EVALUATION SCHEME
&
SYLLABI

FOR

MASTER OF TECHNOLOGY
in
CIVIL ENGINEERING
(INFRASTRUCTURE ENGINEERING)

(Effective from Session: 2021-22)

Offered by

G B Pant Institute of Engineering and Technology
Ghurdauri, Pauri Garhwal, U.K. 246194

EVALUATION SCHEME
M.TECH. (INFRASTRUCTURE ENGINEERING)
I- Year (I-SEMESTER)
(Effective from session: 2021-2022)

S. No.	Course Code	SUBJECT	PERIODS			EVALUATION SCHEME					
						Sessional Exam			ESE	Subject Total	Credits
			L	T	P	CT	TA	Total			
THEORY											
1	TCI 511	Infrastructure Planning	3	1	0	30	20	50	100	150	3
2	TCI 512	Project Management in Construction and BIM	3	1	0	30	20	50	100	150	3
3	ECI 51X	Elective - I	3	1	0	30	20	50	100	150	3
4	ECI 51X	Elective - II	3	1	0	30	20	50	100	150	3
5	TAH 511	Research Methodology and IPR	2	0	0	30	20	50	100	150	2
6	TAH 51X	Audit Course I	2	0	0	30	20	50	100	150	0
PRACTICALS											
7	PCI 511	Infrastructure Engineering Laboratory-1	0	0	2	10	15	25	25	50	2
8	PCI 512	Programming Applications for Engineers	0	0	2	10	15	25	25	50	2
9	GPP 511	General Proficiency	0	0	0	0	50	50	0	50	0
SEMESTER TOTAL			16	4	4	200	200	400	650	1050	18

Elective - I

ECI 511 Optimization Methods
ECI 512 Numerical Methods
ECI 513 Computational Methods in Civil Engineering

Elective - II

ECI 514 Urban Flooding and Disaster Management
ECI 515 Modernization of Water Distribution System
ECI 516 Water resources systems: Planning and Management

AUDIT COURSES I

TAH-514 Constitution of India
TAH-515 English for Research Paper Writing

EVALUATION SCHEME
M.TECH. (INFRASTRUCTURE ENGINEERING)
I- Year (II-SEMESTER)
(Effective from session: 2021-2022)

S. No.	Course Code	SUBJECT	PERIODS			EVALUATION SCHEME					
						Sessional Exam			ESE	Subject Total	Credits
			L	T	P	CT	TA	Total			
THEORY											
1	TCI 521	Financing Infrastructure Projects	3	1	0	30	20	50	100	150	3
2	TCI 522	Construction Methods and Equipment Management	3	1	0	30	20	50	100	150	3
3	ECG 52X	Elective - III	3	1	0	30	20	50	100	150	3
4	ECI 52X	Elective - IV	3	1	0	30	20	50	100	150	3
5	TAH 52X	Audit Course II	2	0	0	30	20	50	100	150	0
PRACTICALS											
6	PCG 522	Subsurface Investigations and Instrumentation Lab	0	0	2	10	15	25	25	50	2
7	PCI 522	Surveying for Infrastructure Projects	0	0	2	10	15	25	25	50	2
8	PCI 523	Mini Project with Seminar	0	0	2	0	25	25	25	50	2
9	GPP 521	General Proficiency	0	0	0	0	50	50	0	50	0
SEMESTER TOTAL			14	4	6	170	205	375	575	950	18

Elective - III

TCG 522	Subsurface Investigations and Instrumentation
ECG 521	Engineering Rock Mechanics
ECG 526	Earth Retaining Structures

Elective - IV

ECI 524	Advanced Concrete Engineering
ECI 525	Urban Environmental Management
ECI 526	Advanced Structural Design

AUDIT COURSES II

TAH 522	Disaster Management
TAH 526	Pedagogy
TAH 527	Stress Management by Yoga
TAH 528	Personality Development through Life Enlightenment Skills

EVALUATION SCHEME
M.TECH. (INFRASTRUCTURE ENGINEERING)
II - Year (III-SEMESTER)
(Effective from session: 2022-2023)

S. No.	Course Code	SUBJECT	PERIODS			EVALUATION SCHEME					
						Sessional Exam			ESE	Subject Total	Credits
			L	T	P	CT	TA	Total			
THEORY											
1	ECI 63X	Elective - V	3	1	0	30	20	50	100	150	3
2	TOE 63X	Open Elective	3	0	0	30	20	50	100	150	3
PRACTICALS											
3	PCI 631	Dissertation I	0	0	20	0	200	200	300	500	10
4	GPP 531	General Proficiency	0	0	0	0	50	50	0	50	0
SEMESTER TOTAL			6	1	20	60	290	300	480	850	16

Elective - V

ECI 631	Urban Transportation Planning
ECI 632	Infrastructure for Smart City Planning
ECI 633	Advanced Highway Engineering

Open Elective

TOE 631	Business Analytics
TOE 632	Industrial Safety
TOE 633	Operations Research
TOE 634	Cost Management of Engineering Projects
TOE 635	Composite Materials
TOE 636	Waste to Energy

EVALUATION SCHEME
M.TECH. (INFRASTRUCTURE ENGINEERING)
II - Year (IV-SEMESTER)
(Effective from session: 2022-2023)

S. No.	Course Code	SUBJECT	PERIODS			EVALUATION SCHEME					
						Sessional Exam			ESE	Subject Total	Credits
			L	T	P	CT	TA	Total			
PRACTICALS											
1	PCI 641	Dissertation II	0	0	32	0	400	400	400	800	16
4	GPP 541	General Proficiency	0	0	0	0	50	50	0	50	0
SEMESTER TOTAL			0	0	34	0	450	450	400	850	16

MASTER OF TECHNOLOGY
in
CIVIL ENGINEERING
(INFRASTRUCTURE ENGINEERING)

SYLLABI
of
FIRST SEMESTER

Unit 1. Introduction to Infrastructure

Types of infrastructure, Role of infrastructure, Infrastructure crisis, Attributes of Infrastructure, Infrastructure and Economic Growth and poverty reduction, Indian scenario and future outlook

Unit 2. Infrastructural Sectors and their Status in India

Overview, Characteristics, Performance, Reforms and Policies, Targets, Subsidies and Privatization, Policy Initiatives, Reforms, National policies, Regulatory Authorities in Power Sector, Water sector, Transportation Infrastructure, Telecommunications Infrastructure in India

Unit 3. Infrastructure Planning-Part A

Infrastructure planning steps: Problem diagnosis (Population and employment, Land use, Economic base, Transportation system, Travel patterns, Social and value factors, Financial resources, Ordinances, statutes and regulations), Goal articulation, Forecasting, Design of alternatives

Unit 4. Infrastructure Planning-Part B

Plan testing (Testing against objectives, Testing against constraints), Evaluation and choice (Economic evaluation, Financial evaluation, Environmental evaluation), Implementation of Plan

Unit 5. Managing the planning process

Management summary, Project description and appraisal, Technical section (Work breakdown structure, Task sheets, Deliverables, Flow diagram, Gantt chart, Budget and cash flow), Organization section (Team's structure, Responsibility matrix, Client interface)

COURSE OUTCOMES:

On the completion of this course the student will be able to:

1. Summarize the concept of Infrastructure and their status in India
2. Outline the details of Infrastructure Planning
3. Prepare the detailed planning process for managing a Infrastructure project

TEXT BOOKS / REFERENCES:

1. Infrastructure Planning, Parkin and Sharma, Thomas Telford Publications
2. https://www.ibef.org, India Brand Equity Foundation
3. Project Management (A Systems Approach to Planning, Scheduling, and Controlling), Harold Kerzner, John Wiley & Sons Publications

TCI 512 PROJECT MANAGEMENT IN CONSTRUCTION & BIM 3L:1T:0P

Unit 1. Introduction to Project Management

Introduction to project management, objectives of a project, Stakeholders, Phases and project organisation. Introduction to resource management in construction projects. Life Cycle of a construction project.

Unit 2. Estimation and Network based project management

Estimating quantities**,** estimation of project cost, rate analysis, measurement in civil engineering, Project planning, Activity time, Time management tools, progress monitoring, introduction to network analysis concepts, scheduling, PERT.

Unit 3. Contract and Quality, Safety Management

Procurement, Types of Contracts, Contract Closure, Quality control in construction, Quality assurance, quality standardisation, Elements and economics of quality, Total Quality Management (TQM), Introduction to construction safety, safety management, safety guidelines.

Unit 4. Modern Developments in Project Management: BIM

The Current Business Model, Inefficiencies of Traditional Approaches

Definition of BIM, Components of BIM, Advantages of BIM over traditional design-build process, Use of BIM, Benefits of BIM for a construction project, Importance of BIM in construction industry.

Unit 5. BIM and Smart cities

Concept and definition of Smart Cities. Understanding Smart cities and BIM. Future of BIM and its role in creating Smart Cities. Introduction to various types of sensors and ICT. Role of above modern tools in the BIM process, scan to BIM.

Course Outcomes:

On the completion of this course the student will be able to:

1. Outline the concept of Project Management and solve the planning by application of various Network Scheduling Techniques
2. Use the concepts of Pricing, quality, safety Management regarding a Project
3. Identify factors of Quality Management
4. Learn new techniques of project management like BIM

TEXT BOOKS / REFERENCES:

1. BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers, Sacks et al., 3rd Edition, John Wiley & Sons Publications, 2018
2. Project Management (A Systems Approach to Planning, Scheduling, and Controlling), Harold Kerzner, 12th Edition, John Wiley & Sons Publications, 2017
3. Construction Project Management: A Practical Guide to Field Construction Management, Sears et al., 6th Edition, John Wiley & Sons Publications, 2015

Unit 1: Introduction to Optimization: Basics of engineering analysis and design, Need for optimal design, Difficulties associated with optimization problems, Problems of global and local optima, Single and multivariable problems, Necessary and sufficient condition for optimality.

Unit 2: Classical Optimization 1: Basics of constrained and unconstrained problems, Stationary points, points of maxima, points of minima and inflection points, Exhaustive search method, Bounding phase method, Region elimination method, Interval halving method, Golden section search method, Newton-Raphson Method and Bisection method.

Unit 3: Classical Optimization 2: Definition of descent direction, Steepest descent direction method, Newton method, Quadratic approximation of a function, Convex and concave functions, Convex optimization problem, Kuhn-Tucker conditions, Linear Programming, Simplex method and Dynamic programming.

Unit 4: Non-Classical and Metaheuristic Optimization Algorithms 1: Introduction to Evolutionary algorithms, Introduction to Genetic Algorithm (GA), Differential Evolution (DE), Simulated Annealing (SA).

Unit 5: Non-Classical and Metaheuristic Optimization Algorithms 2: Particle Swarm Optimization (PSO), Firefly Algorithms (FA), Shuffled Frog Leaping Algorithm (SFLA), Invasive Weed Growth Optimization (IWO) and other metaheuristic principles of biomimicry.

COURSE OUTCOMES:

On completion of the course, the student will be able to:

1. Determine the need for optimal design in engineering, necessary and sufficient conditions of optimality.
2. Determine the optimality of constrained and unconstrained problems using classical search techniques.
3. Determine the optimality of non-linear problems and linear problems using classical optimization methods
4. Apply evolutionary algorithms for basic problems as wells as advanced engineering design problems.

TEXT BOOKS / REFERENCES:

1. Deb. K., Optimization for engineering design: Algorithms and examples, PHI Pvt Ltd., 1998.
2. Arora., J.S., Introduction to optimum design, McGraw Hill International edition, 1989.
3. Hafta, R.T. and Gurdal. Z., Elements of structural optimization, Kluwer academic publishers, Third revised and expanded edition, 1996.
4. Bennis, F. and Bhattacharjya, R.K., Nature-Inspired Methods for Metaheuristics Optimization, Springer, 2020.

Unit 1: Introduction to Numerical Methods: Introduction & Approximations, Motivation and Applications, Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation, Error Analysis.

Unit 2: Linear Systems and Equations: Matrix representation; Cramer's rule; Gauss Elimination; Matrix Inversion; LU Decomposition; Iterative Methods; Relaxation Methods; Eigen Values.

Unit 3: Algebraic Equations: Bracketing Methods, Introduction to Algebraic Equations, Bracketing methods: Bisection, Reguli-Falsi; Open Methods: Secant; Fixed point iteration; Newton-Raphson; Multivariate Newton's method

Unit 4: Numerical Differentiation and Integration: Numerical differentiation; error analysis; higher order formulae, Trapezoidal rules; Simpson's rules; Quadrature, Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines.

Unit 5: Applications of Numerical Methods: Initial Value Problems (IVP), Introduction to ODE-IVP, Euler's methods; Runge-Kutta methods; Predictor-corrector methods; Extension to multi-variable systems; Adaptive step size; Stiff ODEs, Shooting method; Finite differences; Over/Under Relaxation (SOR)

COURSE OUTCOMES:

On completion of the course, the student will be able to:

1. Determine the need for numerical methods in engineering design
2. Evaluate the linear system of equations using numerical analysis
3. Estimate the solution to a system of algebraic equations using different iterative methods
4. Evaluate the techniques of numerical integration and differentiation to solve complex problems
5. Apply numerical methods to initial and boundary valued problems and formulate the finite difference forms of partial and ordinary differentials

TEXT BOOKS / REFERENCES:

1. Scarborough, J.B., Numerical mathematical analysis, Oxford & IBH Publishing CO Pvt., 2000
2. Jain, K.K., Iyengar, S.R.K and Jain, R.K., Numerical methods-problem and solutions, Wiley eastern limited, 2001
3. Hamming, R.W., Numerical methods for scientist and engineers, McGraw Hill, 1998.
4. Mathews, J.H. and Fink, K.D., Numerical methods using MATLAB, Pearson Education, 2004
5. Hayter, A.J., Probability and statistics, Duxbury, 2002.

ECI 513 COMPUTATIONAL METHODS IN CIVIL ENGINEERING 3L:1T:0P

Unit 1: Basic equations used in Civil Engineering: Continuum Mechanics and Mechanics of Materials. Approximation of equations using numerical analysis – Taylor's series of expansion, Error analysis, Sources of errors – truncation error, roundoff error.

Unit 2: Mathematical nature of PDEs, Hyperbolic, Parabolic, Elliptic Equations and flow equations. Basic Discretization techniques: Finite Difference Method (FDM), Implicit and explicit formulations of FDM, Stability criteria of the forms of equations using error minimization.

Unit 3: Application of FDM to wave, Heat and Laplace equations. Linear multi-step methods; Predictor-corrector schemes, ADI methods, Grid transformations according to the appropriate boundaries. Lax-Wendroff Technique and MacCormack's Technique.

Unit 4: The Finite Volume Method (FVM) and conservative discretization. Analysis and Application of Numerical Schemes: Modified equation, The Runge-Kutta schemes, Numerical solution of the compressible Euler equations: Mathematical formulation of the system of Euler equations;

Unit 5: Basics of the Finite Element Method (FEM) and the Galerkin formulations. Basics of the computations of the differential equations using the three methods (FDM, FVM and FEM) in MATLAB, Python etc.

COURSE OUTCOMES:

On completion of the course, the student will be able to:

1. Identify and formulate a solution procedure for different types of equations encountered in civil engineering curriculum.
2. Discretize the total domain of model using different techniques based on the type of equation that needs to be solved.
3. Apply different numerical techniques to solve the equations and to successfully prepare a numerical model in theory.
4. Develop models that can solve a given partial differential equation under different boundary conditions using Finite Difference Method (FDM), or Finite Volume Method (FVM), or Finite Element Method (FEM) using programming.

TEXT BOOKS / REFERENCES:

1. "Numerical Methods" by D. Dahlquist, and A. Bork, Dan Prentice-Hall, Englewood Cliffs, NJ,. 1974.
2. H. C. Martin and G. F. Carey, Introduction to Finite ElementAnalysis - Theory and Application, NewYork, McGraw-Hill
3. J. D. Anderson (Jr.), "Computational Fluid Dynamics", McGraw-Hill International Edition, 1995.
4. Matlab programming for Engineers, Stephen J. Chapman, 5th Edition, Cengage Learning, 2015.

ECI 514 URBAN FLOODING AND DISASTER MANAGEMENT 3L:1T:0P

Unit 1: Basic Concepts of hydrological phenomena: Course overview, Introduction, Why watershed hydrology & management? Water cycle, Precipitation and Interception: Formation, Intensity and types, plant canopy Interception and through fall, Measurements, Precipitation data analysis and statistical analysis of data.

Unit 2: Basic concept of Disaster Management: Vulnerability and disaster. Risk and different types. Flood and its type. Definition of risk mitigation. Different mechanism working on risk mitigation.

Unit 3: Natural Hazards Risk Management and Urban flooding: Types of natural disaster, Meaning of urban flooding, Use of GIS in hazard risk management, Disaster Risk management in different parts of India: case study of different states, Disaster Risk management in different parts of world: case study.

Unit 4: Climate Variability & Disaster Risk and Urban-Rural Risk Management: Climate change, Effect of climate change on Urban flooding, Future sustainability study due to climate change on urban flooding.

Unit 5: Watershed modelling and management: Watershed modelling and analysis: Selection, calibration and validation, Watershed management: Policy, Planning, and Economic evaluation issues in urban areas.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Determine the importance of watershed management and analyse the precipitation data
2. Critique the types of disaster management and mitigation methods
3. Evaluate the natural disaster types with related cases of urban flooding
4. Analyse the variability of climate change and its corresponding impact on urban flooding
5. Design the watershed systems with policies and planning according to the economic issues in urban areas

TEXTBOOKS/REFERENCES:

1. Chow, V.T, Maidment, D.R., Mays.L.W., Applied Hydrology, McGraw Hill, 1988.
2. Tideman, E.M., Watershed Management – Guidelines for Indian Conditions, Omega Scientific Publishers, New Delhi, 1996.

ECI 515 MODERNIZATION OF WATER DISTRIBUTION SYSTEMS 3L:1T:0P

Unit 1: Introduction: Components of water supply systems, Water use and demand estimation, Surface water and Groundwater sources, Water quality and drinking water standards, Determination of reservoir capacity. Design period, population data and flow rates for water supply systems, Factors affecting water consumption and variation in demand.

Unit 2: Basics of Water distribution networks: Basic methods of designing water distribution networks, Basics of treatment of water distribution: Physico - Chemical Processes, Sedimentation, Coagulation, and Flocculation, Granular Media filtration, Disinfection, Adsorption and ion exchange processes. Effects of Hydraulic Transients in design of pipelines, Equations of unsteady flow in pipes, Method of characteristics, Solution procedure to solve equation of hydraulic transients using finite difference method.

Unit 3: Design of Water distribution networks: Transient cases of sudden closure of valves, pump failures and initialization of pumps, Methods of analysis for optimal distribution network design, Air valves, pressure relief valves and surge tanks and their optimal locations. Types of reservoirs and design parameters and methods; Design of water pumping stations.

Unit 4: Wastewater collection systems: Design principles, separate, combined and semi-combined sewers, Estimation of dry weather flows, Sewer Materials and Sewer Appurtenances, Sewer pipe hydraulics: sizing of pipes and design, Manhole chambers and storm water overflows.

Unit 5: Maintenance of water supply and wastewater systems: Cleaning of water towers (Overhead Tanks), Analysis of wastewater – determination of solids, COD, BOD, nutrients and their significance, BOD progression and its formulations. Pumping stations, screens and inverted screens, Regular checks of leakages from sewer lines, monitoring wells near the potential source locations.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Determine the different conditions of water demand according to the areas of urbanization
2. Analyse the basis of water distribution networks and determine the different treatment methods
3. Evaluate the cases of transients in water distribution systems and remediations to control the transients
4. Validate the different wastewater collection systems and design the collection systems
5. Examine the water quality using traditional and modern methods of testing

TEXTBOOKS / REFERENCES:

1. Chaudhry, H., Hydraulic Transients, Tata McGraw Hill, 1998.
2. Chaudhry, H., Applied hydraulic transients, Van Nostrand Reinhold, New York, 1987.
3. Streeter, V.L. and Wylie, E.B., Hydraulic Transients, McGraw Hill, New York, 1967
4. McGhee, T. J., Water Supply and Sewerage, McGraw Hill International, 1991.
5. Peavy, H.S., Rowe D.R., and George Tchobanoglous, Environmental Engineerinf, McGraw Hill, 1985.

ECI 516 WATER RESOURCES PLANNING AND MANAGEMENT 3L:1T:0P

Unit 1: Basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation

Unit 2: Introduction to Optimization, Optimization techniques, Linear Programming, Graphical Method, Simplex Method, Dual Simplex Problem, Reservoir operation and Reservoir sizing using Linear Programming

Unit 3: Non-Linear Programming, Dynamic programming, genetic algorithm, sensitivity analysis, capacity expansion, reservoir operation problems, simulation, case studies, Multi reservoir operation.

Unit 4: Probability, risk and uncertainty analysis for hydrologic and hydraulic design, Chance Constrained Linear Programming, Stochastic Processes and Transitional Probabilities, Stochastic Dynamic Programming, Time series analysis.

Unit 5: Planning, role of a planner, River basin planning and management, Water distribution system, Groundwater system, Flood plain Management, Urban storm water management, National water policies, public involvement, social impact, economic analysis.

COURSE OUTCOMES:

On the completion of course the student will be able to:

1. Understand the need for systems approach for water resources
2. Solve different problems of reservoir operation using linear programming principles
3. Analyse different problems of multiple reservoirs and capacity planning using dynamic programming principles and genetic algorithms
4. Evaluate the effect of time series analysis for the assessment of risk in hydraulic designs
5. Systematize the types of water resource systems and perform analysis related to social and economic impact

TEXTBOOKS/REFERENCES:

1. Loucks, D.P., Stedinger, P.J.R., Haith, D.A., Water Resources Systems Planning and Management, Prentice Hall, New Jersy, 1987
2. Hall, K., A and Draoup, J.A., Water Resources Systems Engineering, Tata McGraw Hill, 1970.
3. Neil, G.S., Water Resources Planning, McGraw Hill, 1985.
4. National Water Policy, Ministry of Water Resources, Government of India, 1987.

PCI 511 INFRASTRUCTURE ENGINEERING LABORATORY-1 0L:0T:2P

Management of infrastructure projects using project management software packages such as Microsoft Project and Primavera (P6 Enterprise Project Portfolio Management). By the use of software perform: Project estimation, Project planning, Project scheduling, Network analysis, Project time reduction and optimization, Resource levelling, Project time, Cost and finance management

COURSE OUTCOMES:

On completion of the course, the students will be able to:

1. Solve the various aspects of project management by the use of software
2. Design the project by the Microsoft Project and Primavera

TEXT BOOKS/REFERENCES:

1. Microsoft Project 2016 Step by Step, Carl Chatfield and Timothy Johnson, Microsoft Press, 2016.
2. Planning and Control Using Oracle Primavera P6, Paul Eastwood Harris, Eastwood Harris Pty Ltd., 2015.

PCI 512 PROGRAMMING APPLICATIONS FOR ENGINEERS 0L:0T:2P

EXPERIMENTS:

1. Introduction to data types, numbers, strings, lists, arrays, vector and tensor arrays
2. Introduction to Python Math, Numpy and Scipy
3. Introduction to for loop, if else condition, while loop and function definitions
4. Conversion of Problems in mathematical form to programming language form
5. Algorithms, Flow charts and pseudo codes for problem examples
6. Practicing iterative optimization and numerical methods of problem-solving using Python
7. Finite difference (FDM) and finite volume (FVM) formulations of Partial Differential Equations (PDEs)
8. Discretization of space and time to solve the different PDEs of Engineering problems
9. Writing a code to solve a given PDE using FDM or FVM techniques
10. Writing a code to write a metaheuristic algorithm (Genetic Algorithm) to solve any optimization problem

COURSE OUTCOMES:

On the completion of this course the student will be able to:

1. Determine the different data types and their specificity of application to problems
2. Analyse the importance of loops, algorithms and pseudo codes along with their applications to engineering problems
3. Construct the formulation of mathematical partial differentials into numerical methods of programming using FDM and FVM techniques
4. Solve a given minimization problem using meta heuristic principles

MASTER OF TECHNOLOGY
in
CIVIL ENGINEERING
(INFRASTRUCTURE ENGINEERING)

SYLLABI
of
SECOND SEMESTER

Unit 1. Introduction to Infrastructure Financing

Introduction to infrastructure financing; Elements of a project-finance structure, Benefits of Project finance, Sponsors and other investors, Procurement of infrastructure projects, Commercial banks, Bonds

Unit 2. Project Agreement

Types of project agreement (BOT, BTO, BOOT, BOO), Offtake contract, Concession agreement, Other 'PPP-like' contracts, Aspects of project agreements, Compensation events, Relief events, Termination of project agreement

Unit 3. Risks in Infrastructure Projects

Commercial risks, Analysis of commercial risks, Macro-Economic Risks, Time value of money, Discounted cash Flow, Internal rate of return, Inflation, Regulatory and Political Risks, Change in law, Investment risks, Risk evaluation and Allocation

Unit 4. Financial Structuring

Investors analysis and equity structure, Debt cover ratios, Debt:Equity ratio, Debt service profile, Interest rate and fees, Additional costs, Optimizing the financial structure

Unit 5. Financial Support

Indirect and direct Public-sector financial support, Gap Financing, Credit Guarantee Finance, Capital Grant, Viability-Gap Funding, Minimum Revenue Guarantee, Tariff Subsidy, Export Credit Agencies, Multilateral Development-Finance Institutions

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Differentiate the concept of Infrastructure financing from general financing and illustrate various types of project agreements
2. Relate to various types of risks in infrastructure projects
3. Demonstrate various financial structures of infrastructure projects and compare between various financial support options

TEXTBOOKS/REFERENCES:

1. Principles of Project Finance, E.R. Yescombe, Elsevier Publications
2. Infrastructure Planning and Management: An Integrated Approach, Virendra Proag Springer Publications

TCI 522 CONSTRUCTION METHODS & EQUIPMENT MGMT. 3L:1T:0P

Unit 1. Introduction to Equipment Economics

Planning Process for Equipment and Methods; Cost of Owning and Operating Construction Equipment - Ownership cost, Depreciation, Operating cost, and Ownership and operating costs calculation methods; Replacement Decisions, Rent and Lease Considerations

Unit 2. Planning for Earthwork Construction, Compaction and Stabilization Equipment

Graphical Presentation of Earthwork, Earthwork Quantities, Mass Diagram, Structural Excavation, Pricing Earthwork Operations, Compaction of Soil and Rock, Compacting Methods, Types of Compacting Equipment, Soil Stabilization

Unit 3. Power Requirements and Equipment

Dozers and Graders: General Information, Project Employment, Production Estimating

Scrapers: General Information, Types, Operations, Performance Charts, Production Cycle

Excavators: General Information, Types

Unit 4. Trucks and Hauling Equipment, Asphalt Mix Production and Placement

Capacities of Trucks and Hauling Equipment, Calculating Truck Productivity, Truck Performance Calculations;

Paving Equipment, Sweeper, Asphalt Distributors, Haul Trucks, Asphalt Pavers, Compaction Equipment

Unit 5. Concrete Equipment and Pile-Driving Equipment

Batching Concrete Materials, Mixing and Placing Concrete, Consolidating Concrete, Finishing and Curing Concrete

Driving Piles, Pile Hammers, Supporting and Positioning Piles During Driving, Spudding and Preaugering

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Explain Equipment Economics and perform Ownership and operating costs calculation
2. Classify various types of equipment and calculate their capacities along with productivity
3. Assess appropriate type of equipment to be employed in a construction activity

TEXTBOOKS/REFERENCES:

1. Construction Planning, Equipment and Methods, Robert L. Peurifoy et al., McGraw-Hill Education Publications
2. Construction equipment management for Engineers, Estimators and Owners, D. G. Gransberg et al., Taylor & Francis Publications

TCG 522 SUBSURFACE INVESTIGATION AND INSTRUMENTATION 3L:1T:0P

Unit –I Introduction to Soil Exploration

Objectives of Site Investigation, Phases of investigation, Classification, Planning for Subsurface Exploration, Fact finding and Geological survey, Reconnaissance, Preliminary Exploration, Detailed Exploration, Codal Provisions

Unit –II Methods of investigations and Sampling

Trial pits/Trenches, Borings/drilling, Auger boring, Wash boring, Percussion drilling, Rotary drilling, Sample Disturbance, Disturbed Sample, Undisturbed Samples, Sampling by standard split spoon, Sampling by thin-wall tube, Sampling by Piston sampler

Unit-III Geotechnical investigation (Semi-direct methods)

Vane Shear test, Standard Penetration Test, Pressuremeter Test, Cone Penetration Test, Dilatometer test, Rock core drilling, Sampling of rock, Core stacking, Rock Quality Designation (RQD), Total Core Recovery (TCR)

Unit –IV Geophysical Tests (Indirect methods)

Seismic reflection survey, Seismic refraction survey, Electrical resistivity Survey, Applications, Advantages, Disadvantages and Limitations

Unit-V Soil Exploration Report and Field Instrumentation

Components of Soil Exploration Report, Drafting of Reports, Graphic Presentations of Bore Log, Study of Sample Reports, Field Instrumentation: Pressure meters, Piezometer, Pressure cells, Sensors, Inclinometers, Strain gauges etc.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Describe the phases of soil investigation in depth and identify the plan for soil investigation
2. Identify various methods of soil investigation and soil sampling
3. Illustrate various field test of soils and rocks
4. Examine components of soil exploration report and estimate properties using correlations.
5. Work with relevant instrumentation required for characterizing the soil

TEXTBOOKS/REFERENCES:

1. Principles of Geotechnical Engineering, Braja M. Das, Cengage
2. Basic and applied Soil Mechanics, Rajan & Rao, New Age International Publishers
3. Soil Properties and their correlations, Micheal Carter and Stephen P. Bentley, Wiley Publications
4. Latest version of relevant IS codes for various tests.

Unit 1: Physical Properties and Classification- Types of rocks and their formations; Distribution of Rocks in Indian Mainland; Laboratory Testing of Rocks; Strength, Modulus and Stress-Strain Response of Rocks; Engineering Classification of Rocks

Unit 2: In-situ Stress Conditions- In-situ stresses; Deformability tests in rock mass; Field shear test; Hydrofracturing technique, Flat jack technique; Estimation of Stresses in Rock Mass; Underground opening in infinite medium, Elastic and Elasto-Plastic approach. Stress concentration for different shapes of opening, Zone of influence.

Unit 3: Failure Criteria- Failure criteria for rock and rock masses; Mohr-Coulomb Yield Criterion, Drucker-Prager Criterion, Hoek-Brown Criterion, Tensile Yield Criterion; Strength and deformability of jointed rock mass; Fracture strength of jointed rock mass; Shear strength of Rock joints, Deformability of Rock joints, Concept of joint compliance.

Unit 4: Slopes and Foundations in Rocks- Stability of rock slopes, Modes of failure, Plane failure, Wedge failure, Circular failure, Toppling failure. Foundation on rocks, Estimation of bearing capacity, Stress distribution in rocks, Settlement in rocks, Pile foundation in rocks.

Unit 5: Excavation methods and Design of Support- Drilling and Blasting for Underground and Open Excavation; Stages of Excavation; TBM; Methods to improve rock mass responses.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Identify the rocks especially in India and understand their engineering properties.
2. Classify rock mass using different classification systems.
3. Understand the in-situ stress conditions in rock mass.
4. Comment upon the behaviour of in-situ stresses.
5. Interpret different failure criteria.
6. Describe the laboratory investigation of shear strength of rock joints.
7. Analyse the stability of slopes in rocks.
8. Propose foundation on rocks.
9. Explain the underground excavation methods.
10. Select support system for excavation in rocks.

TEXTBOOKS/REFERENCES:

1. R. E. Goodman, “Introduction to Rock Mechanics”, John Wiley & Sons.
2. T. Ramamurthy, “Engineering in Rocks for Slopes, Foundation and Tunnels”, Editor Prentice Hall India Pvt. Ltd.
3. Jaeger, Cook and Zimmerman, “Fundamentals of Rock Mechanics”, Fourth Edition, Blackwell Publishing.
4. L. Obert and Wilbur I. Duvall, “Rock mechanics and the design of structures in rock”, John Wiley & Sons, Inc
5. J. A. Hudson and J. P. Harrison, “Engineering Rock Mechanics: An Introduction to the Principles”.
6. John Conrad Jaeger, Neville G. W. Cook, Robert Zimmerman, “Fundamentals of Rock Mechanics”, 4th Edition.

Unit 1: Earth Pressure- Introduction to earth pressure – basic concepts, Earth Pressure Types, Rankine's theory, backfill features – soil type, surface inclination, loads on surface, soil layers, water level, Coulomb's theory, Effects due to wall friction and wall inclination, Graphical methods and their interpretations.

Unit 2: Earth Retaining Structures- Types of earth retaining structures, Rigid Retaining Structures, Types, Empirical methods and Stability analysis. Flexible Retaining Structures, Types, Material, Design specifications and pressure distribution variations.

Unit 3: Sheet Piles and Bulkheads- Sheet Piles and Bulkheads in Granular and Cohesive Soils - Materials Used for Sheet Piles – Free Earth and Fixed Earth Support Methods, Cantilever sheet piles, Anchored bulkheads, moment reduction factors, anchorage, Braced Excavation Types, Construction methods, Pressure distribution in sands and clays.

Unit 4: Seepage Analysis- seepage control in embankments and foundations, seepage analysis, stability analysis: upstream and down-stream for steady seepage, rapid draw down, end of construction, method of slices and Bishop's method, Coffer dams: Braced coffer dams – walls and supports, bottom heave and piping, Arching in Soils - Soil Pressures on Braced Walls and their Design.

Unit 5: Slope Protection and Geo-synthetics- Slope protection, filters, embankment construction materials and construction, quality control, grouting techniques. Instrumentation and performance observations in earth dams, Drum- debris walls, Classification of Geo-synthetics, Functions and applications, Properties of Geo-textiles, Geo-grids and Geo-membranes.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Analyze the earth retaining structures for their stability against earth pressure.
2. Apply engineering knowledge for the designing of earth retaining structures in various site conditions.
3. Evaluation of retaining structures using appropriate design methods, factors of safety, earth pressure diagrams and check their stability.
4. Determine the required depth of penetration and embedment of free and fixed sheet pile walls in cohesion and cohesionless soils.
5. Evaluate anchored sheet pile walls in free and fixed earth support conditions, spacing between bulkheads and anchors, resistance of anchor plates.

TEXT/REFERENCE BOOKS:

1. Terzaghi, K., "Theoretical Soil Mechanics", John Wiley, 1965
2. Bowles, J.W., "Analysis and Design of Foundations", McGraw-Hill, 4th and 5th Ed. 1996
3. Lambe, T.W. and Whitman, R.V., "Soil Mechanics", Wiley Eastern Limited, 1976
4. Gulhati, K. Shashi and M. Datta, "Geotechnical engineering", Mc. Graw Hill book company, 2005

UNIT 1: Materials and Their Properties: Review of properties of cement, their physical and chemical properties, special purpose cements, Classification and properties of aggregates, soundness of aggregates, alkali aggregate reaction, thermal properties of aggregates, Importance of shape and Surface area and grading, gap graded and aggregates. Admixtures & construction chemicals, Use of Fly Ash, Silica Fumes, Metakaolin & GGBS in concrete Introduction to prestressed concrete.

UNIT 2: Properties of Concrete: Rheological behaviour of concrete, requirements of workability of concrete, Durability & Effect of environmental conditions, Strength & maturity of hardened concrete, Impact, Dynamic and fatigue behaviour of concrete, shrinkage and creep of concrete, behaviour of concrete under fire.

UNIT 3: **Permeability and durability of concrete**: Permeability and Durability of concrete, Parameters of durability of concrete, chemical attack on concrete, Production of concrete; batching mixing, transportation, placing, compaction of concrete. Special methods of concreting and curing, Hot weather and cold weather concreting, Guniting (Shotcreting).

UNIT 4: **Concrete Mix Design**: Concrete mix design, Basic considerations and choice a mix proportions, various methods of mix designs including IS Code method. Quality control and quality assurance of concrete, Acceptance criteria, Quality management in concrete construction, Inspection and testing of concrete. Non-destructive testing of concrete, core test and load test.

UNIT 5: **Special Concrete**: Special concrete such as high strength, Lightweight, heavy weight, vacuum processed concrete, Mass concrete, high performance concrete, Pumpable concrete, Self-Compacting concrete, Air entrained concrete, Ferro cement, fiber reinforced concrete, Polymer impregnated concrete. Jet concrete. Recycling & re-use of industrial waste material. Deterioration and repair technology of concrete, Distress and type of repairs, crack sealing techniques.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Understand the physical and chemical properties of cement.
2. Understand the various properties of concrete.
3. Understand, Analyze and Evaluate the Concrete mix design.
4. Understand the various special concrete and its uses.

TEXTBOOKS/REFERENCES:

1. Neville, A.M., Properties of Concrete, Pearson Education Asia (P) Ltd, England, 2000.
2. Concrete Technology, Gambhir M.L, Tata McGraw Hill
3. Concrete Technology, M.S. Shetty, S. Chand & Company New Delhi
4. Concrete microstructure, properties & materials, P. Kumar Mehata, Paulo & J.M. Monteiro,
5. Light Weight Concrete, Short & Kenniburg, Asia Publishing House, Bombay.

Unit 1 Urban Environmental Issues

Urbanization- Population growth scenario migration-Pollution of surface water resources rivers, tanks, channels ground water exploitation - wastewater - characteristics – pollution problems - Solid waste - air pollution – CPCB norms. Urban master plans- Planning and Organizational aspects.

Unit 2 Urban Waste Resources Management

Water in urban ecosystem – urban water resources planning and organization aspects storm water management practices-types of storage-magnitude of storage-storage capacity of urban components - percolation ponds - temple tanks- rainwater harvesting.

Unit 3 Urban Water Supply

Demand estimation - population forecasting - source identification - water conveyance -storage reservoirs - fixing storage capacity -Distribution network - types - analysis –computer applications - Conservation techniques -Integrated urban water planning.

Unit 4 Urban Waste Water Management

Sewage generation - storm drainage estimation-industry contribution-wastewater collection system-separate and combined system - hydraulic design of sewer and storm drain –waste water treatment-disposal methods-concept of decentralization- 3R concepts.

Unit 5 Municipal Solid Waste Management

Sources of solid waste - characteristics - rate of generation - segregation at source -collection of solid waste-methods of collection-route analysis-transfer and transfer stations - processing and disposal of solid waste. Case Studies-Environmental economics- Social and Physiological aspects of pollution- Successful Urban Management -models- Urban Management-Case studies from Developed Nations - Software

TEXTBOOKS/REFERENCES:

1. George Tchobanoglous, Hilary Theisen and Samuel A Vigil" Integrated Solid Waste Management", McGraw Hill Publishers, New York,1993.
2. Martin P. Wanelista and Yousef. "Storm Water Management and Operations", John Wiley and Sons,1993.
3. Neil S. Grigg, "Urban Water Infrastructure Planning-Management and Operations", John Wiley and Sons,1986.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Explain planning of a city and identify various urban environmental issues
2. Prepare project Plans to integrate urban water resource
3. Explain water resource management using available water resources
4. Develop sustainable wastewater management concepts comparing with successful models followed in developed nation
5. Apply the principles of solid waste management

Unit-I Modelling of Reinforced Concrete and Masonry buildings, response spectrum for with special emphasis on Code spectrum, Equivalent static Analysis, Seismic design philosophy, concept of strength, over strength, ductility and capacity design

Unit-II Seismic Design of Building Components: Seismic resistant properties of reinforced concrete; Seismic behavior and design of linear reinforced concrete elements; Seismic behavior of planar reinforced concrete elements, code provisions

Unit-III Design of slabs; One-way slab, Two-way slab, Flat slab and Waffle slab; Yield Line Analysis of slab

Unit-IV Design of Columns; Design of Column section under axial load, axial load and uni-axial moment, axial load and bi-axial moments; Design of short and slender column elements; Ductile reinforcement detailing of column

Unit-V Prestressed concrete and design of prestressed concrete structural elements

COURSE OUTCOMES:

On the completion of course student will be able to:

1. The students will be able to effectively analyse and design the structures for seismic forces.
2. Students will have the understanding of basic concepts, behaviour and design of various reinforced concrete structures
3. Students will be conversant with various IS code provisions of reinforced concrete design and reinforced detailing
4. Students can assess the ductility requirement of design and detailing
5. Students will be well aware about yield line analysis of slabs and prestressed concrete.

TEXTBOOKS/REFERENCES:

1. RCC Design, S.N. Sinha, Tata MacGraw Hill
2. Design of RCC, Pillai and Menon, Tata MacGraw Hill
3. Design of Prestressed Concrete, Krishna Raju, Tata MacGraw Hill
4. Seismic Design of Reinforced Concrete and Masonry Buildings, Pauley, T. and Priestley, M.J.N, John-Wiley & Sons
5. Reinforced Masonry Design, Schneider, R.R. and Dickey, W.L, 3nd Ed., Prentice Hall
6. Concrete Structure in earthquake regions, Edmund Booth, Design & Analysis" Longman Scientific & Technical
7. IS Codes: IS 456: 2002, SP:16 and SP:32, IS 13920: 1993

EXPERIMENTS:

1. Study of various boring tools and techniques
2. Study of various sampling tools
3. Vane Shear test
4. Standard Penetration Test
5. Cone Penetration Test
6. Pressure meter Test
7. Dilatometer Test
8. Seismic refraction Test
9. Electrical resistivity Test
10. Study of Field Instrumentation

COURSE OUTCOMES:

On completion of the course, the students will be able to:

1. Perform various soil investigation tests
2. Plan a soil investigation survey according to the structure and the sub-soil
3. Choose the appropriate field instrumentation for a particular test

TEXTBOOKS/REFERENCES:

1. Geotechnical Testing, Observation, and Documentation, 2nd Edition, Tim Davis, ASCE Press, 2008
2. In Situ Testing Methods in Geotechnical Engineering, Alan J. Lutenegger, CRC Press, 2021
3. Geotechnical instrumentation in practice: Purpose, performance and interpretation, ICE Publishing, 1990
4. Latest version of relevant Indian and International codes for various tests.

EXPERIMENTS:

1. Taking longitudinal and crass sectional levelling profile of a road using Auto level.
2. Setting out the horizontal curve using Rankine's method
3. Setting out the horizontal curve using Two theodolite method
4. Setting out works for buildings & pipe lines
5. Setting out work for bridges
6. Trigonometric Leveling - Heights and distance problem
7. Heights and distance using Principles of tacheometric surveying
8. Determination of remote height using total station.
9. Stake out using total station.
10. Distance, gradient, diff, height between two inaccessible points using total station.

COURSE OUTCOMES:

On completion of the course, the students will be able to:

1. Perform layout the building bridge and curve.
2. Estimate the height and length of inaccessible object.
3. Perform the stake out using total station.

TEXTBOOKS/REFERENCES:

1. Duggal S. K., "Surveying Vol 1 & 2" Tata McGraw Hill.
2. Subramanian R., "Surveying and Levelling" Oxford Higher Education.
3. Anderson, J.M. and Mikhail, E.M., "Surveying: Theory and Practice", McGraw Hill. 1998
4. Schofield, W. and Breach M., "Engineering Surveying", 6th Ed., Butterworth-Heineman. 2007

MASTER OF TECHNOLOGY
in
CIVIL ENGINEERING
(INFRASTRUCTURE ENGINEERING)

SYLLABI
of
THIRD SEMESTER

Unit 1- Introduction

Transport and Socioeconomic Activities; Historical Development of Transport; Transportation in the Cities; Freight Transportation; Future Developments. Transport Planning Process, Problem Definition, Solution Generation, Solution Analysis, Evaluation and Choice, Implementation, Sequence of Activities Involved in transport analysis. Trip Generation Analysis: Trip Production Analysis; Category Analysis; Trip Attraction Modelling.

Unit 2- Mode Choice Modelling

Influencing Factors, Earlier Modal Split Models, Trip-End Type Modal Split Model, Trip-Interchange Modal Split Model, Disaggregate Mode-Choice Model, Logit Model of Mode-Choice, Binary Choice Situations, Multinomial Logit Model, Model Calibration, Case Studies. Presentation of Trip-Distribution Data, PA Matrix to OD Matrix, Basis of Trip Distribution, Gravity Model of Trip Distribution, Calibration of Gravity Model, Growth Factor Methods of Trip Distribution.

Unit 3- Transportation Survey

Definition of Study Area Zoning Types of Movements Types of Surveys, Home-Interview Survey, Commercial Vehicle Survey, Intermediate Public Transport Survey, Cordon-Line Survey, Post-Card Questionnaire Survey, Registration-Number Survey, Tag-on-Vehicle Survey.

Unit 4- Urban Structure

Urban Activity Systems, Urban Movement Hierarchies, Types of Urban Structure, Centripetal - Type Urban Structure, Grid-Type Urban Structure, Linear Type Urban Structure, Directional Grid Urban Structure. Urban Goods Movement: Classification of Urban Goods Movements. Methodology of Approach to Analysis of Goods Movement. Modelling Demand for Urban Goods Transport.

Unit 5- Transportation Plan Preparation

Definitions: corridor, corridor traffic forecasting, corridor traffic study, count, segment, point, segment capacity, screen line, Corridor identification, Mass transit system, Urban mass rapid transit system, Rail based transit – Metro, Light rail transit system (LRT), Mono rail, Sky rail, Road based transit – Bus rapid transit system (BRTS), Electric trolley bus, commuter Bus / City Bus.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Justify the need for urban transportation system planning.
2. Undertake transport surveys followed by a report.
3. Plan the process of trip generation and distribution.
4. Justify the need of a modal split.
5. Prepare the transportation plans for urban mass rapid transit systems.

TEXTBOOKS/REFERENCES:

1. Ortuzar, J.D.D. and Willumsen, L.G."Modelling Transport", John Wiley & Sons, 1990.
2. Ben Akiva, M.E. and Lerman,S.R.,"Discrete Choice Analysis : Theory and Application to Travel Demand", The MIT Press, Cambridge, Massachusetts, 1985.
3. Hutchinson,B.G.,"Principles of Urban Transport Systems Planning", McGraw Hill Book Company, 1974.
4. Kadiyali, L.R.,"Traffic Engineering and Transport Planning" Khanna Publishers, New Delhi, 2006.
5. Vukan R. Vuchic, Urban Public Transportation System & Technology, Prentice Hall, Inc.

Unit 1 Introduction

Understanding – Dimensions – Global experience, Global standards and performance bench marks, Practice codes. India smart cities policy and mission, Smart city planning and development, Financing smart cities development, Governance of smart cities.

Unit 2 Green Building Concepts and Sustainable Development

Green projects in smart cities, sustainability – green building – Rating system – Energy efficient building – energy saving systems.

Unit 3 Smart Urban Transport Systems

Elements of Infrastructure (Physical, Social, Utilities and services), Basic definitions, concepts, significance and importance; Data required for provision and planning of urban networks and services; Resource analysis, Provision of infrastructure. Role of transport, types of transport systems, evolution of transport modes, transport problems and mobility issues. Urban form and Transport patterns. Basic principles of Transport infrastructure design. Urban transport planning process –Transport, environment and safety issues. Principles and approaches of Traffic Management, Transport System Management.

Unit 4 Water Supply and Drainage

Water – sources of water, treatment and storage, transportation and distribution, quality, networks, distribution losses, water harvesting, recycling and reuse, norms and standards of provision, institutional arrangements, planning provisions and management issues.

Sanitation – points of generation, collection, treatment, disposal, norms and standards, grey water disposal. Municipal and other wastes –generation, quantity, collection, storage, transportation, treatment, disposal, recycling and reuse, wealth from waste, norms and standards, institutional arrangements, planning provisions and management issues

Unit 5 E- Governance and IOT

The concept of management, concept of e-management & e-business, e-Government Principles, Form e-Government to e-governance, e-governance and developing countries, E governance: Issues in implementation. IOT fundamentals, protocols, design and development, data analytics and supporting services, case studies.

COURSE OUTCOMES:

On the completion of course student will be able to:

1. Explore and understand the fundamental concepts of smart and sustainable cities.
2. Explain the component of smart cities and dwell into their technological advancement.
3. Appreciate the involvement of stake holders in the design and implementation of responsive smart cities.
4. Explain the importance of different linkages and their roles including government, urban planners, universities, city developers and communities.
5. Identify and recognize the role of ICT and data analytics in addressing the urban challenges and key issues

TEXTBOOKS/REFERENCES:

1. Allen G. Noble, (Eds), 'Regional Development and Planning for the 21st Century: New Priorities and New Philosophies', Aldershot, USA, 1988.
2. Andy Pike, Andres Rodriguez-Pose, John Tomaney, 'Handbook of Local and Regional Development', Taylor & Francis, 2010
3. Andreas Faludi and Sheryl Goldberg, 'Fifty years of Dutch National Physical Planning, Alexandrine Press, Oxford, 1991.
4. Daniel G. Parolek, AIA, Karen Parolek, Paul C. Crawford, FAICP, Form Based Codes: A Guide for Planners.

Unit 1. Introduction: National Road development programmes, financial analysis of highway projects, vehicle operating cost. New Road Materials: Alternate forms of aggregates, theory and specifications of fillers, additives, emulsions, cutbacks and modified binder, Mix designs-Marshall, requirement of a mix

Unit 2. Pavement Structure-Soil Interaction: Tests on soil (Plate Load, CBR and Triaxial), strength of pavement materials, importance and functions of each layer of pavement and subgrade.

Unit 3. Design of Flexible Pavements: Design factors, empirical, semiempirical and analytical design methods, California bearing ratio, triaxial, Mclead and Burmister method, advantages and limitations, IRC method of design, design considerations for expressways.

Design of Rigid Pavements: Design factors, load and temperature stresses, load transfer devices, design of Dowel and Tie bars, joint requirement and working, IRC methods of design, construction techniques and specifications, quality control tests, reinforced concrete pavements, continuously reinforced and prestressed.

Unit 4. Different type of pavements WBM, Premix carpet, bituminous concrete etc. **Stabilized Roads:** Aggregate mixtures, proportioning, types of stabilizations, advantages and limitation, special problems related to drainage, control of seepage and capillary rise.

Unit 5. Pavement Evaluation Techniques for Functional and Structural Evaluation: Benkalman beam deflection method, flexible and rigid overlays. **Maintenance of Pavements:** Routine and periodic maintenance, special repairs, case study of failure of flexible and rigid pavements cracking, settlement, frost heaving and mud pumping in pavements.

COURSE OUTCOME:

On completion of the course student will be able to:

1. Identify different additives admixture and materials and their uses.
2. Will have an understanding of soil and pavement interaction and factors affecting it.
3. Design flexible and rigid pavement as per codes and other methods.
4. Identify different type of road construction and problems related to road stabilisation and drainage
5. Will be able to evaluate pavement and understand maintenance process.

TEXTBOOKS/REFERENCES:

1. Kerbs, R.D. and Walker, R.D., “Highway Materials”, MCGraw-Hill.
2. Khanna, S.K. and Justo, C.E.G. “ highway Engineering”, Chand and Bros.
3. Huang, Y.H. “Pavement Analysis and Design” Prentice Hall
4. Wright, P.H. and Dixon, K.K., “Highway Engineering”, John Wiley.
5. Kadiyali, L.R. and Lal, N.B., “Principles and Practices of Highway Engineering”, Khanna Publishers.