SYLLABUS

FOR

Master of Technology

in

CIVIL ENGINEERING

Specialization in -
Structural Engineering
Geotechnical Engineering
Water Resources Engineering
Transportation Engineering
Environmental Engineering

MANIPUR UNIVERSITY
CANCHIPUR

C O N T E N T S

Vision and Mission (Civil Engineering Department)

Vision of the Institute:
Excellence in Engineering education and technology with good leadership in Human Resource Development

Mission of the Institute:
Engineering and technology for all round development and to produce good engineers

Vision of the Department:
To be a good leader in Civil engineering education

Mission of the Department:
1. To empower students and faculty with broad knowledge in Civil Engineering and applications
2. To produce Civil engineers, capable of handling technical and social challenges
3. To produce entrepreneurs capable of solving present problems of the society
4. To provide technological services which are sustainable and environment friendly

PROGRAMME OUTCOMES
The program outcomes for programmes are as following:

PO1. Scholarship of Knowledge
Acquire in-depth knowledge civil engineering, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

PO2. Critical Thinking
Analyse complex civil engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

PO3. Problem Solving
Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

PO4. Research Skill
Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

PO5. Usage of modern tools
Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

PO6. Collaborative and Multidisciplinary work
Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

PO7. Project Management and Finance
Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

PO8. Communication
Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

PO9. Life-long Learning
Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

PO10. Ethical Practices and Social Responsibility
Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

PO11. Independent and Reflective Learning
Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

CURRICULUM FOR M. TECH
IN
CIVIL ENGINEERING UNDER MANIPUR UNIVERSITY

FIRST SEMESTER

S. No.	Subject Code	Subject details	Periods/Week			Marks allotted				Credit hours
			L	T	P	PA*	CT	SE	Full marks	
1.	PG/CE/T/ 111	**Compulsory Subject** Computer Application in Civil Engineering	3	1	0	20	10	70	100	4
2.	PG/CE/T/112	**Core Subject-I** Finite Element Analysis in Civil Engineering	3	1	0	20	10	70	100	4
3.	PG/CE/T/113A PG/CE/T/113B PG/CE/T/113C	**Elective Subject– I (Interdisciplinary)** Project Management Environmental Impact Assessment Industrial Management	3	1	0	20	10	70	100	4
4.	PG/CE/T/114A PG/CE/T/114B PG/CE/T/114C PG/CE/T/114D PG/CE/T/114E PG/CE/T/114F	**Elective Subject– II (Departmental)** Theory of Elasticity and Plasticity Geotechnical Exploration Advanced Hydrology Urban Transportation Systems Planning Advanced Structural Design Physical-Chemical Processes in Environmental Engineering	3	1	0	20	10	70	100	4
5.	PG/CE/T/115A PG/CE/T/115B PG/CE/T/115C PG/CE/T/115D PG/CE/T/115E	**Elective Subject– III (Departmental)** Structural Dynamics Soil Dynamics Dam Engineering Geometric Design of Transport Systems Air and Noise Pollution	3	1	0	20	10	70	100	4
6	PG/CE/P/116	Practical –I	0	0	3	50	-	50	100	2
7	PG/CE/P/117	Practical –II	0	0	3	50	-	50	100	2
8	PG/CE/S/118	Seminar - I	0	0	4	50	-	-	50	2
		Total	**15**	**5**	**10**	**250**	**50**	**450**	**750**	**26**

L – Lecture **T**–Tutorial **P** – Practical
PA – Progressive Assessment **CT**–Class Test **SE** –Semester Examination
***PA** includes 5 marks for attendance.

CURRICULUM FOR M. TECH
IN
CIVIL ENGINEERING UNDER MANIPUR UNIVERSITY

SECOND SEMESTER

S. No.	Subject Code	Subject details	Periods/Week			Marks allotted				Credit hours
			L	T	P	PA*	CT	SE	Full marks	
1.	PG/CE/T/211	**Core Subject – II** Advanced Soil Mechanics	3	1	0	20	10	70	100	4
2.	PG/CE/T/212	**Core Subject – III** Optimization Techniques in Civil Engineering	3	1	0	20	10	70	100	4
3.	PG/CE/T/213A PG/CE/T/213B PG/CE/T/213C PG/CE/T/213D PG/CE/T/213E PG/CE/T/213F	**Elective Subject – IV (Departmental)** Advanced Concrete Technology Rock Mechanics and Tunneling Ground Water Engineering Traffic Flow Modelling and Simulation Theory of Plates and Shells Environmental System Modelling	3	1	0	20	10	70	100	4
4.	PG/CE/T/214A PG/CE/T/214B PG/CE/T/214C PG/CE/T/214D	**Elective Subject – V (Departmental)** Earthquake Resistant Design of Structures Ground Improvement Techniques Advanced Wastewater Treatment Pavement Analysis and Design	3	1	0	20	10	70	100	4
5.	PG/CE/T/215A PG/CE/T/215B PG/CE/T/215C PG/CE/T/215D PG/CE/T/215E	**Elective Subject – VI (Departmental)** Bridge Engineering Advanced Foundation Engineering Highway Construction Practices and Management Water Resources Systems Planning and Management Municipal Solid Waste Management	3	1	0	20	10	70	100	4
6	PG/CE/P/216	**Practical – III**	0	0	3	50	-	50	100	2
7	PG/CE/P/217	**Term Paper Leading to Thesis**	2	0	0	50	-	-	50	2
8	PG/CE/S/218	**Seminar – II**	0	0	4	50	-	-	50	2
		Total	**17**	**5**	**7**	**250**	**50**	**400**	**700**	**26**

L – Lecture **T**–Tutorial **P** – Practical
PA – Progressive Assessment **CT**–Class Test **SE** –Semester Examination
***PA** includes 5 marks for attendance.

CURRICULUM FOR M. TECH
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THIRD SEMESTER

S. No.	Subject Code	Subject details	Periods/Week			Marks allotted				Credit hours
			L	T	P	PA*	CT	SE	Full marks	
1.	PG/CE/Th1/311	Thesis (Part I)	0	0	20	200	-	-	200	15
2.	PG/CE/S/312	Seminar – III	0	0	4	100	-	-	100	3
		Total	**0**	**0**	**24**	**300**	**-**	**-**	**300**	**18**

L – Lecture **T**–Tutorial **P** – Practical
PA – Progressive Assessment **CT**–Class Test **SE** –Semester Examination
***PA** includes 5 marks for attendance.

FOURTH SEMESTER

S. No.	Subject Code	Subject details	Periods/Week			Marks allotted				Credit hours
			L	T	P	PA*	CT	SE	Full marks	
1.	PG/CE/Th2/411	Thesis (Part II)	0	0	20	200	-	100	300	16
2.	PG/CE/Th3/412	Seminar & Viva – Voce on Thesis	0	0	4	-	-	100	100	2
3.	PG/CE/S/412	Grand Viva	0	0	4	-	-	100	100	2
		Total	**0**	**0**	**28**	**200**	**-**	**300**	**500**	**20**

L – Lecture **T**–Tutorial **P** – Practical
PA – Progressive Assessment **CT**–Class Test **SE** –Semester Examination
***PA** includes 5 marks for attendance.

M. TECH IN CIVIL ENGINEERING with Specialization in Structural Engineering/Geotechnical Engineering/ Water Resources Engineering/Transportation Engineering/Environmental Engineering

FIRST SEMESTER:

PG/CE/T/111: Computer Applications in Civil Engineering (3–1–0) (30+70=100)

Unit: I

Computers as Engineering Tools, Review of computer basics, Advanced Excel routines in problem solving, Optimization concepts, Solution of problems.

Unit: II

Numerical Integration, Numerical Differentiation, Solving Differential Equations, Simulation concepts, Finite difference technique, Solving Eigen value problem.

Unit: III

Introduction to C and C++ programming language: Constants, variables and data type, Operators and Expressions, Input and output, Decision making and branching, Decision making and looping, array, functions, structures and unions, pointers, file management, dynamic memory allocations, object oriented programming concepts.

Unit: IV

User Interface Matlab as computing engine , General functionality , Scalar and array operations , Plot capabilities, Scripts, Linear equations and applications to engineering problems, Matrix computations, Creating Matlab Functions, Decisions and Loops in Programming etc.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Identify the operational features of computer program and their use in engineering computations(C / C++)*
2. *Create user-defined functions in Excel and Matlab*
3. *Perform linear algebra and matrix operations and their application to solve Civil Engineering problems*
4. *Formulate, solve and interpret simple optimization problems (using Excel Solver)*
5. *Learn to solve civil engineering problems with using Matlab.*
6. *Perform numerical integration (using Matlab)*

References:

1. Numerical Methods for Scientific and Engineering Computations: M.K.Jain, R.K. Iyengar and R.K. Jain, Willey Eastern Limited.
2. Numerical Methods: S.S. Shastry.
3. Applied Numerical Analysis: Curtis I. Gerala, Addission Wasley Published Campus.
4. Numerical Methods for Engineers: Stevan C. Chopra, Raymond P. Canal, Mc. Graw Hill Book Company.
5. C Language and Numerical Methods.: C. Xavier, New Age International Publisher.
6. Computer Based Numerical Analysis: Dr. M. Shanta Kumar, Khanna Book Publishers, New Delhi.

PG/CE/T/112: Finite Element Analysis in Civil Engineering (3-1-0) (30+70=100)

Unit: I

Concepts of FEM, steps involved merits and demerits, energy principles, discretization, Raleigh-Ritz method of functional approximation.

Principles of Elasticity: Stress equations, strain displacement relationships in matrix form, plane stress, plane strain and axi-symmetric bodies of revolution with axi-symmetric loading.

One dimensional FEM: Stiffness matrix for beam and bar elements -shape functions for One Dimensional elements.

Unit: II

Two dimensional FEM: Different types of elements for plane stress and plane strain analysis, displacement models, generalized coordinates, shape functions, convergent and compatibility requirements, geometric invariance, natural coordinate system, area and volume coordinates, generation of element stiffness and nodal load matrices.

Unit: III

Isoparametric formulation: Concept, different isoparametric elements for 2D analysis, formulation of 4-noded and 8-noded isoparametric quadrilateral elements, Lagrange elements serendipity elements.

Axi-symmetric Analysis: Bodies of revolution, axi-symmetric modelling, strain displacement relationship, formulation of axi-symmetric elements.

Computation of stiffness matrix, Convergence criteria, Assemblage of element stiffness matrices and solution techniques.

Unit: IV

Analysis of Plane stress/strain and Axi-symmetric stress problems, Analysis of Truss and Framed Structures, Analysis of Plate bending problems and Seepage problems etc, Variational formulation of Finite Element Analysis, Boundary element method.

Unit: V

Three dimensional FEM: Different 3-D elements-strain-displacement relationship, formulation of hexahedral and isoparametric solid element.

Introduction to Finite Element Analysis of Plates: Basic theory of plate bending, thin plate theory, stress resultants, Mindlin's approximations, formulation of 4-noded isoperimetric quadrilateral plate element, Shell Element.

Introduction to non–linear analysis: Basic methods, application to special structures.

Course Learning Outcomes:

After the completion of the course, the students should be able to:

1. *Explain the concept of FEM, energy principles, Raleigh-Ritz method of functional approximation.*
2. *Explain the principles of elasticity, stress equations, strain displacement relationship and axi-symmetric problems.*
3. *Formulation of stiffness matrix of 1D element like beam and bar elements and determining the respective shape functions.*
4. *Explain the different types of 2D element like plane stress and plane strain, shape functions for 4 and 8 node quadrilaterals, 3 and 6 node triangle elements and apply numerical integration technique to formulate 2D elements.*

5. *Formulation of 4 node and 8 node isoparametric quadrilateral elements, Lagrange and serendipity elements.*
6. *Analyze plane stress/strain and axi-symmetric problems.*
7. *Analyze of truss and frame structures, plate bending and seepage problems.*
8. *Explain different of 3D elements, formulation of hexahedral and isoparametric elements.*

References:

1. Concepts and Applications of Finite Element Analysis: Robert D. Cook, David S. Malkus and Michael E. Plesha, John Wiley & Sons.
2. Finite Element Methods: O.C. Zienkiewicz
3. Finite Element analysis: Theory and Programming G.S. Krishna Murthy.
4. Introduction to Finite Element Method: Tirupathi Chandra Patila and Belugunudu.
5. Introduction to Finite element Method: JN Reddy.
6. Introduction to the Finite Element Method: Desai C.S and Abel, J.F., Affiliated East west, Press Pvt. Ltd. New Delhi.
7. Finite element analysis: Bathe & Wilson

PG/CE/T/113X **: Elective-I (Interdisciplinary) (3-1-0) (30+70=100)**

The students can choose any one from the following:

i. **Project Management**
ii. **Environmental Impact Assessment**
iii. **Industrial Management**

i. PG/CE/T/113A **: Project Management**

Unit: I

Necessity of project management, Quantitative methods of management, planning and programming network presentation of a project, hints for drawing networks, Fulkerson's method of numbering the nodes, listing of the activities, milestone charts, procedure for finding the critical path, critical path, C.P.M Bar chart, Short comings of bar charts and remedial measures.

Unit: II

Programming Evaluation and Review Technique (PERT), Optimum scheduling by critical path method.

Unit: III

Principles of management, construction organization and superintendence; operation analysis and statistics; time measurement and scheduling, quantitative management applications, quality management and safety; resource management and inventory; management of accounts; cost and finance; contact and commercial laws; labour and industrial laws; construction practices; earth work and super structure, construction equipment and operation.

Unit: IV

Preliminary estimates, Detailed estimates, call of tenders, publicity of tenders, time limits, scale of charges, Receipt of tender and their acceptance, lowest tender, negotiations, earnest money, forms of earnest money, amount of earnest money, security deposit, contract, payments, deviations, extra substituted items, certificate of completion of contract.

Course Learning Outcomes:

After the completion of the course, the students should be able to:

1. *Apply network analysis in project management*
2. *Apply network planning methods of PERT & CPM for optimum scheduling*
3. *Understand the principles of management and planning*
4. *Knowledge of various construction equipment and their operation.*
5. *Understand the process of project execution*
6. *Analyse, evaluate and design construction contract documents*

References:

1. Effective Project Management: Robert K. Wysocki, Robert Beck. Jr. and David B. Crane; John Wiley & Sons.
2. Project Planning and Control with CPM and PERT: Dr. B.C. Punmiav & K.K. Khandelwal; - Laxmi Publications, New Delhi.
3. Project Management: S. Choudhury, - TMH Publishing Co. Ltd, New Delhi.
4. Total Project Management- The Indian Context: P. K. Joy, - Macmillan India Ltd., Delhi
5. Project Management in Manufacturing and High Technology Operations: Adedeji
6. Bodunde Badiru, - John Wiley and Sons.
7. Course in PERT & CPM: R.C. Gupta, - Dhanpat Rai and Sons, New Delhi.
8. Fundamentals of PERT/ CPM and Project Management: S.K. Bhattacharjee; Khanna Publishers, New Delhi.
9. Project Management: B. Sengupta and H. Guha, Tata McGraw Hill.

PG/CE/T/113B **: Environmental Impact Assessment**

Unit: I

Environmental Impact Assessment (EIA): Environmental impact statement, EIA in project cycle, Legal and regulatory aspects in India according to ministry of environment and forests.

Types and limitations of EIA, Cross sectorial issues and terms of reference in EIA.

Unit: II

Participation of public and non-governmental organizations in environmental decision making.

Prediction tools for EIA: Mathematical modeling for impact prediction, Assessment of impacts- Air, Water, Soil, Noise, Biological, Socio-cultural environments.

Unit: III

Cumulative impact assessment: Documentation of EIA findings, Planning, Organization of information and visual display materials, report preparation.

Preparation, implementation and review: Mitigation and rehabilitation plans, Policy and guidelines for planning and monitoring programmes, Post project audit, Ethical and quality aspects of environmental impact assessment.

Unit: IV

Case studies related to the following sectors – Infrastructure, Mining, Industrial, Thermal Power, River valley and Hydroelectric, Nuclear Power.

Course Learning Outcomes:

After the completion of the course, the students should be able to:

1. *Explain the concepts about the Environmental Impact Assessment (EIA)*
2. *Explain prediction tools for Environmental Impact Assessment (EIA).*
3. *Prepare Environmental Impact Assessment (EIA) reports.*
4. *Undertake case studies of Environmental Impact Assessment (EIA)*

References:

1. Environmental Impact Assessment for Developing Countries: A.K. Biswas, and S.B.C Agarwala, Butterworth Heinemann.
2. Risk assessment in environmental management: A guide for managing chemical contamination problems. K. Asante-Duah, John Wiley and Sons.
3. Environmental and Health Risk Assessment and Management: P.F Ricci, Principles and Practices, Springer.
4. Environmental management: R. H. Theobald, Nova Science Publishers.
5. Environmental planning and management, C. N. Madu, Imperial College Press.

PG/CE/T/113C : Industrial Management

Unit: I

Introduction: Management and Industrial Engineering and relation with other fields, Management concept.

Plant Location and Layout: General considerations, Types of Layout, Cellular Manufacturing.

Unit: II

Work Analysis and Measurement: Design of work methods, Time and motion study, Work sampling, Selection of labour and wage payment, Incentive and motivation. Functional Management: Sources of finance, Balance sheet and Income statement, Different element of costs, Depreciation, Break-even analysis, Economic appraisal of projects.

Unit: III

Production Planning and Control: Methodology, Aggregate Planning, Scheduling, Line of Balancing.

Quality Control: Concepts of quality, Acceptance sampling, Control Charts, Total Quality Management.

Unit: IV

Material Management: Inventory management, Deterministic and probabilistic models of Inventory control, Material requirements Planning, JIT, ERP, SCM Business process reengineering.

Unit: V

Project Management: CPM and PERT, Cost consideration and Crashing.

Course Learning Outcomes:

After the completion of the course, the students should be able to:

1. *Undertake Plant layout for cellular manufacturing.*
2. *Describe the implementation of work and time study at a workplace*
3. *Undertake economic appraisal of projects.*
4. *Explain the philosophy and concept of Total Quality Management in production*
5. *Implement Business Process Reengineering solutions effectively/ Understand concepts and philosophy of Business Process Reengineering.*
6. *Undertake Crash analysis by understanding costs and schedule trade-offs.*

References:

1. Joel Dean, Managerial Economics, PHI Ltd., New Delhi.
2. P. Crowson, Economics for Managers, Macmillan, London.
3. Prasanna Chandra, Financial Management, TMH Pvt. Ltd., New Delhi.

PG/CE/T/114X : Elective-II (Departmental) (3-1-0) (30+70=100)
The Students can choose any one from the following:

i. Theory of Elasticity and Plasticity
ii. Geotechnical Exploration
iii. Advanced Hydrology
iv. Urban Transportation Systems Planning
v. Advanced Structural Design
vi. Physical-Chemical Processes in Environmental Engineering

i. PG/CE/T/114A : Theory of Elasticity and Plasticity

Unit: I

Introduction: Elasticity, notation for forces and stresses, components of stresses, components of strain, Hooks law. Plane stress and plane strain analysis, plane stress, plane strain, differential equations of equilibrium, boundary conditions, compatibility equations, stress function, boundary condition.

Two dimensional problems in rectangular coordinates, solution by polynomials, Saint Venant's principle, determination of displacements, bending of simple beams, application of Fourier series for two dimensional problems, gravity loading. Two dimensional problems in polar coordinates, stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, general solution of two dimensional problems in polar coordinates, application of general solution in polar coordinates.

Unit: II

Analysis of stress and strain in three dimensions, principal stresses, stress ellipsoid, director surface, determination of principal stresses, max shear stresses, homogeneous deformation, principal axes of strain rotation. General Theorems: Differential equations of equilibrium conditions of compatibility, determination of displacement, equations of equilibrium in terms of displacements, principle of superposition, uniqueness of solution, the reciprocal theorem.

Unit: III

Torsion of Prismatic Bars, bars with elliptical cross sections, other elementary solution, membrane analogy, torsion of rectangular bars, solution of torsion problems by energy method, use of soap films in solving torsion problems, hydro dynamical analogies, torsion of shafts, tubes, bars etc.

Bending of Prismatic Bars: Stress function, bending of cantilever- circular cross section, elliptical cross section, rectangular cross section, bending problems by soap film method displacements.

Unit: IV

Introduction to bifurcation of equilibrium, beam column, plates under axial compression, finite element formulation of geometrically non-linear problem.
Theory of Plasticity: Introduction, concepts and assumptions, yield criterions.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Understand concepts, theories and principles underlying elasticity and plasticity theory.*
2. *Define state of stress and strains, equilibrium and compatibility,*
3. *Apply elasticity and plasticity to engineering design and analysis.*
4. *Derive the governing equations and their solutions for application to problems in plane stress state, plane strain state, torsion, bending.*
5. *Derive the governing equations for analysis of stress and strain in three dimensions*

References

1. Theory of Plates and Shells: Timoshenko and Woinowsky-Krieger
2. Design of Thin Shells: Hass A. M.
3. Design and Construction of Concrete Shell Roof: Ramaswamy G. S.
4. Theory of Plasticity: J. Chakarbarthy, McGrawhill Publications.
5. Theory of Elasticity: Y.C. Fung.
6. Theory of Elasticity: Gurucharan Singh.

ii. PG/CE/T/114B : Geotechnical Exploration

Unit: I

Planning and experimental programme, investigations, exploration for preliminary design, exploration for detailed design.

Unit: II

Geo-physical exploration, soundings, probing, drilling and boring techniques.

Unit: III

Excavation methods for exploration, ground water investigations, representative, disturbed and undisturbed samples, samplers, preservation, shipment and storage of samples, bore logs, supervising exploration programs, sub-surface exploration reports.

Unit: IV

Field tests – penetration tests, vane shear tests, pressure meter test, plate load test.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Plan subsurface investigation based on the requirement of civil engineering project and site condition.*
2. *Understand different methods of geo-physical exploration*
3. *Prepare sub-surface exploration reports.*
4. *Understand different types of field tests for geotechnical exploration*

References

1. Foundation Analysis and Design: J. E. Bowles, McGraw Hill Companies
2. Ground Property Characterization from In-Situ Testing: M. D Desai, Published by IGS-Surat Chapter.
3. Sub-Surface Exploration and Sampling of Soils for Civil Engineering Purposes: M. J. Hvorslev, US Waterways Experiment Station, Vicksburg.

iii. PG/CE/T/114C: Advanced Hydrology

Unit: I

Hydrologic cycle, water budget equation, world water quantities, systems concept, transfer function operators, hydrologic model classification.

Reynolds's transport theorem, continuity, momentum and energy equations, discrete time continuity.

Atmospheric circulation, water vapour, formation of rainfall, types and forms of precipitation, monsoon characteristics in India, rainfall measurement, density and adequacy of rain gauges, Thunderstorm Cell model, IDF relationships, Spatial averaging methods of rainfall. Factors affecting evaporation, estimation and measurement of evaporation, energy balance method, aerodynamic method, Priestly- Taylor method, and pan evaporation.

Unit: II

Soil moisture, porosity, saturated and unsaturated flow; Richard's equation, nfiltration, Horton's Phillip's and Green Ampt methods, parameter estimation. Catchment storage concept, Hortonian and saturation overland flow, stream flow hydrographs, base-flow separation. Phi-index, ERH & DRH, algorithm for abstraction using Green Ampt equation, SCS method, overland and channel flow modelling, time area concepts and stream networks**.**

Unit: III

General hydrologic system model, response functions of a linear hydrologic systems and their inter-relationships, convolution equation; definition and limitations of a UH. Derivation of UH from single and complex storms; UH optimization using regression. Matrix & LP methods. Synthetic unit hydrograph, S-Curve, IUH**.**

Unit: IV

Probability concepts, random variables, laws of probability, PDFs & CDFs. Normal and Binomial distributions; Statistical parameters. Fitting of a probability distribution, methods of moments and maximum likelihood: Testing the goodness of fit, Chi- square test. Frequency analysis: Return period, probability plotting, Extreme value distributions, frequency factors, Log-Pearson distribution, confidence limits**.**

Unit: V

Flood estimation by various methods, forecasting of floods, flood frequency analysis, Gumbel's, Pearson type I, II, and III distribution, Log-normal method, design flood for various hydraulic structures.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Analyse components of hydrologic cycle*
2. *Understand advanced hydrological processes and techniques necessary for tackling hydrological and environmental problems.*
3. *Understand and apply the concepts of runoff hydrographs and unit Hydrographs*
4. *Apply probability concept for hydrological forecasting*
5. *Estimate design flood for various hydraulic structures*

References

1. Fluid Mechanics: F. M. White.
2. Fluid Mechanics: Streeter.
3. Fluid Mechanics: K.L. Kumar.
4. Fluid Mechanics: A.K. Jain.
5. Viscous Fluid Flow: White.
6. Computational Fluid Dynamics: Anderson.
7. Applied Hydrology: Ven Te Vhow, David R. Maidment, Larry W. Mays
8. Groundwater hydrology: David Keith Todd
9. Hydrology and water resources engineering: S.K Garg

iv. PG/CE/T/114D : Urban Transportation Systems Planning

Unit: I

Introduction to transportation planning: Systems approach to transportation planning, types of models; concept of travel demand and supply, socio-economic, land use, network, and transport system characteristics affecting transportation planning.

Unit: II

Study area definition, zoning principles, cordon and screen lines, data collection through primary and secondary sources.

Unit: III

Sampling techniques, four-stage sequential modeling approach, trip generation, trip distribution, modal split, trip assignment, land use-transport models.

Unit: IV

Public transport planning, integration of different modes, travel demand management measures, case studies.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Design, conduct and administer surveys for transportation planning.*
2. *Determine travel demand distribution using gravity models and growth factor methods.*
3. *Undertake case studies in public transportation and mass transit planning*
4. *Identify the factors of travel mode choice and develop modal split models.*
5. *Compute the shortest path and assign the travel demand*
6. *Develop land use integrated travel demand models.*

References

1. Modelling Transport: J. de D. Ortuzar and L.G. Willumsen, John Wiley and Sons.
2. Transportation Engineering – An Introduction: C.J. Khisty and B.K. Lall, Prentice Hall of India Pvt. Ltd.
3. Transportation Engineering and Planning: C.S. Papacostas and P.D. Prevedouros, Prentice Hall of India Pvt. Ltd.
4. Principles of Transportation Engineering: P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd.
5. Principles of Urban Transport Systems Planning: B.G. Hutchinson, McGraw-Hill Book Co., New York.
6. Traffic Engineering and Transport Planning: L.R. Kadiyali, Khanna Publishers,
   New Delhi.
7. Public Transportation: G. E. Gray and L. A. Hoel, Prentice Hall, New Jersey.

v. PG/CE/T/114E : Advanced Structural Design

Unit: I

Limit Analysis of R.C. Structures: Rotation of a plastic hinge, Redistribution of moments, moment rotation characteristics of RC member, I.S. code provisions, and applications for fixed and continuous beam. Yield line analysis for slabs: Upper bound and lower bound theorems –yield line criterion –Virtual work and equilibrium methods of analysis for square and circular slabs with simple and continuous end conditions.

Design of Ribbed slabs, Flat slabs: Analysis of the Slabs for Moment and Shears, Ultimate Moment of Resistance, Design for shear, Deflection, Arrangement of Reinforcements.

Unit: II

Flat slabs: Direct design method –Distribution of moments in column strips and middle strip-moment and shear transfer from slabs to columns –Shear in Flat slabs-Check for one way and two way shears -Introduction to Equivalent frame method. Limitations of Direct design method, Distribution of moments in column strips and middle strip.

Design of Reinforced Concrete Deep Beams & Corbels: Steps of Designing Deep Beams, Design by IS 456, Checking for Local Failures, Detailing of Deep Beams, Analysis of Forces in a Corbels, Design of Procedure of Corbels, Design of Nibs.

Unit: III

Folded plates: Introduction, Types of folded plates, structural behaviour of folded plates advantages, Assumptions Whitney method of analysis, Edge shear equation, Analysis of folded plates of Whitney's method. Simpson's method of Analysis of folded plates, moment and stress distribution, no rotation and rotation solutions, continuous folded plates.

Cylindrical and Doubly curved shells.

Unit: IV

Tall RCC and Steel Chimney, Overhead Water tanks and Transmission Tower Design of Machine foundation – Block and Frame type.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Analyse and design a continuous beam and ribbed floor system*
2. *Undertake yield line analysis for slabs.*
3. *Analyse and design a flat slab floor system.*
4. *Analyse and design folded plates*
5. *Analyse cylindrical and doubly curved shells*
6. *Analyse and design tall RCC and steel chimney*

References:

1. Reinforced Concrete Design: S. Unnikrishna Pillai & Menon, Tata Mc. Graw Hill.
2. Advanced Reinforced Concrete Design: P.C. Varghese, Practice Hall.
3. Limit state theory and design of reinforced concrete: S.R. Karve and V.L. Shah, Standard publishers, Pune.
4. Reinforced Concrete Design: Kennath Leet Tata Mc. Graw Hill.
5. Reinforced concrete structural elements –Behaviour, Analysis and Design: P. Purushotham, Tata Mc. Graw Hill.
6. Design of concrete structures: Arthus H. Nilson, David Darwin, and Chorles W. Dolar Tata Mc. Graw Hill

7. Reinforced concrete structures: Vol.1: B.C. Punmia, Ashok Kumar Jain and Arun Kumar Jain, Laxmi Publications.
8. Reinforced concrete structures: I.C. Syaland A.K. Goel, S. Chand & Publishers.
9. Advanced Reinforced Concrete Design: N. Krishna Raju, CBS Publishers & Distributors.
10. Reinforced Concrete: Park and Paulay.
11. Analysis and Design of Concrete Shell Roofs: G.S. Ramaswami.
12. Shell Analysis: N.K. Bairagi.

vi. PG/CE/T/114F : Physical-Chemical Processes in Environmental Engineering

UNIT I

Introduction to Environmental Chemistry; Characteristics of water: pH, Conductivity, TDS, Total solids, Hardness, Alkalinity, Turbidity, DO, BOD, COD; Water quality standards; Unit operations and processes; Principal type of Reactors; Screening; Flow Equalisation.

UNIT II

Coagulation and Flocculation; Sedimentation: Type of settling; Discrete, Flocculent, Hindered & Compression Settling; Flotation: Dissolved air flotation.

UNIT III

Filtration: Type of filters, Head-loss through filters; Design of Slow Sand Filter & Rapid Sand Filter; High rate Filter; Pressure Filter.

UNIT IV

Disinfection; Different Types of Chlorinator (Advantages & Disadvantages); Bleaching Powder; Ozone Treatment; UV radiation; Types of Chlorination; Breakpoint chlorination; Dechlorination.

UNIT V

Suspended and attached growth processes; Aerobic and Anaerobic; Determination of kinetic coefficients.

Course Outcomes:

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

1. *Understand physical and chemical processes in water and wastewater treatment*
2. *Evaluate the influence of various parameters in treatment of water and wastewater treatment systems*
3. *Analyse and design of various unit operations and processes in water and wastewater treatment*
4. *Analyse and design of advanced processes of water and wastewater treatment systems*

References:

1. Pannirselvam. R, "Environmental Engineering Vol-I, Water Supply and Treatment", SPGS Publishers, Chennai.
2. METCALF & EDDY, INC. "Wastewater Engineering - Treatment, Disposal, and Reuse", Third Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi 2005.
3. Casey. T. J. "Unit Treatment Processes in Water and Wastewater Engineering", John Wiley & Sons, England 2003.

PG/CE/T/115X : Elective-III (Departmental) (3-1-0) (30+70=100)

The Students can choose any one from the following:

i. **Structural Dynamics**
ii. **Soil Dynamics**
iii. **Dam Engineering**
iv. **Geometric Design of Transport System**
v. **Air and Noise Pollution**

i. PG/CE/T/115A : Structural Dynamics

Unit: I

Theory of vibration: Elements of vibratory system, Degrees of Freedom, Continuous System, Lumped mass idealization, Oscillatory motion, Simple Harmonic motion, Vectorial representation of S.H.M. , Free vibrations of single degree of freedom system, undamped and damped vibrations, critical damping, Logarithmic decrement, Forced vibration of SDOF systems, Harmonic excitation, Dynamic magnification factor, Phase angle, Bandwidth.

Introduction to Structural Dynamics: Fundamental objectives of dynamic analysis, Types of prescribed loading , Methods of discretization, Formulation of equations of motion by different methods, Direct equilibration using Newton's law of motion / D'Alembert's principle, Principle of virtual work and Hamilton principle.

Single Degree of Freedom Systems: Formulation and solution of the equation of motion , Free vibration response , Response to Harmonic, Periodic, Impulsive and general dynamic loadings, Duhamel integral, Numerical method, Rayleigh's method, Rayleigh, Ritz method.

Unit: II

Multi Degree of Freedom Systems: Selection of the degrees of Freedom, Evaluation of structural property matrices, Formulation of the MDOF equations of motion, Undamped free vibrations , Solutions of Eigen value problem for natural frequencies and mode shapes, Analysis of Dynamic response, Normal co-ordinates, Uncoupled equations of motion, Orthogonal properties of normal modes, Mode superposition procedure.

Vibration Analysis: Introduction, Stodola method, Fundamental mode analysis, Analysis of second and higher modes, Holzer method, Basic procedure.

Unit: III

Continuous Systems: Introduction, Flexural vibrations of beams, Elementary case, Derivation of governing differential equation of motion, Analysis of undamped free vibrations of beams in flexure, Natural frequencies and mode, shapes of simple beams with different end conditions, Principles of application to continuous beams. Consistent Mass Matrix, FEM concept.

Unit: IV

Introduction to Random / Stochastic/Probabilistic Dynamic analysis, Dynamic analysis of frames subjected to blast and earthquake forces: Excitation by rigid base translation, Lumped mass approach, SDOF and MDOF systems, I. S. Code methods of analysis for obtaining response of multi storeyed buildings.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Understand the principles of Structural Dynamics*
2. *Perform dynamic analysis of SDOF and MDOF*
3. *Perform dynamic analysis of continuous systems*
4. *Explain dynamic analysis of multi storeyed buildings as per methods of analysis in IS Code.*

References:

1. Structural Dynamics: Mario Paz, and William Leigh, CBS, Publishers.
2. Structural Dynamics: Roy R Craig, Jr., John Wiley & Sons.
3. Dynamics of Structures Theory and Application to Earthquake Engineering: A.K. Chopra, Pearson Education.
4. Dynamics of Structures: Clough & Penzien, McGraw Hill, New York
5. I.S: 1893, Code of Practice for Earthquake Resistant Design of Structures.

ii. PG/CE/T/115B : Soil Dynamics

Unit: I

Theory of vibration: Single degree, Two degree and Multi degree of freedom system, Free and forced vibration, Transient response, Resonance and its effects, wave propagation, theory and application to dynamic problems.

Dynamic soil properties: General, laboratory and field methods, factors affecting different properties, vibration inducing and measuring instruments,

Shear strength and Liquefaction of soils, Stress, Strain and Strength characteristics of soils under dynamic loads.

Unit: II

Types of machine foundations: General requirements, design criteria for machine foundations, permissible amplitudes and bearing pressure, resonance and its effect, free and forced vibrations with and without damping, constant force and rotating mass type excitation, magnification steady state vibrations, logarithmic decrement.

Natural frequency of foundation: Soil system, Barkan's and I.S. methods of determining natural frequency.

Unit: III

Apparent soil mass: Bulb of pressure concept, Pauw's analogy of foundation, soil systems (Concept only),theory of elastic half space, Lamb and the dynamic Boussinesq's problem Relsner's solution and its limitations, Quinlan and Sung's modifications, Hsiegh's equations for vertical vibration.

Unit: IV

Principles of foundations design for reciprocating and impact type of machine, as per I.S. Codes.

Vibration isolation: types and methods of isolation, isolating materials and their properties.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Explain dynamic properties of soils and various laboratory and non-destructive field tests for determining the properties.*
2. *Determine natural frequency of foundation-soil system*
3. *Determine stresses beneath dynamically applied vertical point loads*
4. *Design reciprocating and impact type of machine as per provisions of BIS Codes.*
5. *Explain various types and methods of vibration isolation*

References:

1. Vibration of Soils and Foundations: D. D. Barkan
2. Vibrations of Soils and Foundations: F E Richart Jr., J R Hall Jr. and R D. Woods, Prentice Hall Inc. NJ.
3. Vibration analysis and design of foundation for machines and turbines: A. A. Major, London Collects Holding Ltd.
4. Soil dynamics and Machine foundation: Swami Saran, Golgotia.
5. Hand book of Machine foundation: P. Srinivasalu and C.V. Vydyanathan Tata McGraw Hill.
6. Soil Dynamics and Earthquake Engineering: Bharath. Bhusan Prasad, PHI, New Delhi.
7. Soil Dynamics: Prakash, McGraw Hill Book Co., New York.
8. Analysis and Design of Machine Foundations: S. Prakash, and V. K. Puri McGraw Hill Book Co., New York.
9. Sreenivasulu, P and Vidyanathan, C. V., Hand Book of Machine Foundation, Tata McGraw Hill, New Delhi.
10. Analysis and Design of Foundation and retaining structures: Sham Sher Prakets.
11. Vibration of Soils & Foundations: Richant Hall & Wood

iii. PG/CE/T/115C : Dam Engineering

Unit: I

Gravity Dams - Forces acting on dam, design criteria, theoretical and practical profile, high and low dam, stability calculations, materials and methods of construction , Galleries, joints.

Arch Dams: types, layout of Constant angle and Constant radius arch dam, forces acting, general concepts of trail load theory, elastic shell methods, thick cylinder theory.

Unit: II

Earth Dam their component and functions, causes of failure. Seepage through dam and its foundations, stability analysis for sudden drawdown condition, steady seepage condition, end of constructions, seismic effects, pore pressures, protection of upstream and downstream slopes. Factors influencing the design of an earth dam. Design criteria for Earth Dam.

Elementary idea of design for spillway and energy dissipaters.

Unit: III

Rock fill Dams: Relevant rock fill characteristics, general design principal method of construction and compaction.

Buttress dams: Types, selection, merits and demerits, Elementary design Principles of buttress dams.

Unit: IV

Determination of capacity, types of spillways e.g. ogee, siphon, chute and. side channel spillway.

Types of gates - tainter, drum, vertical lift and automatic gates.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Describe various types of dams and their characteristics*
2. *Select feasible dam site and type of dam for any hydropower project*
3. *Carry out stability analysis and design of Gravity and Arch dams*
4. *Carry out stability analysis and design of Earthen and Rock fill dams*
5. *Calculate spillway capacity and design Ogee spillway.*

Reference

1. Concrete Dams: R.S. Varshney
2. Irrigation, Water Resources & Water Power Engineering: P.N. Modi
3. Earth Dams: J.L. Sherard.

iv. PG/CE/T/115D : Geometric Design of Transport System

Unit: I

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

Unit: II

Elements of design: sight distances, horizontal alignment, transition curves, superelevation and side friction, vertical alignment - grades, crest and sag curves.

Unit: III

Highway cross sectional elements and their design for rural highways, urban streets and hill roads, at-grade inter-sections – sight distance consideration and principles of design, channelization, mini round-abouts, layout of round-abouts.

Unit: IV

Interchanges - major and minor interchanges, entrance and exit ramps, acceleration and deceleration lanes, bicycle and pedestrian facility design, parking layout and design, terminal layout and design.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Design the longitudinal and cross sectional elements of transportation system.*
2. *Design the horizontal and vertical alignment of roads.*
3. *Design the intersections, interchanges, and parking facilities.*
4. *Design the facilities for bicyclists and pedestrians*
5. *Plan and design mass transit system*

Reference:

1. Highway Engineering: M. Rogers, Blackwell Publishing.
2. Highway Engineering: P. H. Wright, John Wiley & Sons.
3. Highway Engineering: C. H. Oglesby, and R. G. Hicks, John Wiley & Sons.
4. Highway Engineering: R. L. Brockenbrough, and K. J. Boedecker, McGraw-Hill.

v. PG/CE/T/115E : Air and Noise Pollution

UNIT: I

Definitions and scope, Problems and issues, Classification of air pollutants, Sources and effects.

UNIT: II

Monitoring techniques: Sampling methods and measurements of air pollutants and meteorological Parameters; Source monitoring of gaseous and particulate matter, networking of monitoring stations, Analytical techniques.

UNIT: III

Air pollution meteorology; Atmospheric stability; Global air pollution: Acid rain, Ozone layer depletion, Global warming, Greenhouse effect.

UNIT: IV

Legislations and regulations: Ambient air quality standards, Emission standards, emission inventory, and Acts, Methods of air pollution control for defined sources.

UNIT: V

Noise: Definition, Sources, Effects, Noise scales, Decibels and levels, and Noise level monitoring techniques.

Course Outcomes:

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

1. *Understand the various types of air and noise pollutants and its effects*
2. *Understand the processes of monitoring air and noise quality*
3. *Analyse the in-depth knowledge in transportation mechanism of pollutants*
4. *Understand the concepts in controlling air and noise pollutants*

References:

1. Rao, M. N. and Rao, H. V. N., Air pollution, Tata McGraw-Hill Publishing Co; Ltd, New Delhi, 26th reprint 2007.
2. Nevers, N. D., Air Pollution Control Engineering, Waveland Press, Inc., Reissued 2010.
3. S.C. Bhatia, Noise Pollution and its control, Atlantic, 2007.
4. Wark, K. and Warner, C.F., Air Pollution, Its Origin and Control, Harper and Row, New York, 1981.
5. Rao, C. S., Environmental Pollution Control Engineering, New Age Int. Pubs, Reprint, 2012.

PG/CE/P/116 : Practical-I (0-0-3) (50+50=100)

Each Student will carry out a set of experiments from his/her field of study/specialization offered by the department on the recommendation of his/her Sectional in-charge in the First Semester.

COURSE OUTCOME:

1. *Conduct various experiments on Transportation/ Structural/ Environmental/ Geotechnical/ Water Resources Engineering*
2. *Interpret the results of the experiment*
3. *Function effectively as a team member.*
4. *Communicate effectively through written reports and oral presentation.*

PG/CE/P/117 : Practical-II (0-0-3) (50+50=100)

Each Student will carry out a set of experiments from his/her field of study/specialization offered by the department on the recommendation of his/her Sectional in-charge in the First Semester.

COURSE OUTCOME:

At the end of the course, the students will be able to –

1. *Conduct various experiments on Transportation/ Structural/ Environmental/ Geotechnical/ Water Resources Engineering*
2. *Interpret the results of the experiment*
3. *Function effectively as a team member.*
4. *Communicate effectively through written reports and oral presentation*

PG/CE/S/118: Seminar-I (0-0-4) (50+0=50)

Each student will present a seminar on an assigned topic and it will be evaluated by the faculty members of the department.

Course Outcomes:

At the end of the course, the students will be able to –

1. *Undertake research to gain knowledge in new and developing areas in the field of civil engineering.*
2. *Prepare written seminar papers in proper format based on the research*
3. *Prepare seminar presentation in proper format.*
4. *Show communication, interpersonal and presentation skills*
5. *Demonstrate an awareness to maintain professional ethical standards.*
6. *Show commitment to engage in lifelong learning*

SECOND SEMESTER:

PG/CE/T/211: Advanced Soil Mechanics (3-1-0) (30+70=100)

Unit: I

Analysis of stresses and strains of soil: Two and Three dimensional stress tensors, Equation of equilibrium and compatibility, Plane stress and Plane strain problems, stress functions, equations in Cartesian and Polar co-ordinate system.

Unit: II

Consolidation: Terzaghi's one dimensional consolidation, Estimation of total Settlement, Two and three dimensional consolidation, radial consolidation, Sand drains – theory and applications.

Unit: III

Shear Strength: Mohr-Coulomb theory, measurement of shear strength, stress paths, Shear Strength characteristics of Cohesionless Soils, Shear Strength of Saturated Cohesive Soils, Partially saturated soils, State variables, measurement of stress- deformation characteristics.

Unit: IV

Critical State Soil Mechanics: Critical state parameters, Critical state for normally consolidated and over-consolidated soil, Significance of Roscoe and Hvorslev state boundary surfaces- Yielding, Bounding Surfaces.

Unit: V

Permeability, seepage, mathematical analysis, Finite difference formulae for Steady state and transient flows, flow nets, computation of seepage, uplift pressure, and critical hydraulic gradient.

Course Learning Outcomes:

After the completion of the course, the students should be able to:

1. *Calculate and analyze the stresses on soil and be able to draw the stress paths*
2. *Estimate the total settlement of soils*
3. *Evaluate shear strength of various types of soils*
4. *Explain critical state for normally consolidated and over-consolidated soil*
5. *Draw flow nets for various boundary conditions*
6. *Determine critical hydraulic gradient.*

References

1. An Introduction to Geotechnical Engineering: R. D. Holtz and W. D Kovacs, Prentice Hall India.
2. Soil Mechanics: T. W. Lambe and R. V Whitmen, Wiley Eastern Ltd.
3. Mitchel, J. K., Fundamentals of Soil Behavior, John Wiley & Sons.
4. Theoretical Soil Mechanics: K. Terzaghi, John Wiley & Sons.
5. Advanced Soil Mechanics: B. M. Das,Taylor and Francis.
6. An Introduction to the Mechanics of Soils and Foundation through critical state soil mechanics: J. H. Atkinson McGraw-Hill Co.
7. Soil Behavior and Critical State Soil Mechanics: D.M. Wood, Cambridge
a. university press.
8. Soil Mechanics: J A Knappett and R F Craig, Eighth Edition, Spon Press Taylor
a. & Francis.
9. Soil Mechanics and Foundations: Muniram Budhu, John Wiley & Sons, Inc.

PG/CE/T/212: Optimization Techniques in Civil Engineering (3-1-0) (30+70=100)

Unit: I

System concepts: definitions, needs for system approach, different types of system parameters and variables.

Unit: II

Big M Method, duality, sensitivity analysis. Application of Linear Programming for Civil Engineering.

Unit: III

Unconstrained one Dimensional search methods, Dichotomous search method, Fibonacci, Golden section, multivariable unconstrained, gradient techniques, steepest ascent and descent methods, Newton's methods, Application of Dichotomous search method, Fibonacci and Golden section to the various sectors of Civil Engineering, constrained Lagrangian multiplier techniques.

Unit: IV

Principle of optimality, recursive equations, Applications of Dynamic programming to Civil Engineering.

Queuing theory, simulation technique, sequencing model, Morkov's process.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Explain system approach in civil engineering and different types of system parameters and variables.*
2. *Apply Linear Programming to Civil Engineering problems*
3. *Explain different types of search methods for optimisation.*
4. *Apply Dynamic programming to Civil Engineering problems.*

Reference

1. Engineering Optimization Theory & Practice – S.S. Rao.
2. Operation Research – TahaHamdey A.
3. Operation Research – Wagner.

PG/CE/T/213X : Elective – IV (Departmental) (3-1-0) (30+70=100)

The Students can choose any one from the following:

i. **Advanced Concrete Technology**
ii. **Rock Mechanics and Tunneling**
iii. **Ground Water Engineering**
iv. **Traffic Flow Modelling and Simulation**
v. **Theory of Plates and Shells**
vi. **Environmental System Modelling**

i. PG/CE/T/213A : Advanced Concrete Technology

Unit: I

Portland cement: Manufacture, physical and chemical properties, Standard test methods, Different types of Portland and other cements – a brief introduction.

Aggregates: Properties of fine and coarse aggregates.

Unit: II
Properties and standard test method concrete in fresh and hardened state, Mixing, transportation, placing and compaction of concrete.

Unit: III
Effect of chemical admixtures on fresh and hardened concrete, Durability of concrete, Mix proportioning.

Unit: IV
Introduction to special concrete: Lightweight and foam concrete, High performance concrete, Ultra high strength concrete, Ready mix concrete, Roller compacted concrete, fibre reinforced concrete, high density concrete, pumped concrete etc.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Explain concrete ingredients and its influence in strength and durability.*
2. *Explain quality control tests on fresh and hardened concrete*
3. *Explain the relationship between degree of compaction and strength of concrete.*
4. *Describe the effect of chemical admixtures on fresh and hardened concrete*
5. *Explain various types of special concrete and their applications*

References:

1. Advanced Concrete Technology: N. Krishnaraju, CBS Publishers.
2. Concrete Technology: A.M. Nevile, Prentice Hall, New York.
3. Concrete Technology: A.R. Santhakumar, Oxford University Press.
4. Concrete Technology: M. S. Shetty.
5. Concrete Technology: M.L. Ghambir.
6. Concrete – Micro structure, Properties and Material: P. K Mehta and P J Monteiro, McGraw Hill.

ii. PG/CE/T/213B : Rock Mechanics and Tunneling

Unit: I
Classification and characterisation of rock mass, Laboratory Testing of rock specimens, Rock Mass Classification, In-situ testing of rock mass.

Unit: II
Methods of Improving Rock Mass properties: Rock bolting, Pressure grouting, Stability of Rock Slopes, Methods of analysis, Prevention and control of rock slope failure.

Unit: III
Shallow and deep foundations in rock, Allowable bearing pressure, Basement excavation.

Unit: IV
Tunneling in rock - Rock support interaction, Tunnel driving methods, Design of tunnel lining.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Analyse the engineering behaviour of rocks.*
2. *Evaluate allowable bearing pressure of rocks*
3. *Analyse stability of rock slopes*
4. *Explain tunnelling methods.*
5. *Design tunnel lining*

References:

1. Introduction to Rock Mechanics: R. E. Goodman, John Wiley & Sons, New York.
2. Experimental Rock Mechanics: Kiyoo Mogi, Taylor & Francis Group, UK.
3. Rock Engineering Applications: John A. Franklin and B. Dusseault, Maurice, McGraw Hill.
4. Tunnel Engineering Handbook: John O. Bickel, R. Kuesel Thomas and H. King Elwyn, CBS Publishers & Distributors, New Delhi.
5. Tunnel Engineering, Standard Handbook for Civil Engineers: F. I. Lars Christian and G. B. Arthur, McGraw-Hill Co.
6. Engineering in Rocks for Slopes, Foundations and Tunnels: T. Ramamurthy, PHI Learning Pvt. Limited.
7. Rock Mechanics: Wakter Wittke, Springer Verlag, New York.

iii. PG/CE/T/213C : Ground Water Engineering

Unit: I

Definition of Ground Water, Occurrence and movement of groundwater, vertical distribution of subsurface water, Aquifers & their properties, Darcy's law, Permeability, Transmissibility, Stratification, Confined and unconfined groundwater flow under Dupuit's assumptions, Application of Darcy's law to simple flow systems.

Unit: II

Well hydraulics: Governing differential equation for confined and unconfined aquifers, Fully & partially penetrating wells, Interference of wells, Well losses, Pumping test with steady & unsteady flow, Method of images.

Well types, Methods of well construction, Design of wells, Screens, Perforations & gravel packs, Pumping equipment.

Unit: III

Water balance, Assessment of recharge, utilizable recharge, Groundwater estimation norms in India, Constraints on groundwater development, Ground water budget, seepage from surface water artificial recharge.

Unit: IV

Numerical modelling of groundwater flow: Review of differential equations, finite difference solution, direct problem, inverse problem, Groundwater modelling using finite element method.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Explain methods to check the quantity and quality of ground water.*
2. *Explain and design various types of well and pumping mechanism.*
3. *Explain ground water budget and methods to recharge ground water.*
4. *Describe process and procedures of applied groundwater modelling*
5. *Construct numerical groundwater models using popular modelling tools*

References:

1. Hand Book of Applied Hydrology: V. T. Chow, Mc Graw- Hill, N.Y.
2. Groundwater Resources Evaluation: M.C. Graq, McGraw-Hill, N.Y.
3. Groundwater Hydrology: D.K. Todd, John Wiley.
4. Groundwater Modeling: Anderson.

iv. PG/CE/T/213D : Traffic Flow Modeling and Simulation

Unit: I

Traffic flow characteristics: deterministic and stochastic models of stream flows, car flowing models, stability and diffusion phenomena in traffic.

Unit: II

Boltzmann models, signalized and unsignalised intersections, coordination and optimization of network of signalized intersections, pedestrian flow problems.

Unit: III

Fundamentals of traffic simulation modeling, simulation methodologies and model design.

Unit: IV

Simulation languages, application of macro and micro simulation packages.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Understand traffic flow characteristics and traffic flow models*
2. *Model traffic flow on roadways and intersections using traffic flow theory*
3. *Apply the principles of queuing theory to analyse delay at signalized and un-signalized intersections.*
4. *Apply shockwave theory to analyse bottleneck situations on freeways and at signalized intersections.*
5. *Build simulation model to simulate traffic flow at a midblock, intersection and pedestrian crossing.*
6. *Develop empirical and analogy based models of traffic flow*

References:

1. Traffic Flow Fundamentals: A. D. May, Prentice-Hall.
2. Traffic System Analysis: M. Wohl and B. V. Martin, McGraw-Hill Book Company.
3. Traffic Flow Theory and Control: D. R. Drew, McGraw-Hill.
4. Principles of Transportation Engineering: P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd.
5. Traffic Engineering – Theory and Practice: L. J. Pignataro Prentice Hall.
6. Lecture Notes on Recent Developments in Urban Transportation Systems Planning: K. V. Krishna Rao and V. M. Tom, IIT Bombay.

v. PG/CE/T/213E : Theory of Plates and Shells

Unit: I

Cylindrical Bending: Different kind of plates, Assumptions, Derivation of differential equation for cylindrical bending of long rectangular plates, Analysis of uniformly loaded rectangular plates with edges simply supported and fixed subjected to uniform load.

Pure Bending of Plates: Slope and curvature of slightly bent plates, Relations between moments and curvature, Particular cases of pure bending, Strain energy in pure bending, Energy methods like Ritz and Galerkin Methods to rectangular plates subjected to simple loadings.

Unit: II

Small Deflection Theory of Thin Rectangular Plates : Assumptions, Derivation of governing differential equation for thin plates, Boundary conditions, simply supported plate under sinusoidal load, Navier's solution, Application to different cases, Levy's solution for various boundary conditions subjected to different loadings like uniform and hydrostatic pressure.

Circular Plates: Symmetrical loading, Relations between slope, deflection, moments and curvature, Governing differential equation, Uniformly loaded plates with clamped and simply supported edges, Central hole, bending by moments and shearing forces uniformly distributed.

Unit: III

Orthotropic Plates: Introduction, Bending of anisotropic plates, Derivation of governing differential equation, Determination of Rigidities in various cases like R.C. slabs, corrugated sheet Application to the theory of grid works.

Plates on Elastic Foundations: Governing differential equation, deflection of uniformly loaded simply supported rectangular plate, Navier and Levy type solutions, Large plate loaded at equidistant points by concentrated forces.

Unit: IV

Buckling of Plates: Governing equation for Bending of plate under the combined action of inplane loading and lateral loads –Buckling of rectangular plates by compressive forces acting in one and two directions in the middle plane of plate.

Finite Difference Methods: Introduction, Application to rectangular plates subjected to simple loading.

Unit: V

Shells: Classification of shells, Membrane and bending theory for singly curved and doubly curved shells, Various approximations, Analysis of folded plates.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Analyse plates under different boundary conditions subjected to uniform load.*
2. *Analyse rectangular plates subjected to simple loadings using energy methods.*
3. *Derive governing differential equation for thin plates and solve the equation for different boundary conditions and loadings.*
4. *Derive governing differential equation plates on Elastic Foundations and explain the various types of solutions.*
5. *Explain membrane and bending theory for singly curved and doubly curved shells*
6. *Analyse buckling of rectangular plates by finite difference methods*

References:

1. Theory of Plates and Shells: Timoshenko, McGraw Hill Book Co., New York.
2. Theory and Analysis of Plates: P. Szilard, Prentice Hall.
3. Theory of Plates: Chandrasekhar, University Press.
4. Plate Analysis: N. K. Bairagi, Khanna Publishers. New Delhi.

vi. PG/CE/T/213F : Environmental System Modelling

UNIT I

Models: definition, types, uses, systems and models, types of mathematical models: model development; water quality standards; ambient air quality standards.

UNIT II

Historical development of water quality models; rivers and streams water quality modelling; river hydrology and flow analysis; dispersion and mixing.

UNIT III

Estuaries - estuarine transport, - estuary dispersion coefficient; Lakes and impoundments - water quality response to inputs; water quality modelling process - model sensitivity - assessing model performance.

UNIT IV

Air pollution modelling techniques; Transport and dispersion of air pollutants; wind velocity, wind speed and turbulence; Plume rise; estimating concentrations from point sources: the Gaussian Equation.

UNIT V

Exposure to computer models for surface water quality, and air quality.

Course Outcomes:

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

1. *Understand various types of mathematical models and its development*
2. *Analyse the transport mechanism and dispersion of pollutants in environment through mathematical modelling*
3. *Understand the modelling techniques used in environmental system.*
4. *Understand of computer models for surface water quality and air quality*

Reference:

1. Nevers, N. D., Air pollution and control engineering, McGraw Hills Publications, 2003.
2. Zannetti, P., Air Pollution Modelling, Computational Mechanics Publications, Southampton, Boston, 1990.
3. Barratt, R., Atmospheric Dispersion Modelling, Earthscan Publication Ltd, 2003.
4. Steven C. Chapra, "Surface Water quality modelling", The McGraw-Hill Companies Inc., New York, 1997.
5. John Wainwright and Mark Mulligan, “Environmental Modelling Finding Simplicity in Complexity”, John Wiley and sons Ltd, USA, 2004.
6. Deaton and Wine brake, “Dynamic Modelling of Environmental Systems”, Wiley & sons, 2002.

PG/CE/T/214X Elective – V (Departmental) (3-1-0) (30+70=100)

The Students can choose any one from the following:

i. **Earthquake Resistant Design of Structures**
ii. **Ground Improvement Techniques**
iii. **Advanced Wastewater Treatment**
iv. **Pavement Analysis and Design**

i. PG/CE/T/214A : Earthquake Resistant Design of Structures

Unit: I

Engineering Seismology: Earthquake phenomenon, causes of earthquakes, Faults, Plate tectonics, Seismic waves, Terms associated with earthquakes, Magnitude/Intensity of an earthquake, scales, Energy released, Earthquake measuring instruments, Seismoscope, Seismograph, accelerograph, Characteristics of strong ground motions, Seismic zones of India.

Conceptual design: Introduction, Functional planning, Continuous load path, Overall form, simplicity and symmetry, elongated shapes, stiffness and strength, Horizontal and Vertical members, Twisting of buildings, Ductility-definition, ductility relationships, flexible buildings, framing systems, choice of construction materials, unconfined concrete, confined concrete, masonry, reinforcing steel.

Unit: II

Introduction to earthquake resistant design: Seismic design requirements, regular and irregular configurations, basic assumptions, design earthquake loads, basic load combinations, permissible stresses, seismic methods of analysis, factors in seismic analysis, equivalent lateral force method, dynamic analysis, response spectrum method, Time history method.

Reinforced Concrete Buildings: Principles of earthquake resistant design of RC members, Structural models for frame buildings-Seismic methods of analysis, Seismic design methods, IS code based methods for seismic design.

Unit: III

Seismic evaluation and retrofitting: Vertical irregularities, Plan configuration problems, Lateral load resisting systems, Determination of design lateral forces, Equivalent lateral force procedure, Lateral distribution of base shear.

Masonry Buildings: Elastic properties of masonry assemblage, Categories of masonry buildings, Behaviour of unreinforced and reinforced masonry walls, Behaviour of walls, Box action and bands, Behaviour of infill walls, Improving seismic behaviour of masonry buildings, Load combinations and permissible stresses, Seismic design requirements, Lateral load analysis of masonry buildings.

Structural Walls and Non-Structural Elements: Strategies in the location of structural walls, sectional shapes, variations in elevation, cantilever walls without openings, Failure mechanism of non-structures, Effects of non-structural elements on structural system, Analysis of non-structural elements, Prevention of non-structural damage, Isolation of non-structures.

Ductility Considerations in Earthquake Resistant Design of RC Buildings: Introduction, Impact of Ductility, Requirements for Ductility, Assessment of Ductility, Factors affecting Ductility, Ductile detailing considerations as per IS 13920. Behaviour of beams, columns and joints in RC buildings during earthquakes, Vulnerability of open ground storey and short columns during earthquakes.

Unit: V
Capacity Based Design: Introduction to Capacity Design, Capacity Design for Beams and Columns Base Isolation.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Explain characteristics of strong ground motions and general concept of earthquake resistant design.*
2. *Explain various seismic methods of analysis and evaluate seismic forces for RCC buildings as per relevant Indian standards*
3. *Explain seismic evaluation and retrofitting*
4. *Analyse masonry buildings for Lateral load*
5. *Explain ductility considerations in Earthquake Resistant Design of RC Buildings and describe ductile detailing considerations as per IS 13920*
6. *Explain capacity design of Reinforced Concrete Framed Building for Earthquake Loading*

References:

1. Pankaj Agarwal and Manish Shri Khande, Earthquake Resistant Design of Structures, Prentice Hall of India, New Delhi.
2. Introduction to the Theory of Seismology, K.E. Bullen, Great Britain at the University Printing houses, Cambridge University Press.
3. Earthquake Resistant Design of structures: S. K. Duggal, Oxford University Press.
4. Seismic Design of Reinforced Concrete and Masonry Building: Paulay and M.J.N. Priestly, John Wiley & Sons.
5. Masonry and Timber structures including earthquake Resistant Design: A.S. Arya, Nem Chand & Bros.
6. Earthquake Resistant Design of Masonry Building: Miha Tomazev, Imperial College Press.
7. Earthquake Tips –Learning Earthquake Design and Construction: C.V.R. Murty.
8. IS: 1893 (Part-1): Criteria for Earthquake Resistant Design of structures. B.I.S., New Delhi.
9. IS:4326: Earthquake Resistant Design and Construction of Building, Code of Practice B.I.S., New Delhi.
10. IS:13920: Ductile detailing of concrete structures subjected to seismic force Guidelines, B.I.S., New Delhi.

ii. PG/CE/T/214B : Ground Improvement Techniques

Unit: I
Emerging Trends in ground improvement, Mechanical Modification - shallow and deep densification techniques.

Unit: II
Hydraulic Modification: Dewatering techniques, Stabilization with admixtures, Grouting, Injection and principles, grouting pressure criteria, grouting equipment, injection chemicals.

Unit: III
Reinforced Earth Technique: Principles, concepts and mechanism of reinforced earth Ground Anchors and their Uplift capacity, Soil Confinement Systems.

Unit: IV
Construction and application of stone columns and granular piles.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Explain ground improvement using Mechanical modification techniques.*
2. *Explain ground improvement using hydraulic modification techniques.*
3. *Explain ground improvement using reinforced earth technique.*
4. *Design stone columns and granular piles for ground improvement.*

References

1. Engineering Treatment of Soils: F.G. Bell and F.N. Spon, New York.
2. Advances in ground Improvement: Jie Han et al, Allied Pub.
3. Engineering Principles of Ground Modification: Manfred R. Haussmann, Pearson Education Inc. New Delhi.
4. Ground Improvement Techniques, R.P. Purushothama, Laxmi Publications (P) Limited, 2006.
5. Construction and Geotechnical Methods in Foundation engineering: R.M. Koener, McGraw-Hill Pub. Co., New York.
6. Soil Stabilization: Principles and Practice: O.G. Ingles and J.B. Metcalf, Butterworths, London.
7. Methods of Treatment of Unstable Ground: F.G. Bell, Newnes-Butterworths, London.
8. Expansive Soils: J. D. Nelson, and D.J. Miller, John Wiley and Sons, Inc., New York.
9. Designing with Geosynthetics: R.M. Koerner, Prentice-Hall Pub.
10. Earth Reinforcement and Soil Structures: C. J. E. P Jones, Butterworth's, London.

iii. PG/CE/T/214C : Advanced Wastewater Treatment

Unit: I
Objectives of waste water treatment, Purpose of advanced wastewater treatment, Wastewater quantity and transport and waste water characteristics, Alternative flowcharts, function and basic principles involved in different units of conventional wastewater treatment plant.

Reaction and reaction kinetics, Mass balance Reactors and their hydraulic Characteristics, Practical aspects of reactor design.

Screening, Grit removal, flow equalizations and mixing, Flocculation, sedimentation, flotation. Detailed principles and design aspects of Screening, Grit chamber and Sedimentation tank.

Unit: II
Kinetics of biological growth, introduction to suspended and fixed film reactors, Concepts of gas transfer and solids separation, Nitrogen and Phosphorus removal from waste water, Concepts of aerobic and anaerobic treatment of waste water, Design of Activated Sludge system using biological process dynamics.

Unit: III
Process concepts and design aspects of Trickling Filters, Rotating Biological ontactors (RBC) Fluidized bed reactor/treatment.

Aerobic and Anaerobic digestion of sludge, sludge stabilization, dewatering and conditioning.

Miscellaneous methods of dissolved solids removal, sludge disposal methods.

Unit: IV
Principles of tertiary treatment, theory of adsorption and factors affecting adsorption, concepts and different methods of dissolved solids removal, basic principles of Reverse Osmosis, ultra-filtration, electro dialysis, desalination.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Explain unction and basic principles involved in different units of conventional wastewater treatment plant.*
2. *Explain the basic concept of mass balance and design of mass balance reactors*
3. *Design Activated Sludge system using biological process dynamics.*
4. *Explain the various steps of wastewater sludge treatment process*
5. *Explain various tertiary treatment methods of wastewater*

References:

1. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf &Eddy McGraw Hill.
2. Introduction to Environmental Engg.: P.A. Veslind, PWS Publishing Company, Boston.
3. Wastewater Treatment and disposal: S.J. Arceivalla, Marcel Dekker.
4. Wastewater Treatment Plant Planning: Design and Operation, S.R. Quasim, Holt, Rinehart & Winston N.Y.
5. Activated Sludge Process: Theory and Practices, N.F Grey, Oxford.

iv. PG/CE/T/214D : Pavement Analysis and Design

Unit: I
Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods.

Unit: II
Selection of pavement design input parameters – traffic loading and volume, material characterization, drainage, failure criteria, reliability.

Unit: III
Design of flexible and rigid pavements using different methods.

Unit: IV
Comparison of different pavement design approaches, design of overlays and drainage system.

Course Outcomes:
After the completion of the course, the students should be able to:

1. *Select pavement materials as per IRC, AASHTO and Asphalt intitute*
2. *Analyse the stresses and strains in a flexible pavement using multi-layered elastic theory.*

3. *Analyse stresses and strains in a rigid pavement using Westergaard's theory.*
4. *Select pavement design input parameters*
5. *Design flexible and rigid pavement using IRC, Asphalt Institute, and AASHTO methods.*
6. *Design overlays and drainage system.*

References:

1. Pavement Analysis and Design: Y. H. Huang, Pearson Prentice Hall.
2. Pavement Design: Yoder and Witzech, McGraw-Hill.
3. Principles and Practice of Highway Engg.: Sharma and Sharma, Asia Publishing House.
4. Functional Designing of Pavements: Teng, McGraw- Hill.

PG/CE/T/215X : Elective – VI (Departmental) (3-1-0) (30+70=100)

The Students can choose any one from the following:

i. **Bridge Engineering**
ii. **Advanced Foundation Engineering**
iii. **Highway Construction Practices and Management**
iv. **Water Resources Systems Planning and Management**
v. **Municipal Solid Waste Management**

i. PG/CE/T/215A : Bridge Engineering

Unit: I

Investigation and site selection: hydraulic factors, alignment, traffic aspects. Concrete Bridges: Introduction, Types of Bridges, Economic span length, Types of loading, Dead load, live load, Impact Effect, Centrifugal force, wind loads, Lateral loads, Longitudinal forces, Seismic loads, Frictional resistance of expansion bearings, Secondary Stresses, Temperature Effect, Erection Forces and effects, Width of road way and footway.

Unit: II

General Design Requirements: Solid slab Bridges, Method of Analysis and Design. Girder Bridges: Introduction, Method of Analysis and Design, Courbon's Theory, Grillage analogy.

Unit: III

Pre-Stressed Concrete Bridges: Basic principles, General Design requirements, Mild steel reinforcement in prestessed concrete member, Concrete cover and spacing of pre, stressing steel, Slender beams, Composite Section, Propped, Design of Propped Composite Section, Unpropped composite section, Two-stage Prestressing, Shrinking stresses.

Unit: IV

General Design requirements for Road Bridges: bearings and expansion joints, bridge foundation, types of foundation, design of well and pile foundation, bridge vibration, traffic loading, seismic and wind effect, construction techniques and maintenance.

Unit: V

Substructure, Beds block, Piers, Pier Dimensions, and Design loads for piers, Design loads for Abutments.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Discuss various types of loads in road bridges.*
2. *Design and detail superstructure of slab and T-Beam bridges.*
3. *Design of propped composite section and un-propped composite section of Pre-Stressed Concrete Bridges*
4. *Design well and pile foundation for road bridges.*
5. *Design and check the stability of piers and abutments.*

References

1. Essentials of Bridge Engineering: D. J. Victor, Oxford and IBH.
2. Design of Bridges: N. Krishna Raju, Oxford and IBH.
3. Dynamics of Railway Bridges: Thomas Telford.
4. Bridge Deck Behaviour E.C. Hambly.

ii. PG/CE/T/215B : Advanced Foundation Engineering

Unit: I

Bearing Capacity of Foundations: Theories, In-situ tests, Settlement Analysis, control of excessive settlements. Design of spread footings, Combined footings, Strip footings, and Raft Foundations.

Unit: II

Pile Foundations: Carrying capacity of Single pile, cyclic pile load test, Pull out resistance laterally loaded Piles. Pile groups, Negative skin friction,

Unit: III

Pier Foundations: Design and Construction of Piers.

Well Foundations: Design and construction of well foundations, Lateral stability, Foundation Failures.

Unit: IV

Foundations on Collapsible Soils: Origin and occurrence, Identification, Sampling and Testing, Preventive and Remedial measures.

Foundations on Expansive Soils: The nature, origin and occurrence, Identifying, testing and evaluating expansive soils, typical structural distress patterns and Preventive design & construction measures.

Introduction to Reliability-Based Design: Methods, LRFD for structural strength requirements, LRFD for geotechnical strength requirements, Serviceability requirements.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Design shallow foundations to satisfy bearing capacity and settlement criteria.*
2. *Estimate the load carrying capacity and settlement of single piles and pile groups including laterally loaded piles*
3. *Explain analysis and design principles of pier and well foundations.*
4. *Design foundations on collapsible and expansive soils.*
5. *Explain Load and Resistance Factor Design (LRFD) methodology being widely adopted for foundation design*

References

1. Foundation Analysis and Design, J. E. Bowles, McGraw Hill Book Co.
2. Soil Mechanics and Foundation Engineering: V.N.S. Murthy, CBS Publications, Delhi.
3. Designing of Foundation Systems: N. P.Kurian, Nervosa Publishing House, Delhi.
4. Design of Reinforced Concrete Foundations: P. C. Varghese, Prentice Hall of India.
5. Principles of Foundation Engineering: B.M. Das, Thomson Brooks / Cole Publishing Company, Singapore.
6. Foundation Design Principles and Practices: Donald P Coduto, Pearson.
7. Foundation Design and Construction: M.J. Tomlinson, ELBS, London.
8. Analysis and Design of Sub Structures: Swamy Saran, Oxford and IBH Publishing Co., Pvt. Ltd., New Delhi,
9. Foundation Engineering: P.C. Varghese, Prentice Hall of India, New Delhi.
10. Analysis and Design of Shallow and Deep Foundations: M. I. William, L.C. Reese, Shin-Tower Wang.

iii. PG/CE/T/215C : Highway Construction Practices and Management

Unit: I

Embankment, formation cutting in soil and hard rock, sub grade.

Unit: II

Ground improvement, retaining walls on hill roads.

Unit: III

Granular & stabilized sub bases/bases, bituminous surfacing, recycled pavements, concrete roads, non-conventional pavements, road construction equipment.

Unit: IV

Highlights from Handbook on National Highway practices and codes.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Explain how different layers of a road pavement will be constructed*
2. *Explain the importance and construction methods of cross drainage, side drainage and retaining walls in hill roads*
3. *Describe engineering properties of highway construction materials and new technologies and use of road construction equipment in different situations.*
4. *Describe the various construction practices of National Highways as per IRC.*

References

1. Specifications for Road and Bridge Work: MOST, Ministry of Road Transport and Highways.
2. Highways: The Location, Design, Construction, & Maintenance of Pavements: C. A O' Flaherty, Butterworth Heinemann.
3. Bituminous Mixtures in Road Construction: R. N. Hunter, Thomas Telford Services Ltd..
4. Highway Engineering: P. H. Wright, John Wiley & Sons.
5. Highway Engineering: C. H. Oglesby, and R. G. Hicks, John Wiley & Sons.

iv. PG/CE/T/215D : Water Resources Systems Planning and Management

Unit: I

Objectives of water resource planning and management, Necessity, Aspects of water resources planning, water resource development, needs and opportunities, societal goals. Spatial and temporal characteristics of water resources, constraints for its development like non-reversibility, planning region and horizon.

Unit: II

Demand for drinking water, irrigation, hydropower, navigational, planning for flood control.

Cost benefit studies of single and multipurpose projects, multi objective planning models, financial analysis of water resources projects, allocation of cost of multipurpose projects, repayment of cost.

Unit: III

Characteristics and functions of reservoir, reservoir sedimentation, conservation storage, conflict among uses.

Reservoir operation studies: effect on river regime, long term simulation, reliability, resiliency and vulnerability assessment.

Unit: IV

Ground water evaluation, conjunctive use of surface and ground water.

Discounting techniques, benefit cost parameters, estimation of benefits and costs, appraisal criteria, social benefit-cost analysis. Basin planning, inter-basin transfer of water.

Course Outcomes:

After the completion of the course, the students should be able to:

1. *Apply concepts of systems analysis for planning of water resources systems*
2. *Explain various conflicting demands of water resources.*
3. *Undertake cost benefit studies of single and multipurpose projects.*
4. *Undertake Reservoir operation studies by long term simulation.*
5. *Undertake basin water allocation planning for groundwater*

References

1. Economics of Water Resources Planning: L .D. James, and R. R. Lee, McGraw Hill.
2. Irrigation, Water Resources and Water Power Engineering: Modi, P.N. Standard Book Pub., Delhi.
3. Irrigation Engineering and Hydraulic Structure: S.K. Garg, Khanna Publishers.
4. Principles of Water Resources planning: Goodman.
5. Water Resources System Planning: M.C. Chaturvedi.
6. Water Resources Planning and Management: O. J. Helwege.
7. Water Management System Application: A.K. Biswas.

v. PG/CE/T/215E : Municipal Solid Waste Management

UNIT I

Types and Sources of solid wastes - Need for solid waste management - Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, plastics and fly ash.

UNIT II
Waste generation rates and variation - International, global, local level - Composition, physical, chemical and biological properties of solid wastes - waste sampling and characterization plan - Source reduction of wastes - Recycling and reuse - Waste exchange.

UNIT III
Handling and segregation of wastes at source - storage and collection of municipal solid wastes - Analysis of Collection systems - Need for transfer and transport - Transfer stations Optimizing waste allocation - compatibility, storage, labelling wastes.

UNIT IV Objectives of waste processing - material separation and processing technologies - biological and chemical conversion technologies - methods and controls of Composting - energy recovery and other modern techniques in managing solid waste - Case studies.

UNIT V
Waste disposal options - Disposal in landfills - Landfill Classification, types and methods - site selection - design and operation of sanitary landfills, secure landfills - leachate and landfill gas management - landfill closure and environmental monitoring - closure of landfills - landfill remediation.

Course Outcomes:
After the completion of the course, the students will be able to :
1. *Understand the principles of solid waste management*
2. *Identify improper practices of solid waste disposal and management*
3. *Understand the concept of collection and transportation of solid waste management*
4. *Develop and evaluate a proper solid waste management systems*

References

1. George Tchobanoglous et.al, "Integrated Solid Waste Management", McGraw-Hill Publishers, 2003.
2. Bilitewski.B, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, "Waste Management", Springer, 2004.
3. "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2010.
4. Landreth.R.E. and Rebers.P.A., "Municipal Solid Wastes – problems and Solutions", Lewis Publishers, 2002.
5. Bhide A.D. and Sundaresan.B.B., "Solid Waste Management in Developing Countries", INSDOC, 2003.

PG/CE/P/216 : Practical – III (0-0-3) (50+50=100)

Each Student will carry out a set of experiments from his/her field of study/specialization offered by the department on the recommendation of his/her Sectional in-charge in the First Semester.

Course Outcomes:

At the end of the course, the students will be able to –

1. *Conduct various experiments on Transportation/ Structural/ Environmental/ Geotechnical/ Water Resources Engineering*
2. *Interpret the results of the experiment*
3. *Function effectively as a team member.*
4. *Communicate effectively through written reports and oral presentation*

PG/CE/P/217 : Term Paper Leading to Thesis (2-0-0) (50+0=50)

Each student will be given a Thesis/Project problem at the beginning of Second Semester. He/She will work on the literature survey, scope of work, equipment development etc. and submit a report/dissertation. The main Thesis/Project work will, however, be done in the third and fourth semesters.

PG/CE/S/218 : Seminar – II (0-0-4) (50+0=50)

Each student will present a seminar on an assigned topic in the Second Semester. The student will be required to give a write up and present a seminar in the 2ndSemester.

Course Outcomes:

At the end of the course, the students will be able to –

1. *Undertake research to gain knowledge in new and developing areas in the field of civil engineering.*
2. *Prepare written seminar papers in proper format based on the research*
3. *Prepare seminar presentation in proper format.*
4. *Show communication, interpersonal and presentation skills*
5. *Demonstrate an awareness to maintain professional ethical standards.*
6. *Show commitment to engage in lifelong learning*

THIRD SEMESTER:

PG/CE/Th1/311 : Thesis Part – I (0-0-20) (200+0=200)

Each student will devote full time in the Third Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. He/She will present a Thesis/Project Report at the end of the Third Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

Course Outcomes:

After the completion o0f the thesis, the students will be able to-

1. *Apply fundamental and disciplinary concepts and methods to evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.*
2. *Identify and analyze, complex engineering problems critically applying independent judgment.*
3. *Demonstrate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.*
4. *Communicate effectively with engineers and the community at large in written and oral forms.*
5. *Demonstrate an awareness and application of appropriate personal, societal, and professional ethical standards.*
6. *Practice the skills, diligence, and commitment to excel needed to engage in lifelong learning.*

PG/CE/S/312 : Seminar – III (0-0-4) (100+0=100)

FOURTH SEMESTER:

PG/CE/Th2/411 : Thesis Part – II (0-0-20) (200+100=300)

PG/CE/Th3/412 : Seminar & Viva-Voce on Thesis (0-0-4) (0+100=100)

PG/CE/S/412 : Grand Viva (0-0-4) (0+100=100)