different types of failures in pavements. Functional and structural deterioration of flexible and rigid pavements, Deterioration models.			<b>10 Hours</b>
<b>Module -2:</b>			
<b>Structural and functional evaluation of pavements-</b> Structural evaluation of flexible pavements by Rebound deflection method, Analysis of data, interpretation and applications, design of overlay. "Use of FWD and other methods for evaluation of flexible and rigid pavements and their application. Problems. Rating methods. Use of modern equipment for pavement surface condition measurements.			<b>10 Hours</b>
<b>Module -3</b>			

<p><b>Evaluation of new pavement materials-</b> Model studies, pavement testing Under controlled conditions, accelerated testing and evaluation methods. Test track studies. Instrumentation for pavement testing.</p> <p><b>Introduction to pavement management:</b> components &amp; principals of pavement management systems, pavement maintenance measures, planning investment, research management.</p>	<p><b>10 Hours</b></p>
<p><b>Module -4:</b></p>	
<p><b>Pavement Performance Prediction:</b> concepts, modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models. Functional condition deterioration models, unevenness prediction models and other models, comparison. Modeling in rehabilitation budget planning, case studies, Problems.</p>	<p><b>10 Hours</b></p>
<p><b>Module -5:</b></p>	
<p><b>Ranking and Optimization Methodologies:</b> Recent developments, sample size selection, economic optimization of pavement maintenance and rehabilitation.</p> <p><b>Design alternatives and Selection:</b> Design objectives and constraints, alternate pavement design strategies and Expert systems and Pavement Management</p>	<p><b>10 Hours</b></p>
<p><b>Course outcomes:</b></p> <p>After studying this course, students will be able to:</p> <ul style="list-style-type: none"> <li>• Understand the failure mechanism in pavements and suggest suitable corrective measures.</li> <li>• Analyse and evaluate structural and functional adequacy of pavements</li> <li>• Analyse and apply alternate strategies for assessment of pavement distress using pavement management principles.</li> <li>• Apply PMS and use expert system analysis to manage road construction, performance evaluation of pavements.</li> </ul>	
<p><b>Graduate Attributes (as per NBA)</b></p> <p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Scholarship of Knowledge.</i></li> <li>○ <i>Problem Analysis.</i></li> </ul>	

- *Critical thinking*
- *Interpretation of data.*

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full 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:**

1. Freddy L Roberts, Prithvi S Kandhal et al, "Hot Mix Asphalt Materials, mixture design and construction"- (2<sup>nd</sup> Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA.
2. E.J.Yoder & Witczak M.W. "Principles of Pavement Design"- 2<sup>nd</sup> Edition – John Willey and Sons Inc., New York, 1975.
3. Hass R., Hudson. W. R., Zaniewisti .J. "Modern Pavement Management" – Krieger Publishing Company, Florida, 1994.
4. Per Ulitz "Pavement Analysis" - Elsevier Amsterdam.
5. David and Paul Croney, "Design and performance of road pavements"- third edition, Mc Graw hill, 1998.
6. Ralph Hass, Ronald Hudson and Zanieswki, "Modern Pavement management"- Krieger Publications.
7. W. Ronald Hudson, Ralph Haas and Waheed Uddin, 'Infrastructure Management'- Mc Graw Hill

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: TRAFFIC ENGINEERING</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Subject Code	16 CHT 22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Analyse the factors affecting performance of road traffic and the various traffic studies needed for the analysis of traffic flow.</li> <li>2. Evaluate level of service and capacity of roadways and intersections using traffic data.</li> <li>3. Propose and design suitable traffic regulatory system based on traffic requirements such as signs, signals, markings, etc.</li> <li>4. Analyse and design intersections at-grade and grade separated types for smooth and safe movement of vehicles.</li> <li>5. Propose parking facilities, pedestrian facilities and general safety measures required for highways and expressways.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<p><b>Traffic Characteristics, road user characteristics</b> – human factors including reaction time and vehicular characteristics affecting road design and traffic flow</p> <p><b>Traffic studies</b> - data collection, analysis and interpretation of results of classified traffic volume, spot speed, speed and delay, origin and destination. Sampling in traffic studies – sampling techniques, sampling theory, accuracy and sample size. Accident characteristics, causes, studies, investigations and analysis of individual accidents, statistical analysis, measures to improve road safety. Problems on above.</p>			<b>10 Hours</b>
<b>Module -2</b>			

<b>Traffic flow characteristics, traffic flow variables, speed</b> – flow – density relationship, PCU values, level of service, factors influencing roadway capacity, capacity of roads at various levels of service, capacity of intersections	<b>10 Hours</b>
<b>Module -3</b>	
<b>Traffic regulations and control</b> - Regulation on vehicles, drivers and traffic flow, Traffic control devices – Types & objectives of markings, signs, signals and islands, delineators.	<b>10 Hours</b>
<b>Module -4</b>	
<b>Design of signalized intersections</b> including signal timings as per IRC guidelines. Signal system, use of software. Problems.  Design of other types of intersections at grade such as intersections with markings, channelized intersections and traffic rotary. Traffic design of grade separated intersections and interchange facilities.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Design of on-street and off-street parking facilities, pedestrian facilities, bus bays, safety devices.</b>  Design features of expressways and different types of Urban Roads	<b>10 Hours</b>
<p><b>Course outcomes:</b> After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Gets the knowledge of factors affecting performance of road traffic and also the traffic studies needed for the analysis.</li> <li>2. Evaluate level of service and capacity of roadways and intersections.</li> <li>3. Propose and design suitable traffic regulatory system such as signs, signals, markings, etc.</li> <li>4. Analyse and design intersections at-grade and grade separated types for smooth and safe movement of vehicles.</li> <li>5. Propose parking facilities, pedestrian facilities and general safety measures required for highways and expressways.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Engineering Knowledge.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Critical thinking</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full 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.

**Reference Books:**

1. Kadiyali L.R. "Traffic Engineering and Transportation Planning"-Khanna Publication, New Delhi
2. Salter RJ and Hounsell NB, "Highway, Traffic Analysis and Design"- Macmillan Press Ltd., London.
3. Matson T M, Smith W S , Hurd F W, " Traffic Engineering, Mc graw Hill Book Co, NY , USA.
4. Drew D R , " Traffic Flow Theory and Control", McGraw Hill Book Co, NY, USA.
5. Wohl and Martin, "Traffic System Analysis of Engineers and Planners"-Mcgraw Hill Book Co, New York, USA.
6. Pignataro , " Traffic Engineering", John wiley & sons. Nicholas J Garber, Lester A Hoel,
7. "Traffic & Highway Engineering"- Third edition, Bill Stenquist.
8. IRC: SP:41-1994, IRC SP:31-1992, IRC 43-1994, Indian Roads Congress
9. MoRTH "Type Designs for Intersections on National Highways"-Indian Roads Congress
10. MORTH "Manual for Road Safety in Road Design"-Indian Roads Congress
11. IRC3-1983,9-1972,62-1976,64-1990,65-1976, 66-1976,67-2001,69-1977,70-1977,73-1980,79-1981,80-1981,86-1983,92-1985,93-1985,99-1988,102-1988,103-1988,106-1990,110-1996 Indian Roads Congress
12. Khanna and Justo, "Highway Engineering"- Nem Chand and Bros., Roorkee



**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: HIGHWAY PLANNING AND ECONOMIC ANALYSIS</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Subject Code	16 CHT 23	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<b>6. Course objectives:</b>			
The objective of this course is to make students learn Highway Planning, Highway Engineering Economics, principle, supply and demand models, equilibrium & sensitivity of travel demand Elasticity, Economic analysis & Highway financing			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<b>Highway Planning</b> – Objects, need for highway planning, types of planning, planning surveys, Interpretation, Preparation of Master plans, NTP and NTPC in India. Traffic studies – Volume study, types of volume counts viz, key count, control counts, coverage counts etc. Estimation of future traffic by different approaches, speed studies, load meter study,			<b>10 Hours</b>
<b>Module -2</b>			
20 year road development plan including 1 <sup>st</sup> and 2 <sup>nd</sup> 20 year plan in brief and 3 <sup>rd</sup> and 4 <sup>th</sup> 20 year plan in detail, Land use planning, Land use development – models, problems on the above topics, Highway Planning in India			<b>10 Hours</b>
<b>Module -3</b>			
<b>Highway Engineering Economics, principle, supply and demand models, equilibrium, sensitivity of travel demand, Elasticities</b> – types, models (Kraft			<b>10 Hours</b>

demand model) consumer surplus cost – cost elasticity pricing and subsidy policies, rates of interest, Vehicle operation cost, direct and indirect benefits due to road improvement, Total transportation cost, fixed and variable costs. Road user cost studies in India	
<b>Module -4</b>	
<b>Economic analysis</b> , different methods, determination of annual cost, benefit cost ratio, IRR, FIRR, NPV. Sensitivity of economic analysis, Examples of economic analysis for different types of road improvement measures, pavement options, construction of bypasses and upgrading of intersections. Project priorities, methods of dealing with uncertainties.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Highway financing</b> , various options for road and bridge projects, special cess, tolling, BOT, BOOT and other options. Economic and financial analysis of highway projects and use of computer software packages. Road investment decision packages.	
	<b>10 Hours</b>
<b>Course outcomes:</b> On completion of this course, Students would be able to prepare highway plans, Land use planning and development models. They will be able to carry out economic and financial analysis of highway projects	
<b>Graduate Attributes (as per NBA)</b>	
<ul style="list-style-type: none"> <li>○ <i>Engineering Knowledge.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Critical thinking</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<b>Question paper pattern:</b>	
<ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> </ul>	

- 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.

**Reference Books:**

1. Kadiyali L.R. "**Traffic Engineering and Transport Planning**"-Khanna Publishers, New Delhi.
2. Jotin Chisty.C and Kent Lall B "**Transportation Engineering An Introduction**"- PHI, New Delhi.
3. Prasanna Chandra "**Financial Management**"-Tata McGraw, New Delhi.
4. oods K.B, Berry, D.S. and Goetz W.H, "**Highway Engineering**"-McGraw Hill Book Co.
5. Hewes C.I. and Oglesby, C.H., "**Highway Engineering**"-Asia Publishing House.
6. Ian G. Heggie, "**Transportation Engineering Economics**"-McGraw Hill Book Co.
7. "**Road User Cost Study in India**"- Final Report, Central Road Research Institute, New Delhi, 1982.
8. Kadiyali, L.R., et al, "**Value of Travel Time Savings**" - Traffic Engineering, HRB
9. Ministry of Road Transport and Highways, "**Road Development Plan for India**"- 2001-2021, Indian Roads Congress, New Delhi, 2002.

**Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.**

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: ROAD CONSTRUCTION PLANNING AND MANAGEMENT</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Subject Code	16 CHT 24	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the highway planning process and difficulties or failures associated with planning process.</li> <li>2. Understands the cost of materials, man power and equipment in budget preparations for highway projects.</li> <li>3. Identify suitable equipment and their selection in the production of pavement materials.</li> <li>4. Analyse the various tasks involved in a road project and sequence them for effective and optimum outcome using tools like CPM and PERT.</li> <li>5. Use the software or management tools to manage the resources, cost and duration of equipment.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
Various types of highway development projects in progress in India and their scope. Factors to be considered in planning of new highway /expressway / bypass and up-gradation of existing roads.  <b>Planning of Road Projects</b> –project management framework, scope, project objectives, project environment, causes of project failure, project development process		<b>10 Hours</b>	
<b>Module -2</b>			
<b>Resource planning</b> – human resources, project man power grouping, structuring site organisation, construction materials- classification of construction materials, materials usage, materials inventory, cost and budget		<b>10 Hours</b>	
<b>Module -3</b>			
<b>Construction equipment and choice</b> -type, capacity and number, task considerations, cost considerations, engineering considerations, equipment acquisition options, optimum location of crushing and mixing plants, problems.		<b>10 Hours</b>	

<b>Module -4</b>	
<b>Time planning</b> – project work breakdown, determining activities involved, assessment of duration, CPM / PERT network analysis, work scheduling, methods of work scheduling, factors affecting work scheduling, Problems.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Planning Control System</b> – resource production, project cost, project time, codification and project management, information system, use of software	<b>10 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the highway planning process and difficulties or failures associated with planning process.</li> <li>2. Understands the cost of materials, man power and equipment in budget preparations for highway projects.</li> <li>3. Identify suitable equipment and their selection in the production of pavement materials.</li> <li>4. Analyse the various tasks involved in a road project and sequence them for effective and optimum outcome using tools like CPM and PERT.</li> <li>5. Use the software or management tools to manage the resources, cost and duration of equipment.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Critical thinking.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Use of modern tools</i></li> <li>○ <i>Project management and finance</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	
<p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. K.K. Chitkara. “Construction Project Management Planning, Scheduling and Controlling”- Tata McGraw Hill publications</li> <li>2. S.C. Sharma “Construction Equipment and its Management”- Khanna Publishers</li> <li>3. Peurifoy / Schexnayder “Construction Planning, Equipment and Methods”-Tata Mc Graw Hill Publications</li> <li>4. IRC “A Manual for the Application of Critical Path Method to Highway Projects in India”</li> <li>5. Nhai.org, pmgsy.nic.in websites</li> </ol>	

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: ROAD CONSTRUCTION EQUIPMENT</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16 CHT 251	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<b>Course objectives:</b> This course will enable students to			
<ol style="list-style-type: none"> <li>1. Understand major equipment used for road construction works along with their working principle.</li> <li>2. Distinguish the advantages and limitations of the equipment used for earth excavation and grading.</li> <li>3. Evaluate the production capacity of the plants producing aggregates</li> <li>4. Understand the knowledge of pavers and form works used to lay flexible and rigid pavements.</li> <li>5. Workout the cost of hiring the equipment and evaluate optimum turnout from the equipment.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
<b>Introduction:</b> Working principle, capacity, rate of production, applications, advantages and limitations of various types of construction equipment			<b>8 Hours</b>
<b>Module -2</b>			
<b>Equipment for earthwork excavation, hauling and spreading :</b> Dozers; power shovels, Scrappers, Tippers and trucks, Motor graders, - application, types, production capacity, factors affecting production, optimum number of equipments for construction. Different types of soil compactors and their applications			<b>8 Hours</b>
<b>Module -3</b>			
<b>Plants for aggregates production</b> – different types of crushers, Mixing plants: Pug mill for WMM, other cold mix plants, Hot mix Plants for bituminous mixes; factors affecting production capacity, Optimum number and location. Mixing plants for cement concrete			<b>8 Hours</b>
<b>Module -4</b>			
<b>Paving and compacting equipment:</b> Different types of pavers and compacting equipment for bituminous mixes, Fixed form type paver and Slip form type paver for CC pavements – their advantages			<b>8 Hours</b>

<b>Miscellaneous Equipment:</b> Kerb casting equipment, road marking equipment, bitumen sprayers, water tankers	
<b>Module -5</b>	
<b>Equipment Management:</b> Equipment planning, forecasting equipment requirement, maintenance, workshop, work study, Selection of Construction Equipment - task considerations, cost considerations, equipment acquisition options	<b>8 Hours</b>
<b>Course outcomes:</b> After studying this course, students will be able to: <ol style="list-style-type: none"> <li>1. Get the knowledge of major equipment used for road construction works along with their working principle.</li> <li>2. Distinguish the earth excavation and grading equipment based on their advantages and limitations for use in road construction.</li> <li>3. Work out the production capacity of the mixing plants for flexible and rigid pavements producing different sizes of aggregates.</li> <li>4. Understand the use of pavers and form works to lay flexible and rigid pavements and the precautions to be taken while using them.</li> <li>5. Estimate and find the cost of hiring equipment for construction activity.</li> </ol>	
<b>Graduate Attributes (as per NBA)</b> <ul style="list-style-type: none"> <li>○ <i>Scholarship of Knowledge.</i></li> <li>○ <i>Usage of modern tools</i></li> <li>○ <i>Project management and finance</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<b>Question paper pattern:</b> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> The students will have to answer 5 full questions, selecting one full question from each module.	
<b>Reference Books:</b> <ol style="list-style-type: none"> <li>1. Peurifoy/ Schexnayder “Construction Planning, Equipment and Methods”- McGraw-Hill Higher Education</li> <li>2. Sharma S.C. “Construction Equipment and its Management”- Khanna Publishers, Delhi</li> <li>3. K.K. Chitkara, “Construction Project Management,-Planning, Scheduling and Controlling”- Tata McGraw –Hill Publications</li> <li>4. “Operation Manuals of various equipment manufacturers”.</li> </ol>	

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: BRIDGE AND GRADE SEPARATED STRUCTURES</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Subject Code	16 CHT 252	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the types and components of a bridge with specifications for designing them for highways.</li> <li>2. Understand the use of different types of bridge bearings, their installation and maintenance aspects under the action of vehicular loads.</li> <li>3. Understand the design aspects of bridge approaches for RCC, PSC and Steel bridges.</li> <li>4. Analyse the loading conditions on the bridges and design the elements as per IRC load specifications.</li> <li>5. Understand the quality control measures during the execution of bridges both for substructure and super structure portions of the bridge.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<p><b>Introduction to Bridges:</b> Basic Elements of a Bridge.</p> <p><b>Types of bridges and grade separated structures for highways,</b> standard specifications for road bridges and grade separated structures to fulfill traffic and Structural Engineering requirements.</p>		<b>8 Hours</b>	
<b>Module -2</b>			
<p><b>Bridge bearings,</b> joints, approaches, construction and maintenance aspects.</p>		<b>8 Hours</b>	
<b>Module -3</b>			
<p><b>Basic design approaches</b> of RCC, PSC and steel bridges superstructure. Types of bridges for IRC loading conditions</p>		<b>8 Hours</b>	
<b>Module -4</b>			
<p><b>General Design Considerations</b> for grade separated structures and their choices, IRC Class AA Tracked and Wheeled Loading Analysis, Problems.</p>		<b>8 Hours</b>	



<b>Module -5</b>	
<b>Introduction to Construction Specification and quality control:</b> for foundations and substructures of bridges and grade separated structures. Concept of evaluation of existing bridge structures. Methods of rehabilitation and widening.	<b>8 Hours</b>
<b>Course outcomes:</b> After studying this course, students will be able to: <ol style="list-style-type: none"> <li>1. Design the components of a bridge following the specifications for highways.</li> <li>2. Get the knowledge of bridge bearings, their installation and maintenance aspects to withstand vehicular loads.</li> <li>3. Understand the design aspects of bridge approaches for RCC, PSC and Steel bridges.</li> <li>4. Analyse the IRC loading conditions for the design of bridges.</li> <li>5. Understand the quality control measures during the execution of bridges both for substructure and super structure portions of the bridge.</li> </ol>	
<b>Graduate Attributes (as per NBA)</b> <ul style="list-style-type: none"> <li>○ <i>Critical thinking</i></li> <li>○ <i>Problem solving.</i></li> <li>○ <i>Collaborative and multidisciplinary work</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<b>Question paper pattern:</b> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> The students will have to answer 5 full questions, selecting one full question from each module.	
<b>Reference Books:</b> <ol style="list-style-type: none"> <li>1. D.Johnson Victor, “Essentials of bridge Engineering”- Oxford, IBH publishing company.</li> <li>2. Ponnuswamy, “Bridge Engineering”-McGraw Hill Publication, 1989.</li> <li>3. Vazirani Ratwani &amp; M.G.Aswani, “Design of Concrete Bridges”- Khanna Publishers, New Delhi</li> <li>4. “Design of Bridges”- Dr. Krishna Raju, Oxford &amp; IBH Publishing company Limited.</li> <li>5. “Analysis and design of Bridges”- M.A.Jayaram, Sapna Publishers, Bangalore.</li> </ol>	

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: GROUND IMPROVEMENT TECHNIQUES</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16 CHT 253	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Analyse the need for ground improvement in weak, soft soils and likely modifications for better performance by such soils.</li> <li>2. Decide on suitable dewatering method in soils to improve their performance as highway material.</li> <li>3. Understand soil strengthening techniques by stabilisation using either by lime, cement, flyash or bitumen depending upon the type of soil.</li> <li>4. Understand soil strengthening techniques by reinforcing bars or anchoring methods depending on the type of soil.</li> <li>5. Understand the use of ground improvement using geo-synthetics or grouting techniques and precautions to be taken for cohesive type soils.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<p><b>Introduction</b> - Need and objectives of ground improvement, classification of ground modification techniques, trends in ground improvement. Engineering properties of soft, weak and compressible deposits; Principles of treatment;</p>		<b>8 Hours</b>	
<b>Module -2</b>			
<p><b>Methods of compaction</b>, blasting, dynamic consolidation, pre-compression and compaction piles. <b>Methods of dewatering</b> - open sumps and ditches, well point system, electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains.</p>		<b>8 Hours</b>	
<b>Module -3</b>			

<p><b>Stabilisation</b> with admixtures like cement, lime, calcium chloride, flies ash and bitumen, and non-traditional stabilizers. Methods of soil improvement-lime stabilisation and injection; thermal, electrical and chemical methods;</p>	<b>8 Hours</b>
<b>Module -4</b>	
<p><b>Grouting-</b> materials of grouting, grouting techniques and control. <b>Soil reinforcement</b> - Reinforcing materials, concept of confinement, gabion walls, Dynamic consolidation; Vibroflotation; Pre-consolidation with vertical drains; Granular piles; Soil nailing; Anchors; Grouting; Electro-osmosis; Soil freezing; Vacuum consolidation; Case histories</p>	<b>8 Hours</b>
<b>Module -5</b>	
<p><b>Improvement of Foundation Soils</b> (a) Improvement of granular soils: term used to describe degree of compactness – relative density, density ratio and degree of compaction; Methods - Vibration at ground surface, factors influencing roller compaction; deep dynamic compaction, vibro-compaction impact at depth. (b) Improvement of cohesive soils: preloading, or dewatering, methods of installing sand drains, drain wicks, electrical and thermal methods. (c) Grouting: purpose, functions, types of grouts; soil bentonite - cement mix, cement mix, emulsions, solutions: grout injection methods. (d) Geo-synthetics: types, functions, manufacturing of geo-textiles, Classification of geo-textiles. Specific Applications: Bearing capacity improvement, reinforcement, retaining walls, embankment etc. testing of geo-synthetics, usage in India and case study.</p>	<b>8 Hours</b>
<p><b>Course outcomes:</b> After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Analyse the need for ground improvement in weak and soft soils with likely modifications to improve their performance.</li> <li>2. Decide on suitable dewatering method in soils to improve their performance as highway material.</li> <li>3. Apply appropriate soil strengthening techniques by stabilisation using either by lime, cement, flyash or bitumen.</li> <li>4. Evaluate the strengthening techniques by reinforcing bars or anchoring methods depending on the type of soil.</li> <li>5. Use ground improvement techniques such as geo-synthetics or grouting for cohesive soils.</li> </ol>	

**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 16 marks.
- There will be 2 full 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.

**Reference Books:**

1. Manfred R. Hansmann - Engineering principles of ground modification - Me. Graw-Hill pub. Co., NewYork.
2. Robert M. Koerner - Construction and Geotechnical methods in Foundation Engineering - MC.Graw-Hill Pub. Co., New York. .
3. Winterkorn and Fang - Foundation Engineering Hand Book - Van Nostrand Reinhold Co.,New York.
4. Aris C. Stamatopoulos & Panaghiotis C. Kotzios - Soil Improvement by Preloading – John Wiley & Sons Inc. Canada.
5. P. Purushothama Rao - Ground Improvement Techniques - Laxmi Publications

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: ROAD SAFETY ENGINEERING</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16 CHT 254	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<b>Course objectives:</b> This course will enable students to			
<ol style="list-style-type: none"> <li>1. Analyze the effect of driver characteristics, roadway characteristics, climatic factors on highway safety..</li> <li>2. Plan and design a road safety improvement program..</li> <li>3. Analyze accident data and suggest safety measures.</li> <li>4. Conduct road safety audit..</li> <li>5. Interpret accident data using statistical analysis.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			
Introduction to safety: Road accidents, Trends, causes, Collision and Condition diagrams, Highway safety, human factors, Vehicle factors Road Safety Management System: Multi-causal dynamic systems approach to safety, crash vs accident, road safety improvement strategies, elements of a road safety plan, Safety Data Needs.			<b>8 Hours</b>
<b>Module -2</b>			
Statistical Interpretation and Analysis of Crash Data: Before-after methods in crash analysis, Advanced statistical methods, Black Spot Identification & Investigations, Case Studies.			<b>8 Hours</b>
<b>Module -3</b>			

Road Safety Audits: Key elements of a road safety audit, Road Safety Audits & Investigations, Crash investigation and analysis, Describe methods for identifying hazardous road locations, Case Studies.	<b>8 Hours</b>
<b>Module -4</b>	
Crash Reconstruction: Describe the basic information that can be obtained from the roadway surface, Understand basic physics related to crash reconstruction, speed for various skid, friction, drag, and acceleration scenarios, variables involved in jump and flip crashes, variables involved in pedestrian crashes, Case Studies.	<b>8 Hours</b>
<b>Module -5</b>	
Mitigation Measures: Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety.	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Analyze the effect of driver characteristics, roadway characteristics, climatic factors on highway safety..</li> <li>2. Plan and design a road safety improvement program..</li> <li>3. Analyze accident data and suggest safety measures.</li> <li>4. Conduct road safety audit..</li> <li>5. Interpret accident data using statistical analysis.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>o <i>Scholarship of Knowledge.</i></li> <li>o <i>Critical thinking.</i></li> <li>o <i>Ethical practices and social responsibility</i></li> <li>o <i>Use of modern tools</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	

**Reference Books:**

1. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002)
2. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
3. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
4. Leonard Evans, Traffic Safety, Science Serving Society, 2004.
- Lynn B. Fricke, Traffic Accident Reconstruction, Northwestern University Center for Public Safety, 1990.
5. Ogden, K.W. Safer Roads: A Guide to Road Safety Engineering. Avebury Technical, 1996.
6. Popkess C.A, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997
- Rune Elvik and Truls Vaa, The Handbook of Road Safety Measures, Elsevier, 2004.
7. Simon Washington, Matthew Karlaftis, and Fred Mannering, Statistical and Econometric Methods for Transportation Data Analysis, Chapman & Hall/CRC Press, 2003.
8. Towards Safe Roads in Developing country, TRL – ODA, 2004

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

**COURSE TITLE: HIGHWAY MATERIALS LAB - 2**

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

Subject Code	16 CHT L26	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	42	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 bitumen and modified binders, learn bituminous mix design
- Learn field tests on pavement evaluation

**Modules**

**Tests on bitumen / polymer modified binders**

1. Penetration test
2. Viscosity test
3. Specific gravity test
4. Flash and fire point test
5. Ductility and elastic recovery test
6. Softening point test and separation test
7. Tests on bitumen Emulsion & Cutback bitumen

**Tests on bituminous mixes**

1. Proportioning of materials by Rothfutch's method and Mix design by Marshall Method.

**Field Tests**

Field density by sand replacement & Core cutter method  
Bitumen Extraction, bitumen content and aggregate gradation  
Pavement evaluation tests such as:



- Benkelman Beam deflection studies & analysis
- Measurement of Unevenness by Merlin & Bump integrator
- Calibration of Bump Integrator

**Course outcomes:**

After the completion of the course students should have

- Acquired the expertise to conduct various tests on binder, modified binders and bituminous mixes.
- Gained knowledge on various field tests for the pavement evaluation

**Graduate Attributes (as per NBA)**

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

**References:**

1. Relevant IS and IRC codes
2. Khanna, S.K., Justo, C.E.G., and Veeraragavan, A., 'Highway Materials and Pavement Testing', Nem Chand and Bros, Roorkee
3. Gambhir, M. L., 'Concrete Manual', Dhanpat Rai and sons New Delhi

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: SPECIAL PROBLEMS IN ROAD CONSTRUCTION</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – IV			
Subject Code	16 CHT 41	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
<b>CREDITS – 04</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the difficulties of road construction in weak and marshy soils and necessary precautions to be taken during design and construction.</li> <li>2. Understand the methods of strengthening soil fills and embankments to improve their performance as pavement component layer.</li> <li>3. Understand the difficulties associated with construction of high embankments and maintaining stability of hill slopes with precautions to be taken.</li> <li>4. Understand the use of recycled materials in road construction including milled bituminous waste with necessary design methodology.</li> <li>5. Understand the design and construction of roads in coastal and desert environments with exclusive exposure conditions.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<p><b>Problems of construction of roads in marshy areas and weak / expansive soils and water-</b> logged - areas. Various effective measures for solving the problems, machinery required and method of construction. Control of water table, capillary rise and seepage flow in road construction. Design and construction of filter drains and capillary cut-off.</p>		<b>10 Hours</b>	
<b>Module -2</b>			
<p>Methods of strengthening weak foundation soil, acceleration of consolidation and settlement of compressible embankment foundation, vertical sand drains - application, design and construction method.</p>		<b>10 Hours</b>	

<b>Module -3</b>	
Problems in construction of high embankments, stability of foundation and embankment slopes. Stability of hill slopes, control of erosion.	<b>10 Hours</b>
<b>Module -4</b>	
<b>Use of special materials such as</b> geo-synthetics for drainage and in pavement layers. Use of reinforced earth retaining walls, Nailing Technique, Techniques of pavement construction using recycled materials – cold and hot mix recycling of bituminous materials.	<b>10 Hours</b>
<b>Module -5</b>	
<b>Special construction techniques</b> - construction techniques of cell filled concrete pavements – design, economics and construction method, and its application. Road construction on desert region and coastal areas, alternative methods, road construction on high altitudes, hilly and mountainous terrain.	<b>10 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Get the knowledge about the difficulties of road construction in weak and marshy soils and the precautions to be taken.</li> <li>2. Suggest improvement methods of strengthening soil fills and embankments to be a pavement layer.</li> <li>3. Know the difficulties associated with construction of high embankments and maintaining hill slopes stability.</li> <li>4. Use recycled materials in road construction with appropriate design methods.</li> <li>5. Provide design and construction methods for roads in coastal and desert environments.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Critical thinking.</i></li> <li>○ <i>Problem solving.</i></li> <li>○ <i>Ethical practices and social responsibility</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	

**Reference Books:**

1. R.M. Koerner “Designing with Geosynthetics”- 4<sup>th</sup> Edition Prentice Hall, New Jersey, 1997.
2. IRC-75 “Guidelines for the design of High embankments”- IRC, 1979.
3. DSIR “Soil Mechanics for Road Engineers”- HMSO, London, 1954.
4. Leonards G.A. “Foundation engineering”- McGraw Hill Book Company, New York, 1962.
5. Cedgreen H.R. “Drainage of highway and airfield pavement”- John Willey and Sons.Inc., New York, 1974.
6. G. Kassiff M. Livnet. G. Wisemen “Pavements on Expansive clays”- Jerusalem Academy Press, Jerusalem. Israel, 1969.
7. R.D. Krebs & R.D.Walker “Highway Materials”- McGraw Hill Book House, New York, 1971.

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: TRANSPORTATION PLANNING</b> <b>[As per Choice Based Credit System (CBCS) scheme]</b> <b>SEMESTER – IV</b>			
Subject Code	16 CHT 421	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the different modes of transportation and factors affecting planning process for an effective transportation system.</li> <li>2. Understand the characteristics of mass transit system and methods of collecting traffic data to propose an effective transport facility.</li> <li>3. Understand and sources of zonal trip generation or attraction and then inter-zonal trip distribution methods.</li> <li>4. Analyse the mode of transport and its impact on transport system and also the methods of assigning travel trips to various routes for effective management.</li> <li>5. Understand the mass transportation options and evaluation of the systems for economic sustainability.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<p><b>Introduction: Characteristics of different modes of transportation;</b> Principles of co-ordination and operation control, Elements in urban transit system</p> <p><b>Transportation Planning Process:</b> Factors to be considered; land use transportation planning; Systems approach.</p>		<b>8 Hours</b>	
<b>Module -2</b>			
<p><b>Transport Surveys:</b> Planning of different types of surveys and interpretation, travel demand; Traffic surveys for mass transit system planning.</p>		<b>8 Hours</b>	
<b>Module -3</b>			

<b>Trip Generation and Distribution:</b> Factors governing trip generation and attraction; Zonal models; Category analysis; Methods of trip distribution; Application of gravity model.	<b>8 Hours</b>
<b>Module -4</b>	
<b>Modal Split and Assignment:</b> Factors affecting modal split; Modal split in transport planning; principles of traffic assignment; Assignment techniques	<b>8 Hours</b>
<b>Module -5</b>	
<b>Evaluation: Identification of corridor;</b> Formulation of plans; Economic Evaluation. <b>Mass Transit Systems:</b> capacity, Fleet planning and Scheduling.	<b>8 Hours</b>
<p><b>Course outcomes:</b> After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Get the knowledge of different modes of transportation and factors affecting the planning process for the different modes.</li> <li>2. Propose effective transport facility for the mass transportation after collecting the data required.</li> <li>3. Compute the inter-zonal trip generations or attractions and also the trip distributions.</li> <li>4. Analyse the impact of transport mode on the transport system to understand effective management along the routes.</li> <li>5. Evaluate the economic sustainability of the mass transportation systems.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>o <i>Scholarship of Knowledge.</i></li> <li>o <i>Problem solving.</i></li> <li>o <i>Usage of modern tools</i></li> <li>o <i>Interpretation of data.</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	
<p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Hutchinson, B.G., “Principles of Urban Transport System Planning”– McGraw Hill Book Co.</li> <li>2. Kadiyali, L.R., “Traffic Engineering and Transportation Planning”– Khanna Publication.</li> <li>3. Institute of Traffic Engineers – “An Introduction to highway Transportation Engineering”, ITE, USA</li> </ol>	

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: PAVEMENT MANAGEMENT SYSTEM</b> <b>[As per Choice Based Credit System (CBCS) scheme]</b> <b>SEMESTER – IV</b>			
Subject Code	16 CHT 422	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<b>Course objectives:</b> objective of this course is to make students learn evaluation and prediction of pavement performance, to learn Ranking and economic optimization of pavement maintenance and rehabilitation and management.			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>			
<b>Introduction:</b> components & principals of pavement management systems, pavement maintenance measures, planning investment, research management. <b>Pavement Performance Evaluation:</b> general concepts, serviceability, pavement distress survey systems, performance evaluation		<b>8 Hours</b>	
<b>Module -2</b>			
<b>Pavement Performance Prediction:</b> concepts, modeling techniques, structural condition deterioration models, mechanistic and empirical models, HDM and other models, comparison of different deterioration models. Functional condition deterioration models, unevenness prediction models and other models, comparison. Modeling in rehabilitation budget planning, case studies, Problems.		<b>8 Hours</b>	
<b>Module -3</b>			
<b>Ranking and Optimization Methodologies:</b> Recent developments, sample size selection, economic optimization of pavement maintenance and rehabilitation		<b>8 Hours</b>	

<b>Module -4</b>	
<b>Design alternatives and Selection:</b> Design objectives and constraints, basic structural response models, physical design inputs, alternate pavement design strategies and economic evaluation, reliability concepts in pavement engineering, life cycles costing, analysis of alternate pavement strategies based on distress and performance, case studies and Problems.	<b>8 Hours</b>
<b>Module -5</b>	
<b>Expert systems and Pavement Management:</b> role of computers in pavement management, applications of expert systems for managing pavements, expert system for pavement evaluation and rehabilitation, knowledge – based expert systems, case studies. Implementation of Pavement Management Systems.	<b>8 Hours</b>
<b>Course outcomes:</b> On completion of this course, Students would be able to design alternate pavement management systems based on life cycle cost analysis.	
<b>Graduate Attributes (as per NBA)</b>	
<ul style="list-style-type: none"> <li>○ <i>Scholarship of Knowledge.</i></li> <li>○ <i>Problem solving.</i></li> <li>○ <i>Usage of modern tools</i></li> <li>○ <i>Interpretation of data.</i></li> </ul>	
<b>Question paper pattern:</b>	
<ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul>	
The students will have to answer 5 full questions, selecting one full question from each module.	
<b>Reference Books:</b>	
<ol style="list-style-type: none"> <li>1. Ralph Hass, Ronald Hudson and Zanieswki, “<b>Modern Pavement management</b>”- Krieger Publications.</li> <li>2. W. Ronald Hudson, Ralph Haas and Waheed Uddin, ‘<b>Infrastructure Management</b>’- Mc Graw Hill</li> <li>3. <b>Proceedings of North American Conference on Managing Pavement.</b></li> <li>4. <b>Proceedings of International Conference on Structural Design of Asphalt Pavements.</b></li> <li>5. NCHRP, TRR and TRB Special Reports.</li> <li>6. Freddy L Roberts, Prithvi S Kandhal et al, “<b>Hot Mix Asphalt Materials, mixture design and construction</b>”- (2<sup>nd</sup> Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA.</li> </ol>	



**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: CONSTRUCTION QUALITY AND SAFETY MANAGEMENT</b>			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – IV			
Subject Code	16 CHT 423	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the importance of adhering to quality standards and specifications during the construction for achieving satisfactory level in the road works.</li> <li>2. Understands the importance of documents, contracts and construction procedures with their economic implications during the construction.</li> <li>3. Understand the probable accidents during construction with necessary legal and financial implications of the same.</li> <li>4. Understand the ways of bringing in safety in construction at work places, likely compensations if needed, do's and don't's of workers, safety auditing procedures etc.</li> <li>5. Understand the coordination among work force and measures to be followed for safety in handling, storing and use of materials for construction.</li> </ol>			
<b>Modules</b>			<b>Teaching Hours</b>
<b>Module -1</b>			<b>8 Hours</b>
<p><b>Quality and concept of QM</b> - Necessity for improving quality, concept of quality control, quality assurance, quality management and total quality management , Total quality management concepts; ISO9000 documentation; QA/QC systems and organizations, Quality Audits; Problem solving techniques; Statistical Quality Control; Quality Function Deployment; Material Quality Assurance; Specifications and Tolerances.</p> <p><b>Quality Planning</b> - Quality policy, objectives and methods in construction industry - consumers satisfaction, time of completion - statistical tolerance.</p>			
<b>Module -2</b>			

<p><b>Codes and standards quality manuals</b> - documents - contract and construction programming-inspection procedures - processes and products - total QA/QC programme and cost implication.</p> <p><b>Managing Quality</b> in various projects stages from concept to completion by building quality into design of structures, Inspection of incoming material and machinery In process quality inspections and tests.</p> <p><b>Reliability &amp; Probability testing</b>, reliability coefficient and reliability prediction - selection of new materials - influence of drawings, detailing, specification, standardization - bid preparation - construction activity, environmental safety and social factors -natural causes and speed of construction - life cycle costing - value engineering and value analysis.</p>	<b>8 Hours</b>
<b>Module -3</b>	
<p><b>Codes and standards quality manuals</b> - documents-contract and construction programming - inspection procedures-processes and products - total QA / QC programme and cost implication.</p> <p><b>Quality Assurance Department</b> -and quality control responsibilities of the line organization, developing quality culture in the organization, training of people,</p> <p><b>Construction accidents</b> -importance, causes of accident, safety measures, construction industry related laws. Human factors in safety – legal and financial aspects of accidents in construction – occupational and safety hazard assessment.</p>	<b>8 Hours</b>
<b>Module -4</b>	
<p><b>Safety Programmes</b> - elements of safety programmes, job-site assessment, safety meetings, safety incentives, contractual obligations, safety in construction contracts</p> <p><b>Safety in Design</b>- safety culture - Safe Workers- Safety and First Line Supervisors - Safety and Middle Managers - Top Management Practices, Company Activities and Safety - Safety Personnel - Sub-contractual Obligation - Project Coordination and Safety Procedures - Workers Compensation, Safety issues; Injury accidents and their causes; Safety program components; Role of workers, Supervisors, Managers and Owners; Safety Procedures for various construction operations; Safety audits; Safety laws.</p>	<b>8 Hours</b>
<b>Module -5</b>	
<p><b>Safety Management</b> - safety and first line supervisors, safety and middle managers, top management practices, safety audit, safety equipment planning and site preparation, safety system of storing construction materials Excavation - blasting- timbering-scaffolding- safe use of ladders- safety in welding. First- aid- Fire hazards and preventing methods</p>	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the quality standards and specifications during the construction of road works.</li> <li>2. Practice on the preparation of documents, contracts and construction procedures with their economic</li> </ol>	

implications for a road project.

3. Analyse the probable accidents during construction and their legal/financial implications.
4. Provide safe construction practices at sites, likely compensations if needed, educate do's and dont's for workers.
5. Exercise the coordination among work force and safe handling, storing and use of materials at construction sites.

**Graduate Attributes (as per NBA)**

- *Use of modern tools*
- *Problem solving*
- *Management of finance*

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full 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.

**Reference Books:**

1. James, J.O Brian, Construction Inspection Handbook - Quality Assurance and Quality Control, Van Nostrand, New York, 1989.
2. Kwaku, A., Tenah, Jose, M. Guevara, Fundamentals of Construction Management and Organization, Reston Publishing Co., Inc., Virginia, 1985.
3. Juran Frank, J.M. and Gryna, F.M, Quality Planning and Analysis, Tata McGraw Hill, 1982.
4. Hutchins.G, ISO 9000, Viva Books, New Delhi, 1993.
5. Clarkson H. Ogiesby, Productivity Improvement in Construction, McGraw-Hill, 1989.
6. IS, IRC, Other codes
7. Jimmy W. Hinze, *Construction Safety, Prentice Hall Inc., 1997*
8. Richard J. Coble, Jimmie Hinze and Theo C. Haupt, *Construction Safety and Health Management, Prentice Hall Inc., 2001.*
9. Hand Book on Construction Safety Practices, SP 70, BIS 2001.

**SYLLABUS**  
**M.Tech.- HIGHWAY TECHNOLOGY**

<b>Course Title: AIRPORT PLANNING AND DESIGN</b> [As per Choice Based Credit System (CBCS) scheme] SEMESTER – IV			
Subject Code	16 CHT 424	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03
<b>CREDITS – 03</b>			
<p><b>Course objectives:</b> This course will enable students to</p> <ol style="list-style-type: none"> <li>1. Understand the various components of an airport and aircraft characteristics affecting the design of airports.</li> <li>2. Design the runway and taxiway geometrics based on the likely aircrafts using the airport.</li> <li>3. Plan the requirements of terminal area and suggest an optimum layout for the terminal area based on passenger and baggage volume.</li> <li>4. Provide a suitable method of grading and leveling work involved in the area along with drainage provisions for surface and subsurface water flows.</li> <li>5. Understand the various air traffic control aids required for safe landing and take-off of aircrafts at the airport.</li> </ol>			
<b>Modules</b>		<b>Teaching Hours</b>	
<b>Module -1</b>		<b>8 Hours</b>	
<p><b>Introduction:</b> Growth of air transport, airport organization and associations, Classifications of airports airfield components, airport traffic zones and approach areas.  <b>Aircraft Characteristics Related to Airport Design:</b> Components, size turning radius, speed, airport characteristics</p>			
<b>Module -2</b>		<b>8 Hours</b>	
<p><b>Airport planning, surveys and Design :</b> Airport Site Selection, Runway length and width, sight distances, longitudinal and transverse grades, runway intersections, taxiways, clearances, aprons, numbering, holding apron, noise control , Problems.</p>			
<b>Module -3</b>			

<p><b>Planning and Design of the Terminal area:</b> Operational concepts, space relationships and area requirements, vehicular traffic and parking at airports.</p> <p><b>Capacity and Delay:</b> Factors affecting capacity, Determination of runway capacity related to delay, gate capacity, taxiway capacity</p>	<b>8 Hours</b>
<b>Module -4</b>	
<p><b>Airport Grading and Drainage:</b> Grading of airport area, hydrology, design of drainage systems, construction methods, layout of surface drainage and subsurface drainage system, Problems.</p>	<b>8 Hours</b>
<b>Module -5</b>	
<p><b>Air Traffic Control and Aids:</b> Runways and taxiways markings, day and night landing aids, airport lighting, ILS and other associated aids.</p>	<b>8 Hours</b>
<p><b>Course outcomes:</b>  After studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Analyse the various components of an airport and aircraft characteristics affecting the design of airports.</li> <li>2. Design the runway and taxiway geometrics based on the likely aircrafts using the airport.</li> <li>3. Plan the requirements of terminal area and suggest an optimum layout for the terminal area based on passenger and baggage volume.</li> <li>4. Provide a suitable method of grading and leveling work involved in the area along with drainage provisions for surface and subsurface water flows.</li> <li>5. Understand the various air traffic control aids required for safe landing and take-off of aircrafts at the airport.</li> </ol>	
<p><b>Graduate Attributes (as per NBA)</b></p> <ul style="list-style-type: none"> <li>○ <i>Scholarship of Knowledge.</i></li> <li>○ <i>Problem Analysis.</i></li> <li>○ <i>Design / development of solutions (partly).</i></li> <li>○ <i>Ethical practices and social responsibility</i></li> </ul>	
<p><b>Question paper pattern:</b></p> <ul style="list-style-type: none"> <li>• The question paper will have ten questions.</li> <li>• Each full question consists of 16 marks.</li> <li>• There will be 2 full questions (with a maximum of four sub questions) from each module.</li> <li>• Each full question will have sub questions covering all the topics under a module.</li> </ul> <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>	

**Reference Books:**

1. "Planning and Design of Airports" - Robert Horenjeff, 2<sup>nd</sup> edition, McGraw Hill Book Co.
2. "Airport Engineering"- G. Glushkov, V.Babkov, Mir Publuishers, Moscow.
3. "Airport Planning and Design"- Khanna, Arora and Jain, Nem Chand and Bros., Roorkee
4. Harry.R.Cedergern. "Drainage of Airfield pavements"- John Wiley and Sons.
5. Virender Kumar and Satish Chandra, "Airport Planning and Design"- Galotia Publication press.