DEPARTMENT OF CIVIL ENGINEERING
INSTITUTE OF TECHNOLOGY
BANARAS HINDU UNIVERSITY

M. Tech.
in
Civil Engineering

(Specializations: **Hydraulics and Water Resources Engineering**
Geotechnical Engineering
Structural Engineering
Environmental Engineering
Transportation Engineering*)

SYLLABUS
(Effective From 2006-07)

* Effective from 2007-08

DEPARTMENT OF CIVIL ENGINEERING
INSTITUTE OF TECHNOLOGY
BANARAS HINDU UNIVERSIT

M. Tech. in Civil Engineering

(Common Structure of M.Tech. Course in Hydraulics & Water Resources Engineering/ Geotechnical Engineering / Structural Engineering / Environmental Engineering/ Transportation Engineering.)

SEMESTER - I

Subject	Contact Hours/Week (L & T) P	Credits
THEORY		
1. AM 5103 A Mathematics	3	3
2. Elective I	3	3
3. Elective II	3	3
4. Elective III	3	3
5. Elective IV	3	3
Total of Theory	15	15
PRACTICAL		
6. Laboratory (CE 5301/ CE 5302/ CE 5303/ CE 5304/ CE 5305)	3	2
Total for Semester – I	18	17

SEMESTER - II

Subject	Contact Hours /Week (L & T) P	Credits
THEORY		
1. Open Elective (from other Dept.& School)	3	3
2. Elective V	3	3
3. Elective VI	3	3
4. Elective VII	3	3
5. Elective VIII	3	3
Total of Theory	15	15
PRACTICAL		
6. Project (CE 5401/CE5402/ CE 5403/CE 5404/CE 5409)	6	4
7. Seminar (CE 5405/CE 5406/ CE 5407/CE 5408/CE 5410)	2	1
Total for Semester -II	23	20

SEMESTER - III

Subject	Credits
1.Seminar on Dissertation (CE 6301/CE 6302/CE 6303/ CE 6304/ CE 6309)	5
2. Dissertation – Interim Evaluation (CE 6305/CE 6306/ CE 6307/CE 6308 / CE 6310)	5
Total for Semester -III	10

SEMESTER - IV

Subject	Credits
1. Dissertation – Open Defence (CE 6401/CE 6402/CE 6403/ CE 6404/ CE 6409)	5
2. Dissertation –Evaluation (CE 6405/CE 6406/ CE 6407/ CE 6408/ CE 6410)	10
Total for Semester -IV	15
Grand Total for M.Tech.	62

(Hydraulics & Water Resources Engineering)
Electives for Semester – I
(Any Four of the Following)

1.	CE 5101	Fluid Mechanics
2.	CE 5102	Hydraulics of Open Channels
3.	CE 5103	Surface Water Hydrology
4.	CE 5104	Hydraulic Structures
5.	CE 5105	Remote Sensing for Water Resources and Environmental Management
6.	CE 5106	River Pollution and Control
7.	CE 5119	Earth and Rockfill Dam
8.	AM 5103B	Advanced Numerical Methods

Electives for Semester – II
(Any Four of the Following)

1.	CE 5201	Advanced Fluid Mechanics
2.	CE 5202	Unsteady Flow in Hydraulics Engineering
3.	CE 5203	Water Resources Development and Management
4.	CE 5204	Sediment Transportation
5.	CE 5205	Diffusion and Dispersion in Streams and Rivers
6.	CE 5206	River Engineering and Flood Control
7.	CE 5207	Ground Water Hydrology
8.	CE 5208	Computational Techniques in Water Resources Engg.

(Geotechnical Engineering)
Electives for Semester-I
(Any Four of the Following)

1.	CE 5111	Theoretical Soil Mechanics
2.	CE 5112	Advanced Soil Mechanics
3.	CE 5113	Geotechnical Exploration and Measurement Technique
4.	CE 5114	Ground Improvement Technique
5.	CE 5115	Analysis of Settlement of Soils and Foundations
6.	CE 5116	Clay Mineralogy
7.	CE 5117	Computer Aided Design in Geotechnical Engg.
8.	CE 5118	Soil Structure Interaction
9.	CE 5119	Earth and Rockfill Dam
10.	AM 5103B	Advanced Numerical Methods

Electives for Semester-II
(Any Four of the Following)

1.	CE 5211	Advanced Foundation Engineering
2.	CE 5212	Rock Mechanics
3.	CE 5213	Soil Dynamics
4.	CE 5214	Advanced Shear Strength of Soil
5.	CE 5215	Structural Design of Foundation and Retaining Structures
6.	CE 5216	Offshore Geotechnical Engineering
7.	CE 5217	Geosynthetics and Their Applications
8.	CE 5207	Ground Water Hydrology
9.	CE 5225	Optimization Methods

(Structural Engineering)
Electives for Semester-I
(Any Four of the Following)

1.	CE 5121	Matrix Analysis of Structures
2.	CE 5122	Concrete Structures
3.	CE 5123	Elasticity and Experimental Stress Analysis
4.	CE 5124	Stability of Structures
5.	CE 5125	Metal and Cable Structures
6.	CE 5126	Structural Dynamics
7.	CE 5127	Advanced Concrete Technology
8.	CE 5118	Soil-Structure Interaction
9.	AM 5103B	Advanced Numerical Methods

Electives for Semester-II
(Any Four of the Following)

1.	CE 5221	Theory of Plates
2.	CE 5222	Shell Structures
3.	CE 5223	Finite Element Methods
4.	CE 5224	Plastic Design of Structures
5.	CE 5225	Optimization Methods
6.	CE 5226	Advanced Aseismic Design of Structures
7.	CE 5227	Pre-Stressed Concrete Design
8.	CE 5211	Advanced Foundation Engineering
9.	CE 5215	Structural Design of Foundation and Retaining Structures

(Environmental Engineering)
Electives for Semester-I
(Any Four of the Following)

1. AC 5103A Environmental Chemistry
2. CE 5131 Environmental Systems Engineering I
3. CE 5132 Design of Water Supply and Waste Water Collection Systems
4. CE 5133 Environmental Sanitation
5. CE 5134 Industrial Water and Waste Water Treatment
6. CE 5104 Hydraulic Structures
7. CE 5105 Remote Sensing for Water Resources & Environmental Management
8. CE 5106 River Pollution and Control
9. AM 5103B Advanced Numerical Methods

Electives for Semester-II
(Any Four of the Following)

1. CE 5231 Environmental System Engineering II
2. CE 5232 Design of Water and Waste Water Treatment System
3. CE 5233 Air Pollution and Control
4. CE 5234 Environmental Systems Management
5. CE 5235 Solid Waste Engineering and Management
6. CE 5236 Environmental Impact Assessment and Auditing
7. CE 5237 Automobile Pollution and Control
8. CE 5207 Ground Water Hydrology
9. CE 5208 Computational Technique in Water Resource Engg.
10. CE 5225 Optimization Methods

(Transportation Engineering)
Electives for Semester - I
(Any Four of the Following)

1. CE 5141 Modelling, Analysis and Simulation
2. CE 5142 Pavement Materials
3. CE 5143 Geometric Design of Transportation Facilities
4. CE 5144 Traffic Flow Theory
5. CE 5145 Analysis of Transportation Systems
6. CE 5146 Transport and Environment
7. CE 5147 GIS Applications in Transportation Engineering
8. CE 5112 Advanced Soil Mechanics
9. CE 5114 Ground Improvement Techniques
10. AM 5103B Advanced Numerical Methods

Electives for Semester-II
(Any Four of the Following)

1. CE 5241 Analysis and Design of Pavements
2. CE 5242 Urban Transportation Systems Planning
3. CE 5243 Highway Construction Practice
4. CE 5244 Mass and Multimodal Transportation Systems
5. CE 5245 Traffic Engineering and Management
6. CE 5246 Pavement Evaluation, Rehabilitation and Maintenance
7. CE 5247 Transport Economics
8. CE 5211 Advanced Foundation Engineering
8. CE 5223 Finite Element Method
9. CE 5225 Optimization Methods
10. CE 5236 Environmental Impact Assessment and Auditing
11. CE 5237 Automobile Pollution Control

COURSE OF STUDY
M.Tech. in Civil Engineering

CE - 5101 : Fluid Mechanics

Fundamental concepts and scope. Kinematics of fluid motion. Continuity equation, rotational and irrotational motion, circulation, vorticity, velocity potential and stream function, Methods of solving Laplace's equation. Dynamics of ideal fluids, Euler's equation of motion and their integration. Viscous Laminar flow, derivation of Navier-stokes equations and their solutions for simple problems. Instability of Laminar flow. Theory of boundary layer, boundary layer approximations, Separation, Turbulent flow. Prandtl's mixing length theory, Von Karman similarity hypothesis. Turbulent flow in smooth and rough pipes, velocity equation, Resistance of smooth and artificially roughened pipes. Flow around submerged objects. Types of drag; drag at high velocities, circulation and circulation theory of lift. Compressible flow. Hydraulic models and model techniques. Electrical analogies applied to hydraulic problems. Wind tunnels. Water tunnels.

CE - 5102 : Hydraulics of Open Channels

Open channel flow and its classification: Description and types. Energy and momentum equation for prismatic and non-prismatic open channel sections. Critical flow, its computation and application, and depth in channels. Uniform flow : Its computation and application, other uniform flow formulae, conveyance of a channel section, section factor and hydraulic exponent. Gradually varied flow:Basic assumptions, dynamic equation of gradually varied flow, flow profiles, method of singular point and transitional depth. Computation, analytical and graphical methods. Channel transitions in sub-critical and super-critical flow. Spatially varied flow : Basic principles and assumption, dynamic equation for spatially varied flow, analysis of flow profile, methods of numerical integration and the isoclinal method. Rapidly varied flow: Characteristics of the flow, hydraulic jump and jump as an energy dissipater. Flow in channels of non-linear alignment. Discharge measurement techniques in open channels.

CE - 5103 : Surface Water Hydrology

Description and classification of Hydrologic systems and processes: surface, sub-surface and channel processes.Conceptual models, formulation of their structures and applications in Hydrologic planning and design. Probabilistic and Statistical analyses of hydrologic data including frequency analysis and Regional statistical analysis. Design Storms and design floods. Stochastic processes and models, time series analysis, synthetic data generation and their application to stream flow situation.

CE - 5104 : Hydraulic Structures

Types : Storage, Diversion, Regulation and other structures.Basic principles of Hydraulic Design. Concrete Dams : design and analysis of gravity, arch and buttress dams, structural and construction details. Spillways : Types, hydraulic design, energy dissipation below spillways. Hydro power structures. Structures on permeable foundation. Environmental implications of dams. Dam safety and instrumentation.

CE-5105 : Remote Sensing for Water Resources and Environmental Management

Remote Sensing : Principle of Remote Sensing, Electro-magnetic Radiation, Interaction mechanism and Image formation, Type and characteristics of sensors

and platforms for remote sensing. Data Analysis : Different type of Data products in visible and other bands from aerial and satellite systems, fundamentals of photogrammetry and photo-interpretation, stereophoto-grammetry and characteris-tics of photographic images, basic equipment and methodology for photo-analysis, Multiband concept, Spectral signatures, simple, hybrid and digital method of processing of remote sensing data. Analysis of remotely sensed data for Water Resources and environmental anagement : Analysis of land forms, ecology, environmental planning and assessment, geomorphology, drainage characteristics, soil type, erosion features, land use, vegetal cover, pollution of water bodies, and water quality mapping, snow cover and other surface and ground water features, Basic ground-truth required, estimation of surface flows, Ground-water potential and snow-melt runoff, urban hydrology, Water supply system management, Flood zone mapping, Flood damage estimation, Reservoir sedimentation studies, Estimation of irrigation potentials.

CE - 5106 : River Pollution and Control

River water quality description, river ecology. Sources of pollution, point and non-point sources of pollution, characteristics of pollutants. Pollutant transport and mixing in water environment, rivers, lakes and estuaries. River water quality models, river stage and pollution load relationship, interaction between ground water and surface water pollution. Theory of jets and plumes, location of outfalls, separation zones and pollutant logging, hydrological character of river and pollution management. River water quality monitoring, methodologies, standards. River pollution management, Regional and local approaches, preventive and curative methods, natural energy concepts of river pollution management. Environmental regulations for river pollution control.

CE -5201 : Advanced Fluid Mechanics

Basic laws of motion for a viscous fluid : General properties of the Navier-Stokes equation and its solution, very slow motion, Stoke's and Ossen's flow, problems in lubrication. Laminar Boundary layers : Boundary layer on a flat plate, flow past a cylinder, symmetrical case (the Blasius series) Karman momentum integral equation, Karman and Pohlhausen approximation for two dimensional flows, laminar flow against pressure gradient, separation, Boundary layer control. Turbulent Boundary layer : Stability analysis, Turbulent flow, Reynolds equations of motion, mixing length theories, vorticity transfer theory, Karman's similarity hypothesis, Measurement of turbulence. Elementary statistical theory of turbulence

CE - 5202 : Unsteady Flow in Hydraulic Engineering

Gradually varied unsteady flow in open channels: continuity and dynamic equations, wave profile, propagation and subsidence of flood waves. Flood routing in open channel-kinematic and dynamic including diffusion analogy. Rapidly varied unsteady flow in open channels : Uniformly progressive flow, positive and negative surges. Water waves : Translatory, oscillatory and solitary waves, their development and propagation. Wave trains, group velocity, reflection and refraction of surface waves. Unsteady flow through closed conduits : Fundamental differential equations. Applications in water hammer analysis, simple and differential surge tanks.

CE - 5203 : Water Resources Development and Management

Water Resource development, Objectives, Constraints and criteria based on technical, economic, environmental, social and political factors. Multiple

objectives in Water Resource Management, Benefit cost ratio for Water Resources development projects, General formulation of Water Resource Engineering problems in a system engineering frame work, Conjunctive water resource use. Environmental aspects of Water Resources Projects. Deterministic models-linear programming and dynamic programming. Classical optimization techniques and elementary non-linear programming, fundamentals of decision theory and its applications in Water Resource Management. Theory of games. Sustainable water resource development , Watershed development and management, Rain water harvesting.

CE - 5204 : Sediment Transportation

Properties of sediments, Sediment yield, Models of sediment transport, regimes of flow, forms of bed roughness, Resistance to flow. Bed load transport and related equations. Theory of sediment suspension, sediment distribution along vertical, Total load equations. Sediment distribution in a stream section, Sediment distribution with time, fine sediments and bed materials discharge. Bed load and suspended load samples. Design of alluvial channels. Principles of stream power and minimum energy. Meandering and braiding of streams, Reservoir sedimentation, density currents. Coastal sediment problems. Sediment transport through pipelines. Sediment sampling and measuring devices.

CE - 5205 : Diffusion and dispersion in Streams and Rivers

Basic Definitions and concepts - Concentration, Dilution, Average dilution, Dynamically active and passive substances. Diffusion and Dispersion-molecular diffusion, Turbulent diffusion, convective and advective dispersion. Fick's Laws of diffusion and mass balance equation for the tracer released in an open channel flow. Properties of concentration distributions, Gradient flux relationship, solutions of Diffusion Equation for various initial and boundary conditions.Shear Flow Dispersion - Taylor's analysis of laminar flow in a tube. Aris's Analysis, Dispersion in Turbulent shear flow, Dispersion in unsteady shear flow. Mixing in Rivers-Idealised case of uniform, straight, infinitely wide open channel of constant depth. Vertical Mixing, Transverse Mixing and Longitudinal Mixing. Mixing in irregular channels and Natural Streams. Complications in real streams. Computation of concentration. Distributions, Mixing Length and its estimation in laboratory and stream channels. Longitudinal dispersion in rivers. Estimating and using the Dispersion Coefficient in laboratory and natural streams. Other Methods of predicting the concentration distributions in streams and their limitations. Dispersion of decaying substances. Modeling of Dispersion process, Numerical and physical models.

CE - 5206 : River Engineering and Flood Control

Section A : River Engineering: Generalized characteristics of river channels. Charge in principal hydrological characteristics. Local characteristics of river channel. Stability of the channel and rate of the channel process. Hydraulics of alluvial rivers : Variation of bed material, slope along river; dominant discharge; river plan-forms, straight, meandering, braided; cross-sectional shape, Secondary circulation and flow in bends of Alluvial streams : prediction of river plan forms, local scour at hydraulic structures. Aggradation and degradation of streams; occurrence and estimation. Hydraulic and mathematical models for alluvial streams. River training : guide banks, spurs and groynes.

Section B : Flood Control: Flood forecasting. Flood damage mitigation, structural and non-structural methods. Flood routing through reservoirs and channels, principle, hydraulic methods; principles of hydrologic routing, probabilistic method; Flood damages and benefit studies.

CE - 5207 : Ground Water Hydrology

Ground water flow, basic equations. Dupuit's assumptions for ground water flow with phreatic surface, analysis of two dimensional steady flow to a trench, seepage to trench over sloping impermeable bed. Axially symmetric steady flow to a well in confined and unconfined aquifers, partially penetrating wells. Pumping tests, drawdown due to a group of wells, a single well near a stream and a row of wells along the bank of a stream. Representation of two-dimensional steady seepage as potential flow, conformal representation and method of images, analogue solutions. Unsteady ground water flow: Non-equilibrium equation of a fully penetrating well in a confined aquifer, solution by Theiss, Jacob's and Chow's methods. Single well in a leaky aquifer. Extension to unconfined aquifer situations. Steady vertical seepage below canals, Vedernikov's solution. Unsteady unsaturated flow through soils : Basic equation, application to one dimensional vertical flow (infiltration) below saturated ground-solution by Phillips, approximate solution. Ground water pollution.

CE -5208 : Computational Techniques in Water Resources Engineering

Finite difference analysis : Introduction, central forward and backward difference schemes, explicit and implicit formulation for ground water and unsteady flow problems. Stability and accuracy of explicit and implicit schemes. Introduction to finite element method. Method of Characteristics : Outline of the method, Solution of characteristics, application and examples. Stochastic modeling : Introduction, Correlogram analysis, types of stochastic models, Identification, estimation and diagnostic checking of univariate models, use of stochastic models in hydrologic and water quality modeling. Optimization Techniques : Formulation of the problem, constrained and unconstrained problems, application of search technique in the estimation of hydraulic and hydrologic parameters.

CE 5111: Theoretical Soil Mechanics

Elasticity formulation for soil deformation; Stresses in soils under applied loads; Stability problems in Soil Mechanics; Limiting conditions of failure in cohesive soils; Earth pressure theories.

CE 5112: Advanced Soil Mechanics

Water flow in soils, Steady state flow, Transient flow; One, two and three dimensional consolidation theories and applications; Stresses in soil mass under applied loads: Two dimensional and three dimensional problems; Shear strength characteristics of soils; Critical states of soils; Stability of Slopes.

CE 5113: Geotechnical Exploration and Measurement Techniques

General principles of exploration; Methods of exploration; Boring: Different types of borings; Sampling methods: Surface sampling, sampling from boreholes and core boring in soils; Boring and sampling records, Soil profile. Pore pressure measuring devices for laboratory and field use; Earth pressure cells; Instrumentation for measurement of movements in dams; Vibration-meters, Pickups and generators for vibration study of machine foundations; Load measuring devices; Settlement measurements in field

CE 5114: Ground Improvement Techniques

Need of Ground improvement; Shallow compaction, Deep Compaction; Preloading, Drainage, Vibrofloatation, Sand drains and geosynthetic drains; Mechanical stabilization; Chemical stabilization; Thermal improvement methods; Stone columns; Grouting; Geosynthetics and other soil reinforcement methods; Soil nailing; Improvement by Confinement; Effect of environment on soil properties, Case Histories

CE 5115: Analysis of Settlements of Soils and Foundations

Stress-strain relationships; Evaluation of parameters; Settlement theories; Settlement of footings, rafts, piles and pile groups; Analysis of foundation soil system; Case Histories

CE 5116: Clay Mineralogy

Atomic bonds: Primary and Secondary types; Study of clay forming minerals; Base exchange capacity; Clay water electrolyte system; Gouy-Chapman diffuse double layer theory; Structure of clays; Principle of electro-osmosis; Soil stabilization; Consolidation and strength characteristics of clay in light of clay mineralogy; Clay mineral identification: Differential thermal analysis, X-ray diffraction technique and Scanning electron microscopic studies

CE 5117: Computer Aided Design in Geotechnical Engineering.

Computer implementation: Introductory comments; General outline of geotechnical engineering problems; Input data (preprocessor), Calculation of element matrices (processor), Assembly in a banded matrix form, Imposition of boundary conditions, Solution of problem and post processing; Implementation of computer graphics with the aid of readymade packages; Finite Difference Method (FDM) applied to the solution of Laplace equation in seepage analysis, Wave equation for dynamically loaded pile foundation, Beams on elastic foundation, Plate bending equation, etc; Finite Element Method (FEM): Introduction, Element properties, Shape function, Isoparametric element, Numerical integration, Natural
and global coordinate system; Application of FEM: Plane elasticity problem, Bearing capacity and settlement analysis, Earth Gravity dam, pile-soil interaction analysis, Analysis of soil slope, etc.

CE 5118: Soil Structure Interaction

Contact pressure distribution; Foundation models; Model parameters and their evaluation; Analysis of beams and plates resting on foundation soils, Soil

Structure interaction studies pertain to buried structures; Analysis and design of deep foundation; Modern trends in design of earth retaining structures

CE 5119: Earth and Rockfill Dams

Analysis, design and methods of construction of different types of earth and rockfill dams; Stability conditions and analysis; Special design problems; Installation of instruments and their observations; Different methods of foundation exploration and treatment

CE 5211: Advanced Foundation Engineering

Bearing capacity: Shallow and deep foundations; Settlement analysis: Shallow and deep foundations; Different types of foundations and their designs: Raft, Piles, and Well foundation; Sheet pile walls: Cantilevered and anchored; Excavation and bracings; Design of retaining walls. Foundations subjected to dynamic loads; Design of machine foundations.

CE 5212: Rock Mechanics

Exploration and classification of rocks and rock masses; Defects in rock masses; Engineering properties and behaviour of rocks; Creep deformation and fracture of rocks; Shear Strength of rocks; Stresses around opening, Design of structures in rocks; Foundations on rocks; Stability of rock slopes; Improvement in properties of rock mass

CE 5213: Soil Dynamics

Nature of dynamic loads; Theory of free and forced vibrations; Vibration measurement; Wave propagation; Stress deformation and strength characteristics of soils subjected to dynamic loads, Dynamic earth pressure problems; Dynamic bearing capacity; Dynamic behaviour of pile foundations; Liquefaction of soils; Design of Machine foundations.

CE 5214: Advanced Shear Strength of Soils

Factors influencing shearing resistance; Failure theories; Drained and undrained deformation behaviour of soils; Stress – pore pressure – volume change relationship; Path dependent deformation behaviour; Pore pressure and volume change behaviour, Effective stress - water content relationship. Effect of stress history on failure conditions, Introduction to Critical State Soil Mechanics; Slope stability analysis

CE 5215: Structural Design of Foundation and Retaining Structures

Shallow foundations: All types of footings and raft subjected to axial, eccentric and lateral loads; Pile foundations: Types, design and placement; Well foundations: Types, design and methods of construction; Retaining Structures: Types and design; Break Waters: Design and methods of construction.

CE 5216: Offshore Geotechnical Engineering

Classification; Consolidation and shear strength characteristics of marine sediments; Planning and site exploration of offshore drilling, sampling, laboratory testing, in-situ testing methods and geophysical methods; Current design practice of pile-supported and gravity offshore structures; Dynamic analysis of offshore structures. Anchor design, breakout resistance analysis and geotechnical aspects of offshore pipe line and cable design.

CE - 5217 Geosynthetics and their Applications

Geosynthetics – Definitions and classification, Basic functions and selection, Historical development, Raw materials and manufacturing processes, Properties and test methods, Standards and Codes of Practice; Soil-geosynthetic interaction; Application areas – Retaining walls, Embankments, Shallow foundations, Unpaved roads, Paved roads, Airport, Railway tracks, Slopes, Landfills, Earth dams, Containment ponds, Reservoirs, Ponds, Canals, Pipeline and drainage systems, Tunnels; Seismic aspects of geosynthetic applications; Quality control and *in-situ* monitoring; Cost analysis; Case Histories

CE - 5121 : Matrix Analysis of Structures

Force and displacement methods of analysis, Flexibility and stiffness matrix methods of analysis for beams, trusses, grids and frames. Transfer matrix method. General purpose computer program for analysis of different types of structures by direct stiffness matrix methods. Application of Standard software packages. Introduction to Finite-Element Method.

CE - 5122 : Concrete Structures

Shrinkage and creep effects. Silos, bunkers and chimneys. Multistoried buildings and shear walls. Seismic and wind effects on structures. Design of Box girder and Bow String girder bridges. Cable stayed bridges, Intze tanks and its supporting structures.

CE - 5123 : Elasticity and Experimental Stress Analysis

Theory of Stress : Stress components, Equilibrium equations, Stress transformation, principal stresses, Boundary conditions. Theory of Strain : Strain components, Strain transformation, Principal Strain, Compatibility. Stress-strain relationship, Generalized Hookes law, Strain-energy, Uniqueness theorem, St. Venant's principle. Plane problems in cartesian and polar coordinates, Stress function, Axisymmetric problems, stress concentration. Stress and strain measurements, different types of strain gauges, rosettes, Wheat Stone bridge, circuit for simple and multiple strain gauges.

CE - 5124 : Stability of Structures

Buckling of beams, columns and frames. Lateral buckling of beams, Torsional buckling. Post-buckling analysis. Buckling of plates and shells. Ritz and Galerkin method for conservative and non-conservative systems.

CE - 5125 : Metal and Cable Structures

Design of light gauge, tubular and aluminium structures. Analysis and design of cables, cable trusses and cable roofs, Design of tower structures. Suspension bridges: Classical and deflection theories, design considerations. Cable-Stayed bridges : Analysis and design, Aero-dynamic consideration in cable structures.

CE - 5126 : Structural Dynamics

Vibration of Discrete Systems: Free and forced vibrations of single and multi-degree freedom systems, Damping and Forcing functions, Determination of frequencies and mode shapes, Orthogonal relationship of principal modes, Duhamel's integral, Step-by-step response. Calculation and Response spectra. Vibration of Continuum Systems. Earthquake resistant design of structures and IS recommendations.

CE - 5127 : Advanced Concrete Technology

Constituent materials and their properties, types of cement, fresh concrete, workability; strength, elasticity and fracture of hardened concrete : Time dependent properties of concrete, durability of concrete ; Concrete admixtures, mix design methods ; Manufacture and processes ; Codal provisions ; Special concretes.

CE - 5221 : Theory of Plates

Classical theories of plates, Analysis of simply supported, clamped and continuous plates by exact and approximate methods. Large deflection theories. Plates on elastic foundation, Thermal stresses in plates, Buckling and post buckling of plates.

CE - 5222 : Shell Structures

Classification of Shell structures. Membrane theory of Cylindrical shells, Shells of revolution, ellpar, hypar and conoidal shells. Bending theory of cylindrical shells, Shells of revolution, Edge perturbation, Shallow shells. Simplified bending theories, Continuity analysis of composite shell structures. Analysis and design of folded plates.

CE - 5223 : Finite Element Method

Introduction and basic concepts. Energy approach and variational principles in Finite-Element Method. Various element shapes, Isoparametric elements, Axi-symmetric elements, plate bending elements, introduction to 3-D elements, shell elements, interface elements, boundary elements, infinite elements. Direct and

variational formulations of element stiffness and loads. Assemblage of elements, Boundary Conditions and Solution of overall problems. Techniques of nonlinear analysis. Mesh generation, graphic display and software packages. Organization of FEM programs, efficient solutions, input/output, pre and post processors.

CE - 5224 : Plastic Design of Structures

Introduction to plasticity, Limit analysis theorems, Analysis and design of frames, Plastic moment distribution, Minimum weight design, Secondary considerations. Yield line theory-its applications and limitations. Advanced theory of limit design- some practical applications to plates and shells. Design of Concrete Structures with minimum reinforcement.

CE - 5225 : Optimization Methods

Formulation of optimization problems, classical optimization methods. Unconstrained and constrained minimization techniques. Penalty functions. Method of feasible directions and gradient projection. Linear programming. Applications to engineering problems.

CE – 5226 Advanced Aseismic Design of Structures

Behaviour of structures in past earthquakes: Lessons learnt with regards to weak/strong aspects of structural systems. Ground motion characteristics: Choice of ground motion for a major project site. Detailed study of IS:1893 – Seismic analysis of buildings using codal provisions, design considerations. Study of IS:13920 – Detailing for ductility. Introduction to seismic design: considerations for bridges, dams, chimneys, base isolation. Vulnerability of buildings: use of Vulnerability Atlas and understanding techno-legal issues with regard to buildings. Concepts in repair, restoration and seismic strengthening: Retrofitting- weakness in existing buildings, aging, weathering, development of cracks, material and equipment for repairs of masonry and concrete structures, study of IS:13935. Methodologies for repairs: for walls, roofs, slabs, column and foundations of buildings in stone, brick or reinforced concrete.

CE-5227 : Prestressed Concrete Design

Materials, prestressing systems, losses in prestress. Analysis and design of simple and continuous beams by working stress and limit-state methods. Deflection and cracking consideration. Anchorage and bond. End block stresses.

AC - 5103 A : Environmental Chemistry

Fundamentals of Chemistry for Environmental Engg., Basic concept for General Chemistry, Physical Chemistry, Equilibrium Chemistry, Organic Chemistry, Bio-Chemistry, Colloid Chemistry, Polymer Chemistry. Chemical Kinetics for aeration, Coagulation, disinfection, including chlorine demand, Iron removal, defluoridation, demineralisation, Ion-Exchange, Heavy metal pollution and control. Bio-Chemical reaction related to bio-degradation of aquatic pollutants. Electro-Chemicals aspects of Corrosion. Chemistry of Soil/land Pollution with emphasis on pesticide pollution. Atmospheric Chemistry with special reference to formation of secondary pollutants. Instrumental methods for analysis of water and waste water quality parameters.

CE - 5131 : Environmental Systems Engineering – I

Sources of water: surface & ground. Water demand for various purposes; water & wastewater flow measurement devices. Water supply conduits, valves, & fittings,

jointing, laying; water hammer: causes, extent, and mitigation. Ground water management: aquifer properties & parameters, ground water hydraulics, well systems: open well, hand pumps, tube well, infiltration well & galleries, radial collector well. Sewerage system, basic hydraulics relating to wastewater collection and disposal, sewer appurtenances, side weir, depressed sewer. Water quality parameters and their standards. Fundamentals concepts of physical, physico-chemical, & chemical unit operations & processes in water & wastewater treatment with reference to such processes as coagulation –flocculation, sedimentation, filtration, disinfection, equalization, neutralization, precipitation, ion-exchange, corrosion control, oxidation & reduction processes, demineralization.

CE - 5132:Design of Water Supply and Waste Water Collection   Systems

Estimation of water demand based on population projection. Designs of source intakes, raw water pumping main, economic design of rising main, determination of storage capacity of reservoirs. Estimation of aquifer parameters, Design of well systems. Structural design of water supply pipes: structural load on sewers in different situations. Design of water supply pipe network and pumping systems. Design of sewerage system: sanitary & storm sewers, street inlets, inverted siphon, side weirs. Design of wastewater collection systems. Design of rain water harvesting devices.

CE - 5133 : Environmental Sanitation

Linkage between sanitation and human health, low-cost sanitation options & their selection in unsewered areas, travel of pollution and its control, control of vector- and water-borne diseases, water quality surveillance, sanitary survey. Sanitation of swimming pool, hospital, school, & other establishments including fair (mela) and urban slums, disinfection of well, pond, handpumps. General sanitation & vector control measures, Rural sanitation systems and womens' role in ensuring rural sanitation. Pollution of land/ soil and its remediation, noise pollution and abatement.

CE - 5134 : Industrial Water and Waste Water Treatment

Industrial wastewater: sources, types, characteristics. Industrial water demand and quality criteria, General treatment options for industrial effluents, common equipments used for industrial wastewater treatment. Removal of specific pollutants in industrial effluents, eg oil & grease, phenol, cyanide, toxic organics, heavy metals. Treatment of industrial effluents originating from dairy, paper & pulp, textile, tannery, distillery, electro-plating, petroleum & petro-chemical complex, iron & steel industry, pharmaceutical, food processing units.

CE - 5231: Environmental Systems Engineering - II

Fundamental concepts of microbiology: types, characteristics, growth, and reproduction of micro-oragnisms in aquatic environment. Role of micro-organisms in self-purification of water bodies and wastewater treatment; algae

and other higher organisms in wastewater purification; control of algal population in water supply lines and eutrophication in water bodies. Bacteriological quality of water and its assessment. Biological treatment of wastewater: fundamental

concepts of bio-chemical kinetics and reactor engineering. Aerobic biological treatment options: trickiling filter, activated sludge process, waste stabilization pond system, rotating biological contactor, oxidation ditch, aerobic digestion. Anaerobic biological treatment options: digestion, anaerobic pond & lagoon, upflow anaerobic sludge blanket reactor, anaerobic filter. Tertiary treatment of wastewater: removal of nutrients such as nitrogen and phosphorus. Performance evaluation of biological reactors.

CE - 5232 : Design of Water and Wastewater Treatment Systems

Design of conventional water treatment plant: coagulation of dosing and mixing tanks, flocculation unit, sedimentation tanks along with inlet, outlet, and sludge removal mechanisms. Design of conventional wastewater treatment plant: primary treatment units such as screens, grit chambers with control section, primary sedimentation tanks; secondary (biological) treatment units such as trickling (bio-) filters, activated sludge process, waste stabilization ponds, oxidation ditch, aerated lagoon, rotating biological contactor, secondary sedimentation tanks, anaerobic digester. Design of up-flow anaerobic sludge blanket reactor, anaerobic filter, septic tank, Imhoff tank.

CE - 5233 : Air Pollution and Control

Introduction to air pollution; types, sources, effects, and standards of air pollution. Monitoring (sampling & analyses) of common air pollutants. Meteorology and mathematical models related to dispersion & transport of air pollutants, strategies for air pollution control through rational urban planning. Air pollution due to automobiles and its control measures. Engineering control of industrial air pollution: theory & design of particulate control devices such as gravity settling chamber, cyclone separator, electro-static separator, air filters, wet scrubbers; theory & design of gaseous pollutants' control devices such as adsorption, absorption, incineration (natural, thermal, & catalytic), condensation. Some case studies of industrial emission control. Legal aspects of air pollution.

CE - 5234: Environmental Systems Management

Various water & wastewater quality modeling for both point- & non-point sources, wastewater outfall dispersion, water resources modeling, ground water pollution & recharging models including saline water ingress aspects, composite models for water & air pollution system, sound propagation models, solid waste planning & management models. Environmental laws, policies, legislations, and planning practices. Environmental economics. Modern environmental planning techniques using C.P.M. & P.E.R.T concepts.

CE - 5235: Solid Waste Engineering and Management

Introduction; source, types, quantity, characteristics of solid wastes. Health & environmental implication of solid waste handling. Sampling & analyses of solid wastes. Municipal solid waste management: storage, collection, transfer, and transportation. Treatment & disposal of solid wastes: sanitary land filling, composing, incineration. Typical design problems on solid waste management. Resource conservation & recovery. Legal aspects; financial evaluation of solid waste management options.

CE- 5236 : Environmental Impact Assessment and Auditing

Environmental impact assessment (EIA): environmental statement & target areas fixation, scoping, objectives, water & wastewater quality assessment models related to EIA, Air pollutants' transport models, noise propagation models, methods for carrying out EIA starting from feasibility studies; case studies of EIA with special emphasis on developmental projects like high ways, dams, water supply & sewerage, power plants. Preparation of environmental management plan (EMP) Procedure for obtaining environmental clearance, siting guidelines for industries. Public participation in carrying out EIA and EMP. Environmental Auditing including resources auditing, water auditing, energy auditing, health auditing: advantages, procedure, case studies.

CE 5237 : Automobile Pollution Control

Introduction to internal combustion engines; Spark Ignition & Compression Ignition engines; 4-Stroke and 2-Stroke engines, engines' performance parameters, principles of working, other types of engines; sources of emissions in an IC engine. Mechanisms of formation of exhaust pollutants: CO, HC, NOX, SOX, Particulate Matters, Exhaust gas composition, analysis, important factors affecting exhaust composition, air fuel ration. Overview of impact of air pollution due to automobiles. Control strategy: primary & secondary.

CE - 5141 : Modeling, Analysis and Simulation

Taxonomy of model types, steps in model building, Simulation, Algorithms and Heuristics, Simulation languages. Relationships via physical laws, Relationships via Curve fitting, Parameter estimation problems, State transition models. Collection and presentation of data, Measures of Central tendency, Elementary probability theory, Random events, Bay's theorem, Random variables and distributions, Derived distributions, Moments and Expectations, Common probabilistic models, Statistical inference, Estimation of parameters, Tests of hypotheses and significance, Goodness of fit tests, Regression and Correlation analysis, Multivariate analysis and applications, Time services. Neighborhood and distances, Cluster analysis, Individual and group preference patterns. Graphical models and matrix models, Input-Output type models, Decomposition of large systems, Routing problems. Block diagram representation, State space models, Stability, System Control. Discrete and continuous growths, Limits to growth, Competition among species, Growth process and integral equations, Discrete event approach, Population planning. Monte Carlo methods, Stochastic simulation, System identification, Inverse problems, Virtual reality.

CE - 5142 : Pavement Materials

Subgrade functions, Importance of subgrade soil properties on pavement performance. Identification and significance of soil characteristics, Soil classification, Effect of water on swelling and shrinkage, Cohesion and Plasticity. Road making aggregates - Classification, Properties of aggregates, design of aggregate gradation, texture, polishing and skid resistance. Bituminous road binders - Straight- run bitumen, emulsions, Cutback and modified binders. Rheology of bituminous binders, modified binders - adhesion and stripping, penetration index, viscosity, temperature susceptibility of viscosity. Additives and

their suitability, Fillers. Design of Bituminous mixes - Marshall method and super paves procedure. Design of emulsified mixes, Visco-elastic and fatigue properties of bituminous mixtures, resilient modulus of pavement materials. Requirements of paving concrete, design of mixes - IRC, absolute volume, Road Note No.4, Vibrated Concrete mix design, design of DLC and SFRC mixes, Soil stabilization techniques.

CE - 5143 : Geometric Design of Transportation Facilities

Geometric design provisions for various transportation facilities as per AASHTO, IRC and other guidelines, Discussion of controls governing geometric design, route layout and selection. Elements of design - sight distances, horizontal alignment, transition curves, super - elevation and side friction. Vertical alignment - grades, crest and sag curves. Highway cross - sectional elements and their design for rural highways, Urban streets and hill roads. At grade intersections - sight distance consideration and principles of design, Channelisation, mini round - abouts, layout of round - abouts, Inter - Changes - 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.

CE - 5144 : Traffic Flow Theory

Component of Traffic Flow System, Traffic variables and parameters, Driver behaviour modeling, Simulation, Controlled - Access Concept, Freeway Concept, System performances, Measure of effectiveness. Flow through transportation networks - various types of graphs, determination of link and chain flows, finding maximum flow values of capacitated networks. Capacity of a roadway, Botlenecks. Approaches to traffic flow theory, Traffic flow relationships - flow at different densities, Shock wave phenomenon, time - Space diagram. Mathematical modeling, Probabilistic and Stochastic models of traffic flow process, Discrete and Continuous modeling headways, Gaps and process of gap acceptance, Macroscopic models, Car - following model, Queuing models, fundamentals & developments of queuing process, Applications. Indices of Level of Service (LOS) as offered to road users.

CE - 5145 : Analysis of Transportation Systems

Introduction to Transportation systems, Transportation innovations, Social and Economic impacts of Transportation, Decision makers and their options, Demand modeling and prediction, Supply and equilibrium flows, Modelling and transportation technology, Analysis of network flows, Transportation network, Network theory, Concepts in transportation models and location models, Analysis of utility maximizing systems such as entropy Concepts, Major transportation technologies, Cost functions and estimation, Urban transport economic policy, Models for selecting network investments and operation planning, Case Studies.

CE - 5146 : Transport and Environment

Modes of Transportation, Mixed traffic flow, Transport related pollution, Road transport related air pollution, Sources of air pollution, Effects of Weather

Conditions, Vehicular emission parameters, Pollution standards, Measurement and analysis of vehicular emission, Mitigative Measures. Urban and non-urban traffic noise sources, Noise level factors, Effects of traffic noise, Propagation and measurement of traffic noise, Prediction and control measures, Noise studies, Noise standards.   EIA requirements of highway projects, EIA procedures, guidelines, EIA practices in India.

CE - 5147 : GIS Applications in Transportation Engineering

Remote sensing : Physics of remote sensing, Ideal remote sensing system, Remote sensing satellites and their data products, Sensors and orbital characteristics, Spectral reflectance curves, resolution and multi-concept, FCC, Interpretation of remote sensing images. Digital image processing : Satellite image - characteristics and formats, Image histogram, Introduction to image rectification, Image enhancement, Land use and land cover classification system. Geographic information system (GIS) : Basic concept of geographic data, GIS and its components, Data acquisition, Raster and vector formats, Topography and data models, Spatial modeling, Data output, GIS applications. Global positioning system (GPS) : Introduction, Satellite navigation system, GPS- space segment, Control segment, User segment, GPS satellite signals, Receivers; Static, Kinematic and Differential GPS. Applications in Transportation Engineering : Intelligent Transport System, Urban Transport Planning, Accident Studies, Transport System Management, Road Network Planning, Collecting Road Inventory.

CE - 5241 : Analysis and Design of Pavements

Philosophy of design of flexible and rigid pavements, Subsystem of pavement design, Basis of pavement design, Analysis of pavements using different analytical methods, Selection of pavement design input parameters - traffic loading and volume, Material characterization, Drainage failure criteria, Reliability pavement support condition, Properties of components and design tests, Design of flexible and rigid pavements using different Methods for highway and airport pavements, Soil stabilization methods, Quality Control and Tolerance, Comparison of different pavement design approaches, Computer Programming for various pavement analysis and design methods. Design of drainage system.

CE - 5242 : Urban Transportation Systems Planning

Hierarchical levels of planning, Passenger and Good transportation, General concept and planning process, Urban Travel characteristics, Private and Public Travel Behaviour Analysis, Travel Demand Estimation and Forecasting, Trip Generation Method and their comparison, Trip Distribution, Modal Split Analysis and Trip Assignment, Behavioural Approach. Trip Generation modeling - variables influencing trip generation, Regression Analysis and Category Analysis, Trip distribution Modeling - factors governing trip distribution, Growth factor Method, Gravity Model, Intervening opportunity and Competing opportunity Models, Modal Split Modeling - factors influencing Mode choice, Two stage Modal Split Models, Discrete choice Models, Entropy Maximizing and Linear Programming Methods, Transport behaviour of Individuals and Households, Network and Route Assignment, Capacity Restrain and Simultaneous Distribution, Direct Demand Models, Land - Use Transport Planning, Transport

Related Land - use Models, Corridor Type Travel Planning, Statewide and Regional Transportation Planning, Introduction to Urban Freight Transportation.

CE - 5243 : Highway Construction Practice

Embankment Construction: Formation cutting in Soil and hard rock, Preparation of Subgrade, Ground improvement, Retaining and Breast walls on hill roads, Granular and Stabilized, Sub - bases / bases, Water Bound Macadam (WBM), Wet Mix Macadam (WMM), Cement treated bases, Dry Lean Concrete (DLC). Bituminous Constructions: Types of Bituminous Constructions, Interface Treatments, Bituminous Surfacing and wearing Courses for roads and bridge deck slabs, Selection of wearing Course under different Climatic and Traffic conditions, IRC specifications, Construction techniques and Quality Control. Concrete road construction: Test on Concrete mixes, Construction equipments, Method of construction of joints in concrete pavements, Quality Control in Construction of Concrete pavements, Construction of Continuously reinforced, Pre-stressed, Steel Fibre Reinforced (SFRC) Pavements, IRC, MORT&H, ACI Specifications, AASHTO Specifications, Recycled pavements, Non - Conventional Pavements, Overlay Construction. Hill Roads Construction: Stability of Slopes, Landslides - Causes and Control measures, Construction of Bituminous and Cement Concrete roads at high altitudes, Hill road drainage, Construction and maintenance, problems and remedial measures.

CE - 5244 : Mass and Multimodal Transportation Systems

Transportation scenario, Public Transportation, Demand characteristics, Spatial, Temporal and Behavioural Characteristics of Transportation Demand, Urban Mass Transportation Planning, Demand Surveys, Estimation and Demand Projection, Four stages of Planning, Performance Evaluation of Mass Transport System, Structure of Decision Making, Evaluation and Selection Methods, Selection Procedures, Economic Evaluation Methods, Terminals and their Functions, Design, Typical Characteristics Scheduling, Service Analysis, Vehicle Despatch Policy, Vehicle Requirements, Spacing of Bus Stops, Route Spacing and Performance, Operational and Management Issues, Reserved Bus Lanes, Signal Precemption, Dial - a - Bus, Vehicle Monitoring and Control System, Modal Coordination, Underground Transportation, Rail Transit, Case Studies. MRTS, LRT, Street Car, Sky Train and other Multiple modes, Behaviour Analysis, Multinomial and nested logit modals, Revealed and Stated Preference, Parking facilities, Operation Strategy.

CE - 5245 : Traffic Engineering and Management

Traffic Characteristics - road user and Vehicle Characteristics, Traffic Studies - Volume, Speed, O - D and Parking studies. Capacity and Level of Service (LOS) analysis, Statistical analysis of traffic flow variables, Traffic Control - principles, methodologies and devices, advance technologies. Fundamentals of Traffic Management, Principles and Methodology, Traffic Systems Management, Technique of management, Exclusive Bus Lanes Traffic management Techniques, Speed control and Zoning, Parking Control, Traffic Segregation and Channelization, Principles and Design of Traffic Signs, Their Placement and Visibility, Transportation System Management, Route and Network Management, Area Traffic Management, City wide Traffic Control and Management, Centralized Data Processing and Monitoring. Element of traffic flow theory, Characteristics of Uninterrupted traffic, Characteristics of interrupted traffic.

CE - 5246 : Pavement Evaluation, Rehabilitation and Maintenance

Types of pavement distress, techniques for functional and structural evaluation

of pavements, pavement rehabilitation techniques, Overlay design procedures, recycling of flexible and rigid pavements, maintenance of paved and unpaved roads.

CE - 5247 : Transportation Economics

Economic significance of transport, Demand for transport - influencing factors, temporal and spatial variations, elasticity of demand, Supply of transport Costs - Long - term and short - term Costs, fixed and variable costs, and marginal costs, Pricing of services, Road User Costs, Evaluation of transport projects - Cost - benefit ratio, first year rate of return, net present value and internal - rate of return methods, Indirect Costs and benefits of transport projects, Project ownership and financing, Highway finance and Taxation.

AM - 5103 A : Mathematics

Complex Variables : Analytic functions, Cauchy-Reimann equations, Conformal mapping. Cauchy's Integral theorem, Cauchy's formula, Singularities, Taylor's theorem. Laurent's Series. Residues. Matrices : Eigen-values and Eigen-vectors, Cayley Hamilton theorem, Diagonalization of matrices. Jordan Canonical Form of Matrices, Inner product, Unitary and Orthogonal matrices. Calculus of variations : Functionals and their Applications, Euler's equation, Applications to Engineering. Applied Statistics: Analysis of variance, Design of experiments, Linear regression and Multiple regression, Reliability.

AM - 5103 B : Advanced Numerical Methods

Linear Algebra: Matrices, Matrics decomposition: LU decomposition, Cholesky decomposition, spectral decomposition, Matrix Eigen-value problem, Gerchgorin's theorem, Eignenvalue by iteration, generalized inverse of a matrix, solution of linear system by decomposition method, Jacobi method. Nonlinear system of equations: Newton's method, Powel Hybrid method. Differential equations: Generalised characteristic value problems, phase plane and critical points, stability and phase plane methods in nonlinear equations. Boundary value problems, mixed boundary conditions, boundary conditions at infinity, nonlinear boundary value problems, linear eigen value problems. Partial differential equations: Parabolic, elliptic and hyperbolic partial differential equations subject to Diritechlet, Neumann (or flux) and mixed (or Robin or radiation) boundary conditions, Navier Stock's equation. Approximate Analytic methods: Variational methods, weighted residual methods – Galerkin's method, collocation method, Functional, quadraic functionals. Numerical Integration – Gauss Legendre, Quadrature, Error Analysis, Convergence of solution. Finite element and Boundary element method. Software like MATHEMATICA and MATLAB in addition to programming languages C and C++. Application towards plane stress and plane strain two dimensional problems.

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