I SEMESTER
HIGHWAY MATERIALS

Subject Code : 12CHT11
IA Marks : 50
No. of Lecture Hrs/ Week : 04
Exam Hrs : 03
Total No. of Lecture Hrs. : 52
Exam Marks : 100

Basic road construction materials such as soils, aggregates, bitumen and Portland cement – 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.

Aggregates – Origin, classification, requirements, properties. Tests and specifications on road aggregates for flexible and rigid pavements. Importance of aggregate gradation and shape factor in mix design.

Bituminous binders – different types, properties and uses, physical tests on bitumen, rheological and pavement performance related properties. Modified binders, characteristics and applications in road construction, criteria for selection of different binders.

Bituminous mixes, types, requirements, properties, tests, Marshall method of mix design and super pave mix design.

Portland cement and cement concrete for use in road works – requirements, design of mix for CC pavement, use of additives, IRC specifications & Tests, joint filler and sealer materials.


Note: All Relevant Laboratory & Field Test will be conducted in Batches

REFERENCE 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
4. 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
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
10. “Soil Mechanics for Road Engineers”- HMSO Publication
11. “Bituminous materials in Road Construction”- HMSO Publication

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

PAVEMENT DESIGN AND MANAGEMENT

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Road Pavements and pavement layers - 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, 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.

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.

Flexible 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

7
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.

Pavement management system – Pavement deterioration, objects and Principle of pavement management, use of HDM – 4

REFERENCE BOOKS:
3. Huang, "Pavement Analysis"- Elsevier Publications
7. Khanna and Justo “Highway Engineering”- Nemchand & Bros, Roorkee

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

HIGHWAY CONSTRUCTION AND MAINTENANCE

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Components of road and pavement structure including subgrade, drainage system, functions, requirements and sequence of construction operations

Plants and equipment for production of materials - crushers, mixers, bituminous mixing plants, cement concrete mixers – various types, advantages and choice

Drainage – Assessment of drainage requirements for the road and design of various components, drainage materials, Construction of surface and subsurface drainage system for roads. drainage of urban roads
Road construction equipment – different types of excavators, graders, soil compactors / rollers, pavers and other equipment for construction of different pavement layers – their uses and choice

Pre-construction surveys and marking on ground - Specifications and steps for the construction of road formation in embankment and cut, construction steps for granular sub-base, quality control tests

Different types of granular base course – WMM, CRM, WBM, specifications, construction method and quality control tests.

Different types of bituminous layers for binder and surface courses, their specifications (as per IRC and MORTH), construction method and quality control tests

Different types of sub-base and base course for cement concrete (CC) pavement and construction method. Construction of cement concrete (PQC) pavements and joints, quality control during construction. Construction details of interlocking concrete block pavements

General Aspects: 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

Road maintenance works – 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.

Special problems in construction & maintenance of hill roads, land slide, causes, investigation, and preventive and remedial measures, protection of embankment and cut slopes.

REFERENCE BOOKS:
3. 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
5. “Hand Book on Cement Concrete Roads”- Cement Manufacturers Association, New Delhi

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

TRAFFIC ENGINEERING AND DESIGN

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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.

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,

Accident characteristics, causes, studies, investigations and analysis of individual accidents, statistical analysis, measures to improve road safety.
Traffic regulations and control - Regulation on vehicles, drivers and traffic flow, Traffic control devices – Types & objectives of markings, signs, signals and islands, delineators.

Design of signalized intersections including signal timings as per IRC guidelines. Signal system, use of software.

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.

Design of on-street and off-street parking facilities, pedestrian facilities, bus bays, safety devices

Geometric design features of expressways and different types of Urban Roads

REFERENCE BOOKS:
5. MoRTH “Type Designs for Intersections on National Highways”- Indian Roads Congress
6. MORTH “Manual for Road Safety in Road Design”-Indian Roads Congress
8. Khanna and Justo, “Highway Engineering”- Nem Chand and Bros., Roorkee

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Various steps of preparation and execution of road projects. Investigations for preparation of project reports for new and upgradation 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

Topographic surveys and investigations for finalisation of horizontal alignment and vertical profile of roads, Application of GIS. Design standards and specification for relevant road geometrics.

Soil investigations for assessing the design details of road embankments and cuts, drainage requirements and foundation of cross drainage structures

Material surveys and investigations for availability and choice of basic and alternate materials for road construction and for soil stabilisation

Traffic studies – 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

Environmental and social impact studies and assessment relevant to road upgradation / 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

Preparation of DPR design details, estimates, BOQ, drawings and detailed project report, use of software

Tendering process - Preparation of tender documents for different types of road projects, tender evaluation
REFERENCE BOOKS:
5. MoRTH “Specifications for Road Bridge Works”- 2001, fourth revision, Indian Roads Congress
7. MoRTH “Model Concession Agreement for Small Road Projects”-2000, Indian Roads Congress

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

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.


Stability of slopes: Introduction, Types, Different methods of analysis of slopes for Øu+0 & C-Ø soil, 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, Design of subsurface
drainage system, Road construction in water logged areas, 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.

Reference books

6. IRC – Relevant Codes.
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.

**Pavement surface condition** - Causes, effects, methods of measurement / evaluation and treatment of: a) Pavement slipperiness b) riding quality and unevenness c) rutting d) cracking e) potholes f) edge breaking etc. Rating methods Use of modern equipment for pavement surface condition measurements. Analysis of data, interpretation and application.


Discussion on choice of overlay type and pavement materials over existing flexible and rigid pavements, with different degrees of distress.

Evaluation of new pavement materials, model studies, pavement testing Under controlled conditions, accelerated testing and evaluation methods.

Test track studies. Instrumentation for pavement testing.

**REFERENCE BOOKS:**
3. Per Ulitz “Pavement Analysis” - Elsevier Amsterdam.
5. HRB/TRB/IRC/ “International Conference on structural design of Asphalt pavements”.

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

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No. of Lecture Hrs/ Week : 04
Exam Hrs : 03

Total No. of Lecture Hrs. : 52
Exam Marks : 100

Highway Planning – 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, 20 year road development plan including 1st and 2nd 20 year plan in brief and 3rd and 4th 20 year plan in detail, Land use planning. Land use development – models, problems on the above topics. Highway Planning in India

Highway Engineering Economics, principle, supply and demand models, equilibrium, sensitivity of travel demand, Elasticities – types, models (Kraft 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

Economic analysis, 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.

Highway financing, 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.

REFERENCE BOOKS:
7. “Road User Cost Study in India”- Final Report, Central Road Research Institute, New Delhi, 1982.

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

ROAD CONSTRUCTION PLANNING AND MANAGEMENT

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No. of Lecture Hrs/ Week : 04 Exam Hrs : 03

Total No. of Lecture Hrs. : 52 Exam Marks : 100

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.

Planning of Road Projects – project management framework, scope, project objectives, project environment, causes of project failure, project development process

Resource planning – human resources, project man power grouping, structuring site organisation, construction materials-classification of construction materials, materials usage, materials inventory, cost and budget

Construction equipment and choice-type, capacity and number, task considerations, cost considerations, engineering considerations, equipment acquisition options, optimum location of crushing and mixing plants

Time planning – project work breakdown, determining activities involved, assessment of duration, CPM / PERT network analysis, work scheduling, methods of work scheduling, factors affecting work scheduling,

Planning Control System – resource production, project cost, project time, codification and project management, information system, use of software
REFERENCE BOOKS:
4. IRC “A Manual for the Application of Critical Path Method to Highway Projects in India”
5. Nhai.org, pmgsy.nic.in websites

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

PAVEMENT MANAGEMENT SYSTEM

Subject Code : 12CHT24          IA Marks : 50
No. of Lecture Hrs/ Week : 04    Exam Hrs : 03
Total No. of Lecture Hrs. : 52    Exam Marks : 100

Introduction: components of pavement management systems, pavement maintenance measures, planning investment, research management.

Pavement Performance Evaluation: general concepts, serviceability, pavement distress survey systems, performance evaluation

Pavement Performance Prediction: 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.

Ranking and Optimization Methodologies: Recent developments, sample size selection, economic optimization of pavement maintenance and rehabilitation.

Design alternatives and Selection: 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.
Expert systems and Pavement Management: 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.

REFERENCE BOOKS:
5. NCHRP, TRR and TRB Special Reports.

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

ELECTIVE – II
ADVANCED TRAFFIC ENGINEERING

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

Traffic Forecast – objects, factors governing traffic growth, estimation of traffic growth from past trends, econometric models. Common methods of traffic forecast

Road accidents, causes, scientific investigations and data collection. Analysis of individual accidents to arrive at causes; statistical methods of analysis of accident data, computer analysis. Road safety issues, various measures for road safety - engineering, educational and enforcement measures, Short term and long term measures. Road safety education and training. Economic evaluation of improvement measures by "before and after studies".
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, Elements of area traffic control and Intelligent transportation systems.

**Environmental issues** – air and noise pollution due to road traffic, measurement, control of environmental deterioration. Management of environmental pollution due to road traffic.

**REFERENCE BOOKS:**

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

**APPLIED STATISTICS**

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Introduction to statistical methods, scope aim and limitations, sample, attribute and types of data, sources and collection of data. Accuracy of data

Representation and summarizing data. Frequency distribution, histogram and frequency curves. Ogive curve, Measure of central tendency – arithmetic mean, median and mode dispersion- range, standard deviation, variance and co-efficient of variation, skewness and kurtosis
Introduction to probability & statistics for Traffic Engineering Design –
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

Sampling Techniques – 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.

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


Chi-square test of goodness of fit, student’s t test, Confidence interval.

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

Use of soft wares in statistical analysis – MATLAB, MINITAB

REFERENCE BOOKS:

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
System and Technologies: Urban passenger transportation modes, transit classifications and definitions, theory of urban passenger transport modes, rail transit, bus transit, Para transit and ride sharing, designing for pedestrians, trends in transit ridership and use of different modes.

Comparing Alternatives: Comparing costs, comparative analysis, operational and technological characteristics of different rapid transit modes, evaluating rapid transit

Planning: Transportation system management, system and service planning, financing public transportation, management of public transportation, public transportation marketing.

Transit System Evaluation: Definition of quantitative performance attributes, transit lane capacity, way capacity, station capacity, theoretical and practical capacities of major transit modes, quantification of performance

City traffic: Classification of transportation systems, conventional transportation systems, unconventional transportation systems, prototypes and tomorrow's solutions, analysis and interpretation of information on transportation systems, perspectives of future transportation.

REFERENCE BOOKS:


Methods of strengthening weak foundation soil, acceleration of consolidation and settlement of compressible embankment foundation, vertical sand drains - application, design and construction method.


Use of special materials such as geo-synthetics for drainage and in pavement layers.

Special construction, technique such as reinforced earth retaining walls – design, economics and construction method, Nailing technique and its application

Road construction on desert region and coastal areas, alternative methods, road construction on high altitudes, hilly and mountainous terrain.

REFERENCE BOOKS:
2. IRC-75 “Guidelines for the design of High embankments”- IRC, 1979.

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Introduction: Working principle, capacity, rate of production, applications, advantages and limitations of various types of construction equipment

Equipment for earthwork excavation, hauling and spreading: 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

Plants for aggregates production – 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

Paving and compacting equipment: Different types of pavers and compacting equipment for bituminous mixes, Fixed form type paver and Slip form type paver for CC pavements – their advantages

Miscellaneous Equipment: Kerb casting equipment, road marking equipment, bitumen sprayers, water tankers

Equipment Management: Equipment planning, forecasting equipment requirement, maintenance, workshop, work study, Selection of Construction Equipment - task considerations, cost considerations, equipment acquisition options

REFERENCE BOOKS:
4. “Operation Manuals of various equipment manufacturers”.

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

Planning and 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.

REFERENCE BOOKS:

3. “Airport Planning and Design” - Khanna, Arora and Jain, Nem Chand and Bros., Roorkee
RURAL ROADS

Planning of rural road network – general principle, guidelines laid down in recent 20-year plans and in PMGSY

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

Investigations and surveys, soil and material surveys, scope for use of alternate marginal / low cost / waste / stabilized local materials in rural road works

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.

REFERENCE BOOKS:

2. IRC SP- 26 “Report Containing Recommendations of IRC Regional Workshops on Rural Road Development”- 1984, Indian Roads Congress
5. MoRTH “Specifications for Road and Bridge Works”- 2001, fourth revision, Indian Roads Congress
6. MORD “Specification for Rural roads”
7. MORD “Standard data book for analysis of rates for rural roads”
8. CRRI “Low Volume Roads’ Central Road Research Institute”- New Delhi

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

**TRANSPORTATION PLANNING**

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**Introduction:** Characteristics of different modes of transportation; Principles of co-ordination and operation control, Elements in urban transit system

**Transportation Planning Process:** Factors to be considered; land use transportation planning; Systems approach.

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

**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

**Evaluation:** Identification of corridor; Formulation of plans; Economic Evaluation.

**Mass Transit Systems:** capacity, Fleet planning and Scheduling.

**REFERENCE BOOKS:**

3. Institute of Traffic Engineers – “An Introduction to highway Transportation Engineering”.

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Types of bridges and grade separated structures for highways; standard specifications for road bridges and grade separated structures to fulfill traffic and Structural Engineering requirements.

Investigations for foundation and abutment (flyovers, underpass, interchange ramps). Types of substructures, design consideration and choice.

General Design Considerations for superstructure. Types of bridge, grade separated structures and their choices,

Basic design approaches of RCC, PSC and steel bridges.

Bridge bearings, joints, approaches, construction and maintenance aspects.

Construction specification and quality control for foundations and substructures of bridges and grade separated structures.

Evaluation of existing bridge structures. Methods of rehabilitation and widening.

REFERENCE BOOKS:
3. VAzirani RAtwani & M.G.Aswani, “Design of Concrete Bridges”- Khanna Publishers, New Delhi

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

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

Design Elements: Sight distances - types, analysis, factors affecting, measurements, Horizontal alignment - design considerations, stability at curves, superelevation, 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.

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.

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

Design Of Intersections: Characteristics and design considerations of at-grade intersections; Different types of islands, channelization; median openings; Rotary intersections; Grade separations and interchanges - types, warrants, adaptability and design details; Interchanges - different types, ramps. Computer applications for intersection and interchange design.

Note: Computer Lab. using highway geometric design software for design of intersections, interchanges and parking lots to be carried out.

REFERENCE BOOKS:

5. Relevant IRC publications
**P.G CERTIFICATE COURSE IN ROAD TECHNOLOGY**

**HIGHWAY MATERIALS**

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Basic road construction materials such as soils, aggregates, bitumen and Portland cement – 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

**Aggregates** – Origin, classification, requirements, properties. Tests and specifications on road aggregates for flexible and rigid pavements. Importance of aggregate gradation and shape factor in mix design

**Bituminous binders** – different types, properties and uses, physical tests on bitumen, rheological and pavement performance related properties, Modified binders, characteristics and applications in road construction, criteria for selection of different binders.

Bituminous mixes, types, requirements, properties, tests, Marshall method of mix design and super pave mix design

**Portland cement and cement concrete for use in road works** – requirements, design of mix for CC pavement, use of additives, IRC specifications & Tests, joint filler and sealer materials

**Soil stabilization** – principle, methods and tests, proportioning of materials and mix design, application of Rothfutch method. Marginal and waste materials in road construction, properties and scope in road construction. Use of Fly-ash in road embankment and cement concrete mixes

**Note:** All Relevant Laboratory & Field Test will be conducted in Batches

**REFERENCE 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
4. 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
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
10. “Soil Mechanics for Road Engineers”- HMSO Publication
11. “Bituminous materials in Road Construction”- HMSO Publication

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

**PAVEMENT DESIGN AND MANAGEMENT**

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Road Pavements and pavement layers - 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. 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.

**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.

**Flexible 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

**Pavement management system** – Pavement deterioration, objects and Principle of pavement management, use of HDM – 4

**REFERENCE BOOKS:**
3. Huang, “Pavement Analysis”- Elsevier Publications
7. Khanna and Justo “Highway Engineering”- Nemchand & Bros, Roorkee

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

**HIGHWAY CONSTRUCTION AND MAINTENANCE**

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Components of road and pavement structure including subgrade, drainage system, functions, requirements and sequence of construction operations

**Plants and equipment for production of materials** - crushers, mixers, bituminous mixing plants, cement concrete mixers – various types, advantages and choice
Drainage – Assessment of drainage requirements for the road and design of various components, drainage materials, Construction of surface and subsurface drainage system for roads, drainage of urban roads.

Road construction equipment – different types of excavators, graders, soil compactors / rollers, pavers and other equipment for construction of different pavement layers – their uses and choice.

Pre-construction surveys and marking on ground - Specifications and steps for the construction of road formation in embankment and cut, construction steps for granular sub-base, quality control tests.

Different types of granular base course – WMM, CRM, WBM, specifications, construction method and quality control tests.

Different types of bituminous layers for binder and surface courses, their specifications (as per IRC and MORTH), construction method and quality control tests.


General Aspects: 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.

Road maintenance works – 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.

Special problems in construction & maintenance of hill roads, land slide, causes, investigation, and preventive and remedial measures, protection of embankment and cut slopes.

REFERENCE BOOKS:
3. 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
5. “Hand Book on Cement Concrete Roads” - Cement Manufacturers Association, New Delhi

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

TRAFFIC ENGINEERING AND DESIGN

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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.
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,

Accident characteristics, causes, studies, investigations and analysis of individual accidents, statistical analysis, measures to improve road safety.

Traffic regulations and control - Regulation on vehicles, drivers and traffic flow, Traffic control devices – Types & objectives of markings, signs, signals and islands, delineators.

Design of signalized intersections including signal timings as per IRC guidelines. Signal system, use of software.

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.

Design of on-street and off-street parking facilities, pedestrian facilities, bus bays, safety devices

Geometric design features of expressways and different types of Urban Roads

REFERENCE BOOKS:
5. MoRTH “Type Designs for Intersections on National Highways”- Indian Roads Congress
6. MORTH “Manual for Road Safety in Road Design”-Indian Roads Congress
8. Khanna and Justo, “Highway Engineering”- Nem Chand and Bros., Roorkee
Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Various steps of preparation and execution of road projects. Investigations for preparation of project reports for new and upgradation 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.

Topographic surveys and investigations for finalisation of horizontal alignment and vertical profile of roads. Application of GIS. Design standards and specification for relevant road geometrics.

Soil investigations for assessing the design details of road embankments and cuts, drainage requirements and foundation of cross drainage structures.

Material surveys and investigations for availability and choice of basic and alternate materials for road construction and for soil stabilisation.

Traffic studies – 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.

Environmental and social impact studies and assessment relevant to road upgradation / 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.

Preparation of DPR design details, estimates, BOQ, drawings and detailed project report, use of software.

Tendering process - Preparation of tender documents for different types of road projects, tender evaluation.
REFERENCE BOOKS:
5. MoRTH “Specifications for Road Bridge Works”- 2001, fourth revision, Indian Roads Congress
7. MoRTH “Model Concession Agreement for Small Road Projects”-2000, Indian Roads Congress

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

RURAL ROADS

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Total No. of Lecture Hrs. : 52
Exam Marks : 100

Planning of rural road network – general principle, guidelines laid down in recent 20-year plans and in PMGSY

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

Investigations and surveys, soil and material surveys, scope for use of alternate marginal / low cost / waste / stabilized local materials in rural road works

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.

REFERENCE BOOKS:
2. IRC SP- 26 “Report Containing Recommendations of IRC Regional Workshops on Rural Road Development”- 1984, Indian Roads Congress
5. MoRTH “Specifications for Road and Bridge Works”- 2001, fourth revision, Indian Roads Congress
6. MORD “Specification for Rural roads”
7. MORD “Standard data book for analysis of rates for rural roads”
8. CRRI “Low Volume Roads’ Central Road Research Institute”- New Delhi

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Types of bridges and grade separated structures for highways; standard specifications for road bridges and grade separated structures to fulfill traffic and Structural Engineering requirements.

Investigations for foundation and abutment (flyovers, underpass, interchange ramps). Types of substructures, design consideration and choice.

General Design Considerations for superstructure. Types of bridge, grade separated structures and their choices,

Basic design approaches of RCC, PSC and steel bridges.

Bridge bearings, joints, approaches, construction and maintenance aspects.

Construction specification and quality control for foundations and substructures of bridges and grade separated structures.

Evaluation of existing bridge structures. Methods of rehabilitation and widening.

REFERENCE BOOKS:

3. VAzirani RAtwani & M.G.Aswani, “Design of Concrete Bridges”- Khanna Publishers, New Delhi

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

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.


Stability of slopes: Introduction, Types, Different methods of analysis of slopes for Øu+0 & C-Ø soil, 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, Design of subsurface
drainage system, Road construction in water logged areas, 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.

**Reference books**

6. IRC – Relevant Codes.
<table>
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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.

**Pavement surface condition** - Causes, effects, methods of measurement / evaluation and treatment of: a) Pavement slipperiness b) riding quality and unevenness c) rutting d) cracking e) potholes f) edge breaking etc. Rating methods Use of modern equipment for pavement surface condition measurements. Analysis of data, interpretation and application.


Discussion on choice of overlay type and pavement materials over existing flexible and rigid pavements, with different degrees of distress.

Evaluation of new pavement materials, model studies, pavement testing Under controlled conditions, accelerated testing and evaluation methods

Test track studies. Instrumentation for pavement testing.

**REFERENCE BOOKS:**

8. Per Ulitz “Pavement Analysis” - Elsevier Amsterdam.
10. HRB/TRB/IRC/ “International Conference on structural design of Asphalt pavements”.

Standard Data Book on Highway Technology issued by the University may be referred in the P.G Examination of VTU.
Highway Planning – 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, 20 year road development plan including 1st and 2nd 20 year plan in brief and 3rd and 4th 20 year plan in detail, Land use planning, Land use development – models, problems on the above topics, Highway Planning in India

Highway Engineering Economics, principle, supply and demand models, equilibrium, sensitivity of travel demand, Elasticities – types, models (Kraft 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

Economic analysis, 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.

Highway financing, 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.

REFERENCE BOOKS:
18. “Road User Cost Study in India”- Final Report, Central Road Research Institute, New Delhi, 1982.

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

ROAD CONSTRUCTION PLANNING AND MANAGEMENT

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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.

Planning of Road Projects – project management framework, scope, project objectives, project environment, causes of project failure, project development process

Resource planning – human resources, project man power grouping, structuring site organisation, construction materials-classification of construction materials, materials usage, materials inventory, cost and budget

Construction equipment and choice-type, capacity and number, task considerations, cost considerations, engineering considerations, equipment acquisition options, optimum location of crushing and mixing plants

Time planning – project work breakdown, determining activities involved, assessment of duration, CPM / PERT network analysis, work scheduling, methods of work scheduling, factors affecting work scheduling,

Planning Control System – resource production, project cost, project time, codification and project management, information system, use of software

48
REFERENCE BOOKS:
10. Nhai.org, pmgsy.nic.in websites

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

PAVEMENT MANAGEMENT SYSTEM

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Introduction: components of pavement management systems, pavement maintenance measures, planning investment, research management.

Pavement Performance Evaluation: general concepts, serviceability, pavement distress survey systems, performance evaluation

Pavement Performance Prediction: 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.

Ranking and Optimization Methodologies: Recent developments, sample size selection, economic optimization of pavement maintenance and rehabilitation.

Design alternatives and Selection: 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.
Expert systems and Pavement Management: 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.

REFERENCE BOOKS:
10. NCHRP, TRR and TRB Special Reports.

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

ELECTIVE – II

ADVANCED TRAFFIC ENGINEERING

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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 Forecast – objects, factors governing traffic growth, estimation of
traffic growth from past trends, econometric models. Common methods of
traffic forecast

Road accidents, causes, scientific investigations and data collection. Analysis
of individual accidents to arrive at causes; statistical methods of analysis of
accident data, computer analysis. Road safety issues, various measures for
road safety - engineering, educational and enforcement measures, Short term
and long term measures. Road safety education and training. Economic
evaluation of improvement measures by “before and after studies”.

50
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, Elements of area traffic control and Intelligent transportation systems

Environmental issues – air and noise pollution due to road traffic, measurement, control of environmental deterioration. Management of environmental pollution due to road traffic.

REFERENCE BOOKS:

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

APPLIED STATISTICS

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Introduction to statistical methods, scope aim and limitations, sample, attribute and types of data, sources and collection of data. Accuracy of data

Representation and summarizing data. Frequency distribution, histogram and frequency curves. Ogive curve, Measure of central tendency – arithmetic mean, median and mode dispersion- range, standard deviation, variance and co-efficient of variation, skewness and kurtosis
Introduction to probability & statistics for Traffic Engineering Design –
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

Sampling Techniques – 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.

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


Chi-square test of goodness of fit, student’s t test, Confidence interval.

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

Use of soft wares in statistical analysis – MATLAB, MINITAB

REFERENCE BOOKS:
    Graw Hill Series
8. Johnson R and G Bhattacharya,“Statistics – Principles and
    methods”- John Wiley & sons, New york, 1985
    Decisions for Civil Engineers”- McGraw Hill Co.
    Delhi.
    Delhi

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

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**System and Technologies:** Urban passenger transportation modes, transit classifications and definitions, theory of urban passenger transport modes, rail transit, bus transit, Para transit and ride sharing, designing for pedestrians, trends in transit rider ship and use of different modes.

**Comparing Alternatives:** Comparing costs, comparative analysis, operational and technological characteristics of different rapid transit modes, evaluating rapid transit

**Planning:** Transportation system management, system and service planning, financing public transportation, management of public transportation, public transportation marketing.

**Transit System Evaluation:** Definition of quantitative performance attributes, transit lane capacity, way capacity, station capacity, theoretical and practical capacities of major transit modes, quantification of performance

**City traffic:** Classification of transportation systems, conventional transportation systems, unconventional transportation systems, prototypes and tomorrow’s solutions, analysis and interpretation of information on transportation systems, perspectives of future transportation.

**REFERENCE BOOKS:**