

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)

Faculty of Engineering and Technology

Course Scheme and Syllabus

of

**Master of Technology (Regular)
Transportation Engineering**

Effective from 2011-12

**MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)
Faculty of Engineering and Technology**

Two – Year (Regular) M Tech: Transportation Engineering

Eligibility for Admission: A candidate for being eligible for admission to the Master of Technology in *Transportation Engineering* in the faculty of engineering and technology should have passed B.Sc. (Engg.)/ B. Tech/ B.E. or any other equivalent degree in the relevant discipline / branch from any recognized Indian or foreign University.

A candidate should have at least 55% marks or equivalent CGPA in the qualifying examination (50% marks or equivalent CGPA for Scheduled Caste/Scheduled Tribes Candidates) on the basis of which the admission is being sought.

Overview of the Programme: The normal duration of programme shall be four Semesters for regular students. However, in exceptional circumstances, only dissertation work may be extended and has to be completed within five years from the date of enrolment for this programme. This extension requires the prior approval of the Vice-Chancellor of the University.

The complete programme comprises of 12 theory courses (08 Core and 04 elective) and 02 Lab courses followed by a seminar and the research/ project work in the form of a dissertation. Student has to obtain at least 40 % marks to pass the examination (both internal and external examination separately) for all the courses specified in the scheme of the programme. The degree will be awarded on the basis of cumulative marks obtained in all the four semesters and the division obtained will be as under:

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)
Scheme of Two – Year (REGULAR) M Tech (Transportation Engineering)

First Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments /Lab Record	Teacher's Evaluation		
HE-611	Geometric Design	4	-	4	30	10	60	100
HE-613	Traffic Engineering	4	-	4	30	10	60	100
HE-615	Road Safety and Audit	4	-	4	30	10	60	100
HE-711/713/715	Elective - I	3	-	3	20	10	45	75
HE – 721/ 723/725	Elective - II	3	-	3	20	10	45	75
HE-617	Traffic Engineering Lab	-	2	2	15	10	25	50
Total Semester Credits = 20					Total Semester Marks = 500			

Second Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments /Lab Record	Teacher's Evaluation		
HE-612	Pavements Design and Construction Techniques	4	-	4	30	10	60	100
HE-614	Highway Materials	4	-	4	30	10	60	100
HE-616	Environmental and Social Impact Assessment of Highway Projects	4	-	4	30	10	60	100
HE-712/714/716	Elective III	3	-	3	20	10	45	75
HE-722/724/726	Elective IV	3	-	3	20	10	45	75
HE-618	Highway Materials Lab	-	2	2	15	10	25	50
Total Semester Credits = 20					Total Semester Marks = 500			

Third Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments /Report	Teacher's Evaluation		
HE-621	Transport Planning	4	-	4	30	10	60	100
HE-623	Research Methodology	4	-	4	30	10	60	100
HE-625	Seminar	2	-	2	25	25	-	50
Total Semester Credits = 10					Total Semester Marks = 250			

Fourth Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Report	Supervisor (s) Evaluation		
HE – 628	Dissertation	-	16	16	75	75	250	400
Total Semester Credits = 16					Total Semester Marks = 400			

LIST OF ELECTIVES

ELECTIVE – I

1. HE-711 Airport infrastructure Design
2. HE-713 GIS in Highway Engineering Systems
3. HE-715 Mass Transportation Systems

ELECTIVE – II

1. HE-712 Low volume Roads
2. HE-714 Highway Subgrade and Foundation Analysis
3. HE-716 Highway Drainage Systems

ELECTIVE – III

1. HE-721 Corridor management
2. HE-723 Design and construction of bridges and flyovers
3. HE-725 Concrete Technology

ELECTIVE – IV

1. HE-722 Project planning and Management
2. HE-724 Transportation data analysis
3. HE-726 Ground Improvement Engineering

Internal Assessment/Examination: The internal evaluation for all theory courses (40% of the total marks) will be based on the evaluation of **three assignments** provided during the semester and assessment of the teacher concerned. Similarly, the internal evaluation for all Lab courses (50% of the total marks) will be based on the evaluation of lab record and assessment of the teacher concerned.

External Examination/Viva -voce: For all the theory courses, there will be **08 (Eight)** questions to be set by the external paper setter (nominated /approved by the competent authority) out of which the candidate will have to attempt only **05 (Five)** questions all carrying equal marks. Duration of each external examination will be **three hours**. Similarly, the external evaluation for all Lab courses (50% of the total marks) will be based on the evaluation/viva-voce conducted by an external examiner (from the relevant field) nominated/approved by the competent authority.

Evaluation of Seminar: The seminar topic should belong to the core area of specialization. Senior faculty will supervise the students in selecting and preparation of the same. The student will submit two copies of seminar report and shall make oral presentation as per time schedule decided by the faculty concerned. Internal Evaluation will be made on the basis of report, presentation and the discussion during the presentation.

Submission and Evaluation of Dissertation:

- a) A dissertation supervisor (s) having at least post- graduate qualification, from industry/research organization shall be assigned to the student approved by the competent authority. *In no case, the candidate can have more than two dissertation supervisors.*
- b) Dissertation work shall comprise of literature survey, problem formulation, methodology used, S/W, H/W tools used, Results and discussion followed by the conclusions & further scope of work in that area. Industry oriented projects may be encouraged for the purpose.
- c) The submission of dissertation shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, and certified in the report) in the relevant refereed journal/ conference.
- d) The final dissertation external examination in 4th semester shall be taken by a panel of examiners comprising of concerned Supervisor (s), one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, one for each supervisor (s), examiner and the university/ department, are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: TRANSPORTATION ENGINEERING

HE – 611 GEOMETRIC DESIGN

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Introduction: Classification of rural highways and urban roads. Objectives and requirements of highway geometric design: Design Control and Criteria.

Cross Section Elements: Right of way and width considerations, roadway, shoulders, kerbs traffic barriers, medians, frontage roads; Facilities for pedestrians, bicycles, buses and trucks, Pavement surface characteristics - types, cross slope, skid resistance, unevenness.

Sight distances - types, analysis, factors affecting, measurements,

Horizontal alignment - design considerations, stability at curves, super-elevation, widening, transition curves; curvature at intersections,

Vertical alignment - grades, ramps, design of summit and valley curves, combination of vertical and horizontal alignment including design of hair pin bends, design of expressways, IRC standards and guidelines for design, Problems.

Design Considerations: Design considerations for rural and urban arterials, expressways, and other rural and urban roads - design speeds, volumes, levels of service and other design considerations.

Geometric design of parking areas.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna publishers
- Khanna and Justo, "Highway Engineering"- Nem Chand and Bros., Roorkee
- The Institute of Transportation Engineers, Transportation and Traffic Engg. Hand Book, Prentice Hall (1982) Chapters 8,17,21.23 and 24.

M TECH: TRANSPORTATION ENGINEERING

HE – 613 TRAFFIC ENGINEERING

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Traffic Characteristics, road user characteristics – human factors including reaction time and vehicular characteristics affecting road design and traffic flow.

Traffic studies - data collection, analysis and interpretation of results of classified traffic volume, spot speed, speed and delay, origin and destination and parking studies. Sampling in traffic studies – sampling techniques, sampling theory, accuracy and sample size. Economic evaluation of improvement measures by "before and after studies".

Traffic flow characteristics, traffic flow variables, speed – flow – density relationship, PCU values, level of service, factors influencing roadway capacity, capacity of roads at various levels of service, capacity of intersections,

Traffic flow theory – scope, relationship between flow variable, bottle necks, Queuing theory and applications; vehicle arrivals, delays at intersections, Elements of simulation technique in traffic Engineering.

Traffic Control Devices: Traffic signs and markings and road lightings. Different types of Traffic islands, channelization; median openings, Delineators, Barriers and other road furniture.

Design of at Grade Intersections: Characteristics and design considerations of at-grade intersections; Rotary intersections; Design of signal phasing.

Grade separations and interchanges - Types, warrants, adaptability and design details; Interchanges - different types, ramps. Computer applications for intersection and interchange design.

Traffic management techniques: Local area management. Transportation system management. Low cost measures. Various types of medium and long term traffic management measures and their uses. Evaluation of the effectiveness and benefits of different traffic management measures. Traffic Calming measures.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Kadiyali L.R. "Traffic Engineering and Transportation Planning"-Khanna Publication, New Delhi
- Salter RJ and Hounsell NB, "Highway, Traffic Analysis and Design"- Macmillan Press Ltd., London
- Nicholas J Garber, Lester A Hoel, "Traffic & Highway Engineering"- Third edition, Bill Stenquist.

M TECH: TRANSPORTATION ENGINEERING

HE – 615 ROAD SAFETY AND AUDIT

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Introduction: Road Safety scenario in India and World, Road Accident Characteristics.

Need of Planning for Network, Land Use and Road Environment for Safety, Designing for Safety: Road Link Design, Junctions.

Introduction to Road Safety Engineering and Crash Investigation, Human Factors Relating to Crashes/Accidents, Crash/Accident Investigation & Crash Problem Diagnosing, Crash Problems into Solutions & Crash, Investigation Reporting, Crash/Accident Costing, Economic Appraisal.

Safety at Construction Site: Safety provisions for workers at construction site, Construction Zone markings, signs.

Road Safety Auditing: An Introduction, Concept and need of Road Safety Audit (RSA). Procedures in RSA, design standards, audit tasks, stages of road safety audit, Road Safety Audit Types, key legal aspects, process, audit team and requirements, Checklist, how to use Checklists Road Safety inspection. Road design issues in RSA's. Overview of Road Safety Hazards. Report Writing including deficiency identification, corrective actions recommendations, prioritisation. Structuring RSA report.

Street Lighting & Traffic Signals, Provisions for NMT Vehicles in India, Safety Provisions for Pedestrians & Cyclists, Road Signs and Pavement Markings.

Safe System Approach: A Global Perspective, Speed Management & safety, Safe System and Speed & Assessing speed limit, Type of speed limit & Speed zone signing Infrastructure to support safe speed feedback and enforcement.

Hazard Identification and Management, Organizational commitment & encouraging RSA. Risk Assessment & Prioritization of audit recommendations, Solutions and effectiveness & Corrective, Action Report.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- BABKOV, V.F. 'Road conditions and Traffic Safety', MIR publications, - 1975.
- K.W. Ogden, 'Safer Roads – A Guide to Road Safety Engg.' Averbury Technical, Ashgate Publishing Ltd., Aldershot, England, 1996.
- Kadiyali, L.R., 'Traffic Engineering and Transport Planning', Khanna Publications.
- Road safety audit Manual

M TECH: TRANSPORTATION ENGINEERING

HE – 617 TRAFFIC ENGINEERING LAB

Internal Assessment/Evaluation: 25 Marks

External Examination: 25 Marks

Duration of Examination: 03 Hours

List of experiments:

1. Traffic surveys like traffic volume count and classified traffic volume count
2. Parking study
3. Intersection turning movements
4. Spot speeds
5. Traffic Volume and speed study using Videography
6. Study of Performa for Road side and house hold interviews
7. At least two full day Visits at site

M TECH: TRANSPORTATION ENGINEERING

HE – 612

PAVEMENTS DESIGN AND CONSTRUCTION TECHNIQUES

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Factors affecting design and performance of pavements—Pavement layers - types, functions, choice. Pavement design factors, loads – axle load distribution, ESWL, EWL, VDF due to varying loads and CSA, 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.

Flexible pavement design: Stresses and Deflection / strain in flexible pavements: Application of elastic theory, stresses, deflections / strains in single, two and three layer system, Applications in pavement design. Empirical, 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.

Rigid pavement design: 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.

Brief introduction to earthwork machinery: shovel, hoe, clamshell, dragline, bulldozers, cleaning and grubbing, excavation for road and drain, principles of field compaction of embankment/subgrade. Compacting equipments. Granular roads. Construction steps of GSB, WBM and WMM. Construction of cement concrete roads: machinery involved in construction, slip-form pavers, joints in CC pavements, IRC and MORTH specifications.

Construction of bituminous pavements: various types of bituminous constructions. Prime coat, tack coat, seal coat and surface dressing. Construction of BUSG, premix carpet, BM, DBM and AC. Brief coverage of machinery for construction of bituminous roads: bitumen boiler, sprayer, pressure distributor, hot-mix plant, cold-mix plant, tipper trucks, mechanical paver or finisher, rollers. Mastic asphalt. IRC and MORTH specifications.

Construction of other types of pavements: basic concepts of the following: reinforced cement concrete pavements, prestress concrete pavements, roller compacted concrete pavements and fibre reinforced concrete pavements. Use of fly ash in concrete roads.

Special problems in construction & maintenance of hill roads, land slide, causes, investigation, and preventive and remedial measures, protection of embankment and cut slopes. Drainage: Construction of surface and subsurface drainage system for roads. Drainage of urban roads.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Khanna and Justo, "Highway Engineering", Nem Chand and Bros., Roorkee
- Peurifoy, R.L., and Clifford, JS "Construction Planning Equipment and Method" - McGraw Hill Book Co. Inc.
- MoRTH "Manual for Construction and Supervision of Bituminous Works"- 2001, Indian Roads Congress

M TECH: TRANSPORTATION ENGINEERING

HE – 614 HIGHWAY MATERIALS

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Soils: Characteristics of soil, Centrifuge moisture equivalent, Colour, Field moisture equivalent, Grain shape, Lineal shrinkage and volumetric change, Particle sizes and distribution, Plasticity, Presence of fines, Specific gravity, State of compaction. Grain or particle size classification, Textural classification, Highway research Soil classification systems board classification of soils, Indian Standard soil classification Soil stabilizers: Bituminous materials, Cementing agents, Chemical stabilizers

Aggregates: Types of road aggregates, Requirements of a good road aggregate, Tests for road aggregates.

Bituminous Materials: Asphalt, Bitumen, Cutback bitumen, Bitumen emulsion, Tar, Road oil, Primers, Manufacturing of bitumen, Functions of bituminous materials, Tests for bituminous materials.

Portland cement– types, source, functions, requirements, properties, tests and specifications for use in various components of road.

Low Cost Materials: Earth roads, Kankar roads, Gravel roads, Moorum roads, Traffic bound macadam roads, Water bound macadam roads.

Polymer and Rubber Modified binders: Physical and chemical properties. Marginal and waste materials in road construction, properties and scope. Performance based mix design Approaches. Visco-elastic properties of bitumen and bituminous mixture.

Soil stabilized roads: use of geo-synthetics. Use of Fly-ash in road embankment and cement concrete mixes. Innovative Materials.

Mix design: Proportioning of materials, Requirement of bitumen mixes, design of bituminous mix, Marshall method, Hubbard method, Rothfutch method of bituminous mix design.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Khanna and Justo, "Highway Materials Testing" - Nem Chand and Bros., Roorkee.
- "Bituminous materials in Road Construction"- HMSO Publication
- W.Ronald Hudson, Ralph Haas and Zeniswki "Modern Pavement Management"- Mc Graw Hill and Co

M TECH: TRANSPORTATION ENGINEERING

HE – 616 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF HIGHWAY PROJECTS

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Environmental effects of transport; problems of identification; Environmental Impact Assessment: Evaluation of environmental impact due to construction. of new facilities and the effect of traffic thereon due to Bypasses, widening/four laning, expressway; grade separators.

Assessment and attenuation; Noise; vibration; air pollution; Measurement of Noise and Air pollution. emission levels, air-pollution dispersion, The box model, noise generation, noise measurement, noise propagation and mitigation strategies, noise measures, mathematical models of transportation noise, energy consumption and related issues.

Environmental traffic management. Co-ordinated signal system on urban. arterial road intersections to reduce air pollution.

Pedestrian delay and danger; severance; accidents; Visual intrusion and aesthetics; Toxic freight; construction effects; Land consumption and land-use effects; planning blight and compensation; Global climate, energy and resource use; and sustainability, Gov policies and requirements for clearances for Road projects.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Betty Bowers Marriott, Environmental Impact Assessment: A Practical Guide, McGraw-Hill Professional, 1997.
- Peter Morris & Riki Therivel, Methods of Environmental Impact Assessment, Routledge, 2001.
- R. K. Jain, L. V. Urban, G. S. Stacey, H. E. Balbach, Environmental Assessment, McGraw-Hill

M TECH: TRANSPORTATION ENGINEERING

HE – 618 HIGHWAY MATERIALS LAB

Internal Assessment/Evaluation: 25 Marks

External Examination: 25 Marks

Duration of Examination: 03 Hours

List of Experiments:

1. Aggregate crushing value test.
2. Abrasion test.
3. Aggregate impact test.
4. Soundness test
5. Shape test.
6. Water absorption and specific gravity tests.
7. Penetration test.
8. Stripping value test.
9. Ductility test.
10. Softening point test.
11. Flash & fire point test.
12. Viscosity test.
13. Float test,
14. Loss on heating test,
15. Solubility test,
16. Specific gravity test,
17. Water content test
18. CBR test.

M TECH: TRANSPORTATION ENGINEERING

HE – 621 TRANSPORT PLANNING

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Introduction: Transportation Problems in Developing Countries, Characteristics of different modes of transportation; Principles of co-ordination and operation control, Elements in urban transit system. Introduction to transport planning, approaches to transport planning, objectives-led planning, environment, economy, equity, safety, option generation, pricing, issues related to the role of transport in development; identification and analysis of problems, issues and constraints in regional and urban development.

Transportation Planning Process: Factors to be considered; land use transportation planning; Aims of sustainable land-use and transport planning; approaches to urban planning; urban planning & travel patterns; zoning and development control exercise; designing for sustainability: local, city, national; integrated case study. Systems approach. Dimension of the widening role of urban transportation systems planning, and transport system models. Comparison and evaluation of various Models. Simultaneous travel demand models: Parameter Estimation and Validation.

Transport Surveys: Planning of different types of surveys and interpretation, travel demand; Traffic surveys for mass transit system planning. Fleet planning and scheduling.

Trip Generation and Distribution: Factors governing trip generation and attraction; Zonal models; Category analysis; Methods of trip distribution; Application of gravity model.

Modal Split and Assignment: Factors affecting modal split; Modal split in transport planning; principles of traffic assignment; Assignment techniques

Transportation impact study: development concepts. Data Collection and use of surveys. The role of Transport planning in the overall models for regional system. Methodology and models for regional transportation system, planning, implication frame work, case studies.

Regional Transport Models and Network Planning: Factors affecting goods and passenger traffic; Prediction of traffic; Growth factor models; Time function iteration models; Internal volume forecasting models. Network Characteristics - Circuitry, Connectivity, Mobility, Accessibility and Level of Service Concepts - Network Structures and Indices – Network Planning – Evaluation - Rural Road Network Planning.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Hutchinson, B.G., "Principles of Urban Transport System Planning" – McGraw Hill Book Co.
- Kadiyali, L.R., "Traffic Engineering and Transportation Planning" – Khanna Publication.
- Institute of Traffic Engineers – "An Introduction to highway Transportation Engineering".

M TECH: TRANSPORTATION ENGINEERING

HE – 623 RESEARCH METHODOLOGIES

Internal Assessment/Evaluation: 40 Marks

External Examination: 60 Marks

Duration of Examination: 03 Hours

Introduction to Educational Research: Concept; types – basic; applied and action; Need for educational research; Reviewing Literature; Need; Sources – Primary and Secondary; Purposes of Review; Scope of Review; steps in conducting review.

Identifying and defining research problem: Locating; analyzing stating and evaluating problem. Generating different types of hypotheses and evaluating them.

Methods of Research: Descriptive research design - survey; case study; content analysis; Ex-post Facto Research; Co relational and Experimental Research; Design and development of measuring instruments; Tests; questionnaires; checklists; observation schedules; evaluating research instruments; selecting a standardized test.

Data Collection: Procedure of data collection; Aspects of data collection; coding data for analysis; Statistical Methods of Analysis.

Descriptive statistics: Meaning; Graphical representations; mean; Range and standard deviation; characteristics and uses of normal curve; Inferential statistics: t-test; Chi-square tests; correlation (rank difference and product moment); ANOVA (one way); Selecting appropriate methods.

Procedure for writing a research proposal: Purpose; types and components of research proposal; Procedure for writing a research report; Audiences and types of research reports; Format of research report and journal articles.

Strategies for evaluating; Research disseminating and utilizing research – An Overview

Practice Tasks:

- *Define a research problem in engineering education/industry after studying problem situation and literature*
- *Given the purpose, objectives of research, write hypotheses*
- *Select research designs for the given research objectives*
- *Identify the measuring instruments for the given research objectives/hypotheses*
- *Identify the appropriate statistical methods of analysis for the given research proposal.*
- *Critically analyse the given research reports its hypothesis, design, measuring tools, statistical analysis, interpretation etc. to identify the gaps or weaknesses in the study.*

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Kothari, C. R., Research Methodology: Methods and Techniques, New age International publication.
- Borg; W and Gall; M. Educational Research: An Introduction; New York; Longman.2003
- Cohen; L. Educational Research in Classrooms and Schools! A Manual of Materials and Methods NY: Harper and Row Publishers.2000

M TECH: TRANSPORTATION ENGINEERING

HE – 625 SEMINAR

Internal Assessment/Evaluation: 50 Marks

The student is required to deliver a seminar on some emerging topics of Highway Engineering. Senior faculty will supervise the students in selecting and preparation of the same. The student will submit two copies of seminar report and shall make oral presentation as per time schedule decided by the faculty concerned. Internal Evaluation will be made on the basis of report, presentation and the discussion during the presentation.

M TECH: TRANSPORTATION ENGINEERING

MSE – 628 DISSERTATIONS

Internal Assessment/Evaluation: 150 Marks

External Examination: 250 Marks

The primary objective of this course is to enhance the student ability to analyze and carry out independent investigations etc. Each student will carry out independent work which should involve creativity, innovation and ingenuity. A dissertation supervisor (s) having at least post- graduate qualification, from industry/research organization shall be assigned to the student approved by the competent authority. *In no case, the candidate can have more than two dissertation supervisors.* Dissertation work shall comprise of literature survey, problem formulation, methodology used, S/W, H/W tools used, Results and discussion followed by the conclusions & further scope of work in that area. Industry oriented projects may be encouraged for the purpose.

The submission of dissertation shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, and certified in the report) in the relevant refereed journal/ conference. The final dissertation external examination in 4th semester shall be taken by a panel of examiners comprising of concerned Supervisor(s), one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, one for each supervisor (s), examiner and the university/ department, are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: TRANSPORTATION ENGINEERING

HE – 711 AIRPORT INFRASTRUCTURE DESIGN

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Introduction: Growth of air transport, airport organization and associations, Classifications of airports airfield components, airport traffic zones and approach areas.

Aircraft Characteristics Related to Airport Design: Components, size turning radius, speed, airport characteristics

Capacity and Delay: Factors affecting capacity, Determination of runway capacity related to delay, gate capacity, taxiway capacity

Airport planning and surveys: Runway length and width, sight distances, longitudinal and transverse grades, runway intersections, taxiways, clearances, aprons, numbering, holding apron.

Design of the Terminal area: Operational concepts, space relationships and area requirements, noise control, vehicular traffic and parking at airports.

Airport Grading and Drainage: Grading of airport area, hydrology, design of drainage systems, construction methods, layout of surface drainage and subsurface drainage system.

Air Traffic Control and Aids: Runways and taxiways markings, day and night landing aids, airport lighting and other associated aids.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- "Planning and Design of Airports" - Robert Horenjeff, 2nd edition, McGraw Hill Book Co.
- "Airport Planning and Design"- Khanna, Arora and Jain, Nem Chand and Bros., Roorkee
- Virender Kumar and Satish Chandra, "Airport Planning and Design"- Galotia Publication press.

M TECH: TRANSPORTATION ENGINEERING

HE – 713 GIS IN HIGHWAY ENGINEERING

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

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

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

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

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

Implementing a GIS: Awareness, Developing System Requirements, Evaluation of alternative systems, System justification and Development of an implementation plan, System acquisition and start up, Operation of the system.

Applications in Transportation Engineering I: Intelligent Transport System, Urban Transport Planning, Highway Alignment, Traffic Congestion analysis and Accident Studies.

Applications in Transportation Engineering II: Environmental impact assessment, Transport System Management, Road Network Planning, Collecting Road Inventory.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Remote Sensing and Image Interpretation, by Lillisand, T.M. & Kiefer R.W., John Wiley and Sons.
- Introduction to Remote Sensing, by Campbell, J.B. Taylor and Francis.
- Principles of Geographic information systems, Burrough, P.A and MacDonnel, R.a , Oxford University press

M TECH: TRANSPORTATION ENGINEERING

HE – 715 MASS TRANSPORTATION SYSTEMS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Role of Transportation: History of transit, Recent Trends in transit, Mass transportation characteristics, Demand Characteristics: Spatial, temporal and behavioral characteristics.

Mass Transportation Planning: Transportation demand surveys, Mass transportation demand estimation, Demand projection, Trip generation, Trip distribution, Model split and route assignment. Bus scheduling, Transit corridor identification.

Transport system Performance: Performance evaluation and analysis, Structure of decision making, Evaluation and selection methods, and selection procedure.

Generation of alternative schemes, Economic evaluation methods.

Terminals: Public transport infrastructures, Functions of terminals, Design, Typical Terminal characteristics.

Scheduling and Routes: Service analysis, Vehicle dispatch policy, Vehicle Requirements, Spacing of bus stops, Route spacing and performance.

Management: Operational and management issues in transport planning, integration of public transport modes, Reserved bus lanes and signals, Vehicle monitoring and control system, Nodal coordination. BRT corridors.

Special Systems: Multimodal transport systems, People mover systems, Underground transportation, para transit, Rail transit system, case studies.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Khisthy, Lal, Transporation Engineering, PHI, Delhi, 2008 Hay, W.W., An Introduction to Transportation Engineering, 2nd Ed., John Wiley & Sons, 2001
- Dickey, J.W., et. al., Metropolitan Transportation Planning, TMH edition, 2002.
- Paguette, R.J., et.al, Transportation Engineering - Planning and design, 2nd Ed., John Wiley & Sons.

M TECH: TRANSPORTATION ENGINEERING

HE – 712 LOW VOLUME ROADS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Planning of rural road net work – Concept of core and non-core roads, general principle, guidelines laid down in recent 20-year plans and in PMGSY

Guidelines for alignment and geometric design of rural / low volume roads and safety aspects.

Investigations and surveys, soil and material surveys, Promoting use of alternate marginal / low cost / waste / stabilized local materials in rural road works, fly ash in fill and other layers, use of other waste materials. Soil stabilization methods – mechanical, soil cement, soil lime, soil-lime-pozzolana, soil-lime-cement stabilization

Design of different types of pavements for rural roads, choice of pavement type / pavement materials. Guidelines and specifications by IRC, NRRDA and MORD

Road drainage – study of requirements of surface and subsurface drainage, and cross drains, standard design of culverts and small bridges

Specifications and steps for the construction of different components of rural / low volume roads including pavement layers, quality control during construction

Maintenance of rural roads – shoulders, side and cross drains. Pavement distress, different types of failures and maintenance measures. Preventive maintenance works.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- IRC "Rural Roads Manual"-Special Publication 20 – 2002, Indian Roads Congress.
- IRC SP- 26 "Report Containing Recommendations of IRC Regional Workshops on Rural Road Development"- 1984, Indian Roads Congress
- MORD "Specification for Rural roads"
- CRRRI "Low Volume Roads' Central Road Research Institute"-New Delhi

M TECH: TRANSPORTATION ENGINEERING

HE – 714 HIGHWAY SUBGRADE AND FOUNDATION ANALYSIS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Introduction: Soil Mechanics applications to Highway Engg. Soil formations, Types, Regional Soil deposits of India, Index properties, their determination, importance, various soil classification systems, HRB classification, problems.

Soil Compaction: Introduction, Lab Tests, Factors affecting, Structure & Engg behavior of compacted cohesive soil, Field compaction specifications Filed compaction control, Different types of Equipments used for compaction, their choice.

Shear strength of soil: Introduction, Importance, Measurements, shear strength of clay, Sand, Elastic properties of soil – Tangent, Secant modulus, Stress – Strain curves, Poisson's ratio, Shear Modulus.

Stability of slopes: Introduction, Types, Different methods of analysis of slopes for various soils, Location of most critical circle, Earth dam slopes stability, Taylor's stability number. Effect of Earthquake Force, problems on above.

Permeability of soil: Darcy's Law, Validity, Soil-water system, Types, Determination of permeability, problems.

Site Investigation: Introduction, Planning exploration programmes, Methods, Samplers, SPT, Subsoil investigation Report, Geophysical methods.

Highway Drainage: Introduction, Importance, Surface drainage, Sub-surface drainage, methods, , Land slides – definition, classifies, factors producing.

Reinforced Earth structures: Introduction , Components, Advantages, Types of stability – external, Internal, (No problems), Geo textiles – types, Functions, their uses in road embankments and railway works, other uses.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- "Basic and Applied soil Mechanics", Gopal Ranjan, ASR Rao, New Age International Publishers
- "Soil Mechanics & Foundation Engg", Dr.B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Laxmi Publications (P) Ltd, 16th edition.
- "Soil Mechanics & Foundation Engg" – K.R. Arora Standard Publishers Distributors.

M TECH: TRANSPORTATION ENGINEERING

HE – 716 HIGHWAY DRAINAGE SYSTEMS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Drainage materials. Methods of maintenance of different types of pavements;

Special problems in high rainfall areas. Frost heave

Subgrade Drainage and Earthworks Consolidation

Sub-Base Drainage

Failure Due To Hydraulic Pressure, Failure Due To Binder Stripping, effect of water table variations

Drainage of Porous Surface Courses

Design procedures and IRC Guidelines for Drainage of Urban Roads and maintenance of drainage system

Design and construction of surface and sub-surface drainage systems for highways and airports.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Highway Engineering by L.R. Kadyali, Nem Chand & Brothers, Roorkee
- RC SP: 42 –1994, "Guidelines on Road Drainage"- Indian Roads Congress
- Harry.R.Cedergern. "Drainage of Airfield pavements"- John Wiley and Sons.

M TECH: TRANSPORTATION ENGINEERING

HE – 721 CORRIDOR MANAGEMENT

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Congestion: Management of congested facilities, Expressway and surface streets, types of congestion, key issues in Expressway congestion, congestion issues related to the surface street system, administrative and planning actions, techniques for addressing Expressway system congestion, congestion due to a bottleneck, cumulative demand and capacity, signal remedies in addressing surface street congestion, Expressway surveillance and control.

Introduction to Expressway Systems: Expressway as part of highway system, operations and design features of Expressway, capacity analysis of basic freeway sections, capacity analysis of Expressway weaving sections, capacity analysis of ramps and ramp junctions, calibrating relationships for freeway analysis. Non access controlled multilane Highways.

Expressway Corridor Management: Management strategies, Components of corridor management, Surveillance and control, Corridor Signage, Building Construction and Land Use, Entrances to Provincial Highways, Encroachments on the MTO Right-of-Way, high occupancy vehicle facilities and incentives, enforcement and control, traffic restrictions, organisational structure, policies and procedure for effective corridor management.

Intelligent Vehicle Highway Systems: Introduction, IVHS programs, role of IVHS in transportation systems of tomorrow, IVHS categories, benefits and costs of IVHS, institutional issues, key considerations. Safety management systems.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Papacostas, C.A.,, Fundamentals of Transportation Engineering', Prentice-Hall of India Private Limited, New Delhi.2000.
- William R. McShane and Roger P. Roess,, Traffic Engineering', Prentice hall, New Jersey.2000.
- MOST, 'Manual For Safety in Road Design', Ministry of Surface Transport. Govt. of India.
- "Vehicle routing : methods and studies" / edited by Bruce L. Golden and Arjang A. Assad. Amsterdam : North-Holland

M TECH: Transportation ENGINEERING

HE – 723 DESIGN AND CONSTRUCTION OF BRIDGES AND FLYOVERS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Introduction–classification and components of bridges– layout and planning– Structural forms of bridge decks – grillage analysis of slab decks, beam and slab decks, and cellular decks. Standard specifications for bridges – IRC loadings for road bridges – standards for railway bridges. Loads on Bridges: Dead loads, live loads, dynamic effects of vehicles, longitudinal forces, centrifugal forces, wind loads, earth quake forces, stream flow pressure, load combinations, design examples

Design of T beam bridges – balanced cantilever bridges – rigid frame bridges – Arch bridges – bow string girder bridges.

Design of Bridge Slabs: Longitudinally reinforced deck slabs, transversely reinforced bridge slabs

Design of plate girder bridges – steel trussed bridges – Introduction to long span bridges: cable stayed bridges and suspension bridges –instability.

Principles of Planning of Elevated Rail Transit System, grade separation structures, pedestrian crossing and sub- ways.

Forces on piers and abutments – Design of piers and abutments – types of wing walls – types of bearings – design of bearings.

Design of Prestressed Concrete Bridges: Design code, design examples. Segmental Box bridges - precast sections, criteria, design examples

Sub-Structure Design: Foundation investigation, bearings, bridge pier design, and abutment design. Examples.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- D.Johnson Victor, Essentials of bridge engineering, Oxford & IBH publishing Co. Ltd., New Delhi.
- N.Krishna Raju, Design of bridges, Oxford & IBH publishing Co. Ltd., New Delhi.
- Jaikrishna and O.P Jain, Plain and reinforced concrete-vol.II, Nem Chnand & Bros,Roorkee.
- Raina, R.K, 'Principles of Design of RCC Bridges, Tata McGraw Hill,1999.

M TECH: Transportation ENGINEERING

HE – 725 CONCRETE TECHNOLOGY

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Cements & Admixtures: concrete as a structural material, various types of cements, Portland cement – chemical composition – Hydration, Setting of cement – Structure of hydrate cement – Test on physical properties – Different grades of cement – Admixtures – Mineral and chemical admixtures.

Aggregates: Classification of aggregate – Particle shape & texture – Bond, strength & other mechanical properties of aggregate – Specific gravity, Bulk density, porosity, adsorption & moisture content of aggregate – Bulking of sand – Deleterious substance in aggregate – Soundness of aggregate – Alkali aggregate reaction – Thermal properties – Sieve analysis – Fineness modulus – Grading curves – Grading of fine & coarse Aggregates – Gap graded aggregate – Maximum aggregate size.

Fresh Concrete: Workability – Factors affecting workability – Measurement of workability by different tests – Setting times of concrete – Effect of time and temperature on workability – Segregation & bleeding–Mixing and vibration of concrete–Steps in manufacture of concrete – Quality of mixing water.

Hardened Concrete : Water / Cement ratio – Abram's Law – Gelspae ratio – Nature of strength of concrete – Maturity concept – Strength in tension & compression – Factors affecting strength – Relation between compression & tensile strength - Curing.

Testing Of Hardened Concrete: Compression tests – Tension tests – Factors affecting strength – Flexure tests – Splitting tests – Non-destructive testing methods – codal provisions for NDT.

Elasticity, Creep & Shrinkage – Modulus of elasticity – Dynamic modulus of elasticity – Poisson's ratio – Creep of concrete – Factors influencing creep – Relation between creep & time – Nature of creep – Effects of creep – Shrinkage – types of shrinkage.

Mix Design : Factors in the choice of mix proportions – Durability of concrete – Quality Control of concrete – Statistical methods – Acceptance criteria – Proportioning of concrete mixes by various methods – BIS method of mix design.

Special Concretes: Light weight aggregates – Light weight aggregate concrete – Cellular concrete – No-fines concrete – High density concrete – Fibre reinforced concrete, Polymer concrete, High performance concrete – Self consolidating concrete.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Concrete Technology, by M.L. Gambhir, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

- Concrete Technology, by A. R. Santhakumar, Oxford University Press

M TECH: Transportation ENGINEERING

HE – 722 PROJECT PLANNING AND MANAGEMENT

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Definitions, Functions, characteristics of project planning and principles of Planning and Management.

Network Techniques: Bar milestone charts, Planning and scheduling of PERT / CPM
Time cost optimisation, Probability concepts

Allocation of resources and resource levelling, Updating, controlling and monitoring.

Equipment: Importance, need, functions and principles, types of equipment and their uses, selection planning and matching of construction plant and equipment.

Financial Management: Concept of cost, profit, price, budgeting, cash flow, cost control methods, sources of funds, balance sheet, profit and loss statement.

Account Procedure of PWD Works. Classification of Works, Muster Roll, Deposit works. Cash Book, Imprest, temporary Advance, MAS Account, Stores, Indent , Tools and Plants

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Construction Planning, Equipment and Methods by Robert L. Peurifoy, Tata Mcgraw Hill Publication New Delhi
- Project Planning and Control with PERT and CPM by B.C. Punima and Khandelwal, Laxmi Publication New Delhi.
- Construction Management & Planning by B. Sengupta and Guha, Tata Mcgraw hill Publication New Delhi

M TECH: **Transportation** ENGINEERING

HE – 724 TRANSPORTATION DATA ANALYSIS

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Multivariate Data Analysis Techniques: Types of Data, Basic Vectors and Matrices, Sample Estimate of Centroid, Standard Deviation, Dispersion, Variance and Covariance, Correlation Matrices, Principle Component, Factor Analysis, ANOVA and Cross Classification Procedure in Multivariate Data Analysis and Application to Problems in Traffic and Transportation Planning.

Analysis and Modelling of Travel Choices: Fundamentals of Micro-Economic Demand Theory – Choice Function – Direct and Cross Elasticities of Demand – Properties of some Empirically Derived Demand Functions – Market Demand; Theory of Behavioural Models, Deterministic and Stochastic Models, Random Utility Model, Probit, Logit and Discriminant Model Formulations for Mode and Route Choices, Implications; Value of Travel Time Studies.

Concept of Entropy and its Application in Travel Demand Modelling: Definition of Entropy, its relations to Probability and Uncertainty, Entropy of Probability Distribution, Entropy and Bayesian Statistics, Application of Entropy Concepts in Transport Models: Theory of Trip Distribution, Mode Split and Route Split, Production, Attraction, Doubly Constrained Gravity Models and Derivation of Intervening Opportunity Model, Missing Information and Use of Entropy in Travel Demand Modelling: Entropy and Information Theory Approaches for Estimating the Travel Demand using Indirect Methods such as Use of Link Volume Counts, Turning Counts, etc.

Forecasting using Time Series Analysis: Basic Components of Time Series – Stationery and Non-Stationery Processes- - Smoothing and Decomposition Methods – Correlation and Line Spectral Diagrams – Auto Correlations and Moving Averages; Introduction to Box-Jenkins Forecasting

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, Multivariate Data Analysis, Prentice Hall; 2005.
- Richard A. Johnson, Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall.
- Simon P. Washington, Matthew G. Karlaftis & Fred L. Mannering, Statistical and Econometric
- Methods for Transportation Data Analysis, Chapman & Hall/CRC.

M TECH: **Transportation** ENGINEERING

HE – 726 GROUND IMPROVEMENT TECHNIQUES

Internal Assessment/Evaluation: 30 Marks

External Examination: 45 Marks

Duration of Examination: 03 Hours

Introduction to different methods of ground improvement and its importance. Mechanical method of ground improvement, Ruthfuch method; methods based on PI.

Ground Freezing, methods, Hydrogeology of frozen soils, strength and behaviour of frozen soils. Ground heating, effect on soil properties, methods.

Drainage Techniques, filter drains, sand drains, sandwicks & band drains, lime columns. Electro-osmosis and Electrochemical stabilization.

Compaction & consolidation techniques viz. pre-compression, compaction piles, vibro-compaction (Vibro-floatation, Terra-probe, vibro-replacement, concrete columns & vibro-displacement) Dynamic compaction, explosive compaction.

Soil Reinforcement, load transfer mechanism, strength development, anchored earth. In-situ reinforcement techniques viz soil nailing, reticuled micropiles, soil dowels and anchors. Grouts, properties, penetration, clay, cement clay, cement, clay-chemical, chemical and Bituminous grouts, grouting methods viz penetration, claquage, compaction & jet.

Reinforced earth; Introduction, Mechanism of reinforced types of reinforcement strength characteristics. Design of reinforced earth retaining walls, abutments, earth slopes.

Exclusion techniques viz. sheet piles, contiguous bored piles, secant piles, slurry trenches. Diaphragm walls. Design of stone columns.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Ground Improvement Techniques by P. Purushotham Raj, Tata McGraw Hill, New Delhi.
- Engineering Treatment of Soils by F.G. Bell, E & FN Spon Publishers, UK.
- Engineering Principles of Ground Modification by M.R. Hausmann, McGraw Hill Publishers, New York.

Recommended Books

M TECH: Transportation ENGINEERING HE – 611 GEOMETRIC DESIGN

- Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna publishers
- Khanna and Justo, "Highway Engineering"- Nem Chand and Bros., Roorkee
- The Institute of Transportation Engineers, Transportation and Traffic Engg. Hand Book, Prentice Hall (1982) Chapters 8,17,21.23 and 24.

M TECH: Transportation ENGINEERING HE – 613 TRAFFIC ENGINEERING

- Kadiyali L.R. "Traffic Engineering and Transportation Planning"-Khanna Publication, New Delhi
- Salter RJ and Hounsell NB, "Highway, Traffic Analysis and Design"- Macmillan Press Ltd., London
- Nicholas J Garber, Lester A Hoel, "Traffic & Highway Engineering"- Third edition, Bill Stenquist.

M TECH: Transportation ENGINEERING HE – 615 ROAD SAFETY AND AUDIT

- BABKOV, V.F. 'Road conditions and Traffic Safety', MIR publications, - 1975.
- K.W. Ogden, 'Safer Roads – A Guide to Road Safety Engg.' Averbury Technical, Ashgate Publishing Ltd., Aldershot, England, 1996.
- Kadiyali, L.R., 'Traffic Engineering and Transport Planning', Khanna Publications.
- Road safety audit Manual

M TECH: Transportation ENGINEERING HE – 612 PAVEMENTS DESIGN AND CONSTRUCTION TECHNIQUES

- Khanna and Justo, "Highway Engineering", Nem Chand and Bros., Roorkee
- Peurifoy, R.L., and Clifford, JS "Construction Planning Equipment and Method"- McGraw Hill Book Co. Inc.
- MoRTH "Manual for Construction and Supervision of Bituminous Works"- 2001, Indian Roads Congress

M TECH: Transportation ENGINEERING HE – 614 HIGHWAY MATERIALS

- Khanna and Justo, "Highway Materials Testing"- Nem Chand and Bros., Roorkee.
- "Bituminous materials in Road Construction"- HMSO Publication
- W.Ronald Hudson, Ralph Haas and Zeniswki "Modern Pavement Management"- Mc Graw Hill and Co

M TECH: Transportation ENGINEERING

HE – 616 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF HIGHWAY PROJECTS

- Betty Bowers Marriott, Environmental Impact Assessment: A Practical Guide, McGraw-Hill Professional, 1997.
- Peter Morris & Riki Therivel, Methods of Environmental Impact Assessment, Routledge, 2001.
- R. K. Jain, L. V. Urban, G. S. Stacey, H. E. Balbach, Environmental Assessment, McGraw-Hill

M TECH: Transportation ENGINEERING

HE – 621 TRANSPORT PLANNING

- Hutchinson, B.G., "Principles of Urban Transport System Planning"– McGraw Hill Book Co.
- Kadiyali, L.R., "Traffic Engineering and Transportation Planning"– Khanna Publication.
- Institute of Traffic Engineers – "An Introduction to highway Transportation Engineering".

M TECH: Transportation ENGINEERING

HE – 623 RESEARCH METHODOLOGIES

- Kothari, C. R., Research Methodology: Methods and Techniques, New age International publication.
- Borg; W and Gall; M. Educational Research: An Introduction; New York; Longman.2003
- Cohen; L. Educational Research in Classrooms and Schools! A Manual of Materials and Methods NY: Harper and Row Publishers.2000

M TECH: Transportation ENGINEERING

HE – 711 (ELECTIVE I) AIRPORT INFRASTRUCTURE DESIGN

- "Planning and Design of Airports" - Robert Horenjeff, 2nd edition, McGraw Hill Book Co.
- "Airport Planning and Design"- Khanna, Arora and Jain, Nem Chand and Bros., Roorkee
- Virender Kumar and Satish Chandra, "Airport Planning and Design"- Galotia Publication press.

M TECH: Transportation ENGINEERING

HE – 713 (ELECTIVE I) GIS IN HIGHWAY ENGINEERING

- Remote Sensing and Image Interpretation, by Lillisand, T.M. & Kiefer R.W., John Wiley and Sons.
- Introduction to Remote Sensing, by Campbell, J.B. Taylor and Francis.
- Principles of Geographic information systems, Burrough, P.A and MacDonnel, R.a , Oxford University press

M TECH: Transportation ENGINEERING

HE – 715 (ELECTIVE I) MASS TRANSPORTATION SYSTEMS

- Khisthy, Lal, Transporation Engineering, PHI, Delhi, 2008 Hay, W.W., An Introduction to Transportation Engineering, 2nd Ed., John Wiley & Sons, 2001
- Dickey, J.W., et. al., Metropolitan Transportation Planning, TMH edition, 2002.
- Paguette, R.J., et.al, Transportation Engineering - Planning and design, 2nd Ed., John Wiley & Sons.

M TECH: Transportation ENGINEERING
HE – 712 (ELECTIVE II) LOW VOLUME ROADS

- IRC "Rural Roads Manual"-Special Publication 20 – 2002, Indian Roads Congress.
- IRC SP- 26 "Report Containing Recommendations of IRC Regional Workshops on Rural Road Development"- 1984, Indian Roads Congress
- MORD "Specification for Rural roads"
- CRRRI "Low Volume Roads' Central Road Research Institute"-New Delhi

M TECH: Transportation ENGINEERING
HE – 714 (ELECTIVE II) HIGHWAY SUBGRADE AND FOUNDATION ANALYSIS

- "Basic and Applied soil Mechanics", Gopal Ranjan, ASR Rao, New Age International Publishers
- "Soil Mechanics & Foundation Engg", Dr.B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Laxmi Publications (P) Ltd, 16th edition.
- "Soil Mechanics & Foundation Engg" – K.R. Arora Standard Publishers Distributors.

M TECH: HIGHWAY ENGINEERING
HE – 716 (ELECTIVE II) HIGHWAY DRAINAGE SYSTEMS

- Highway Engineering by L.R. Kadyali, Nem Chand & Brothers, Roorkee
- RC SP: 42 –1994, "Guidelines on Road Drainage"- Indian Roads Congress
- Harry.R.Cedergern. "Drainage of Airfield pavements"- John Wiley and Sons.

M TECH: Transportation ENGINEERING
HE – 721 (ELECTIVE III) CORRIDOR MANAGEMENT

- Papacostas, C.A., Fundamentals of Transportation Engineering', Prentice-Hall of India Private Limited, New Delhi.2000.
- William R. McShane and Roger P. Roess,, Traffic Engineering', Prentice hall, New Jersey.2000.
- MOST, 'Manual For Safety in Road Design', Ministry of Surface Transport. Govt. of India.
- "Vehicle routing : methods and studies" / edited by Bruce L. Golden and Arjang A. Assad. Amsterdam : North-Holland

M TECH: Transportation ENGINEERING
**HE – 723 (ELECTIVE III) DESIGN AND CONSTRUCTION OF BRIDGES
AND FLYOVERS**

- D.Johnson Victor, Essentials of bridge engineering, Oxford & IBH publishing Co. Ltd., New Delhi.
- N.Krishna Raju, Design of bridges, Oxford & IBH publishing Co. Ltd., New Delhi.
- Jaikrishna and O.P Jain, Plain and reinforced concrete-vol.II, Nem Chnand & Bros,Roorkee.
- Raina, R.K, 'Principles of Design of RCC Bridges, Tata McGraw Hill,1999.

M TECH: Transportation ENGINEERING
HE – 725 (ELECTIVE III) CONCRETE TECHNOLOGY

- Concrete Technology, by M.L. Gambhir, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Concrete Technology, by A. R. Santhakumar, Oxford University Press

M TECH: Transportation ENGINEERING
HE – 722 (ELECTIVE IV) PROJECT PLANNING AND MANAGEMENT

- Construction Planning, Equipment and Methods by Robert L. Peurifoy, Tata McGraw Hill Publication New Delhi
- Project Planning and Control with PERT and CPM by B.C. Punima and Khandelwal, Laxmi Publication New Delhi.
- Construction Management & Planning by B. Sengupta and Guha, Tata McGraw hill Publication New Delhi

M TECH: Transportation ENGINEERING
HE – 724 (ELECTIVE IV) TRANSPORTATION DATA ANALYSIS

- Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, Multivariate Data Analysis, Prentice Hall; 2005.
- Richard A. Johnson, Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall.
- Simon P. Washington, Matthew G. Karlaftis & Fred L. Mannering, Statistical and Econometric
- Methods for Transportation Data Analysis, Chapman & Hall/CRC.

M TECH: Transportation ENGINEERING
HE – 726 (ELECTIVE IV) GROUND IMPROVEMENT TECHNIQUES

- Ground Improvement Techniques by P. Purushotham Raj, Tata McGraw Hill, New Delhi.
- Engineering Treatment of Soils by F.G. Bell, E & FN Spon Publishers, UK.
- Engineering Principles of Ground Modification by M.R. Hausmann, McGraw Hill Publishers, New York.