JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

Credit Courses and Pre-PhD Courses for Civil Engineering Faculty

S. No.	Credit Courses	S. No.	Credit Courses
1	Finite Element Method	11	Experimental Stress Analysis
2	Stability Of Structures	12	Structural Dynamics & Earthquake Resistant Design
3	Design of offshore structures	13	Pavement Analysis and Design
4	Principles and Applications of Remote Sensing & GIS	14	Expansive Soil
5	Foundation Engineering	15	Fracture Mechanics of concrete structures
6	Ground Improvement Techniques	16	Repair & Rehabilitation of Concrete Structures
7	Traffic Engineering	17	Computational And Statistical Methods
8	Advanced Concrete Technology	18	Neuro-Fuzzy Techniques And Computer Programming
9	Theory of Elasticity and Plasticity	19	Solid & Hazardous Waste Management
10	Design of Masonry structures	20	Physico-Chemical Process For Water And Wastewater Treatment

Pre-Ph. D Courses

S. No.		Paper -I	S. No.		Paper -II
1	Structural Engineering	Theory of Elasticity and Plasticity	1	Structural Engineering	Design of Masonry Structures
2		Experimental Stress Analysis	2		Structural Dynamics
3		Finite Element Method	3		Earthquake Resistant Design of structures
4		Mechanics of composite Materials	4		Low Cost Housing Techniques
5		Advanced Structural Analysis	5		Repair and Rehabilitation of Structures
6		Fracture Mechanics of concrete structures	6		Stability of Structures
7		Mechanical Vibrations	7		Pre-Stressed Concrete and steel structures
8		Theory of plates and shells	8		Artificial Neural Networks and Fuzzy Logic
9		Structural Reliability	9		Analysis And Design Of Tall Buildings

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

Credit Courses and Pre-PhD Courses for Civil Engineering Faculty

10		Advanced Concrete Technology	10		Optimization Techniques in Structural Engineering
1	Geotechnical Engineering	Ground Improvement Techniques	1	Geotechnical Engineering	Design With Geosynthetics
--		----	2		Geo-Environmental Engineering
2		Advanced Soil Mechanics	3		Finite Element Method
3		Earth And Rock Fill Dams	4		Rock Mechanics and Engineering
4		Pavement Analysis and Design	5		Soil Dynamics and Machine Foundations
5		Expansive Soils	6		Soil-Structure Interaction
6		Foundation Engineering	7		Critical State Soil Mechanics
7		Numerical Methods In Geotechnical Engineering	8		Geotechnical Earthquake Engineering
8		Earth Retaining Structures	9		Theory of Elasticity
1	Water Recourse Engineering	Computational And Statistical Methods	1	Water Recourse Engineering	Channel And River Hydraulics
2		Ground Water Exploration And Watershed Management	2		Engineering Hydrology
3		Hydraulic Structures	3		Geo-Environmental Engineering
4		Irrigation Management	4		Ground water management & modelling
5		Stochastic Hydrology	5		Hydropower development
6		Urban Drainage & Waste Water Treatment	6		Neuro-Fuzzy Techniques & Computer Programming
7		Water resources systems planning and Management	7		Principles and Applications of Remote Sensing and GIS
1	Transportation Engg	Traffic Engineering	1	Transportation Eng	Environmental Impact Assessment
2		Pavement Analysis and Design	2		Pavement Construction, Evaluation and Management
3		Urban Transportation Planning	3		Principles and Applications of Remote Sensing and GIS
4		Intelligent Transportation System	4		Urban Transportation Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
Credit Courses and Pre-PhD Courses for Civil Engineering Faculty

1	Env. Engg	Environmental Chemistry	1	Env. Engg	Air Pollution & Control Technology
2		Environmental Impact Assessment	2		Solid & Hazardous Waste Management
3		Industrial Wastewater Management	3		Physico-Chemical Process For Water and Waster water treatment

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
Credit Courses and Pre-PhD Courses for Civil Engineering Faculty

S. No.	Credit Courses
S. No.	Credit Courses
1	**Finite Element Method**
	FINITE ELEMENT METHOD **Unit I:** Introduction: Review of stiffness method- displacement field - Integral form-differential form - "Rayleigh-Ritz method" of functional approximation - variational approaches -weighted residual methods- concept of FEM. Bar and torsional elements: Degree of freedom –simple element- higher order element-nodal displacement vector- shape functions- FE formulation-discrimination- stiffness matrix of element- element nodal load vector-assembling- total potential in terms of FEM formulation-boundary conditions- strain, stress and force in element-reaction- torsional element. trusses-Iso-parametric element. –natural coordinates. **Unit II:** Beam, frame and grid elements: Degree of freedom - displacement vector - simple element- higher order element-nodal displacement vector - shape functions- discrimination- stiffness matrix of element- element nodal load vector-assembling-total potential in terms of FE formulation- boundary conditions- strain, stress and forces in elements-reactions- frame element-Grid element-Beams - frames- Grid structures. Iso-parametric element –natural coordinates. **Unit III:** Membrane element: 2 Dimensional structures- Plane stress-plane strain- triangular elements-CST element-LST element-rectangular elements-Legrangian family of elements-Serendipity family of elements Shape functions – nodal displacement vector-FEM formulation-element stiffness matrix- element nodal load vector due to body forces, traction and concentrated loads- Iso-parametric element- Area coordinates- strain vector and stress vector in element. Axisymmetric solids: Modelling as 2D problem: stress-strain relations- material stiffness matrix-dof - Triangular element- rectangular element-shape functions-Displacement function- FE formulation -stiffness matrix of element- nodal loads- strain vector, stress vector in elements-reactions. Iso-parametric element-Area coordinates.

	Unit IV: 3 Dimensional stress analysis: dof – types of elements- simple elements – higher order elements-displacement function- shape functions- nodal displacement verctor- Nodal load vector- stiffness matrix of element- FE formulation – volume coordionates- isoparametric elements- strain vector and stress vector in element. Plate structures & shell structures: dof- displacement field – nodal displacement vector- shape function- Finite Element Formulation of plate structures- types elements- strain vector and stress vector in element-types of elements. **Unit V:** Introduction to Non-linear Finite Element Methods- types of nonlinear problems-Introduction to dynamic analysis using Finite Element Method - Development of simple programs for simple structures- Introductio of FEM package(only class work) REFERENCES: 1. Concepts and applications of Finite Element Analysis – Robert D. Cook, Michael E Plesha, John Wiley & sons Publications 2. A first course in the Finite Element Method – Daryl L. Logan, Thomson Publications. 3. Introduction to Finite Elements in Engineering- Tirupati R. Chandrupatla, Ashok D. Belgunda, PHI publications 4. Fundamentals of Finite Element Analysis- David V. Hutton, Tata McGraw-Hill 5. Finite element Analysis- Theory and programming – C.S. Krishna Murthy, Tata Mc Gra Hill. 6. Finite element Analysis – P.Seshu, PHI 7. Finite element method – O.C. Zeinkiewicz, Tata Mc Gra Hill, 2007
2	**Stability Of Structures**
	STABILITY OF STRUCTURES **UNIT-I** Beam columns: Differential equation for beam columns – Beams column with concentrated loads – continuous lateral load – couples – Beam column with built in ends – continuous beams with axial load – application of Trigonometric series – Determination of allowable stresses. **UNIT-II**

	Elastic buckling of bars : Elastic buckling of straight columns – Effect of shear stress on buckling – Eccentrically and laterally loaded columns –Sway & Non Sway mode - Energy methods – Buckling of a bar on elastic foundation – Buckling of bar with intermediate compressive forces and distributed axial loads – Buckling of bars with change in cross section – Effect of shear force on critical load – Built up columns – Effect of Initial curvature on bars – Buckling of frames – Sway & Non Sway mode. **UNIT-III** In Elastic Buckling: Buckling of straight bars – Double modulus theory Tangent modulus theory. **UNIT-IV** Experiments and design formulae: Experiments on columns – Critical stress diagram – Empirical formulae of design – various end conditions – Design of columns based on buckling. Mathematical Treatment of stability problems: Buckling problem orthogonality relation – Ritz method – Timeshinko method, Galerkin method. **UNIT-V** Torsional Buckling: Pure torsion of thin walled bars of open cross section – Non uniform torsion of thin walled bars of open cross section - Torsional buckling – Buckling of Torsion and Flexure. Lateral Buckling of simply supported Beams: Beams of rectangular cross section subjected for pure bending, Buckling of I Section subjected to pure bending. REFERENCES: 1. Theory of Elastic stability by Timshenko & Gere-Mc Graw Hill 2. Stability of Metal Structures by Bleinch – Mc Graw Hill 3. Theory of beam columns Vol I by Chem. & Atsute Mc. Graw Hill. 4. Theory of Stability of Structures by Alexander Chases.
3	**Design of Offshore Structures**
	DESIGN OF OFFSHORE STRUCTURES **UNIT-I** Introduction- Physical Environmental aspects of Marine and offshore construction- Materials and offshore construction equipment – Marine operations – Sea floor modification and improvements. Marine and Offshore construction equipment-

	Basic motions in sea- Buoyancy, Draft and freeboard- Stability- Damage control- Barges - Crane - offshore Derrick – Catamaran and Semi submersible Barges- Jack up Barges- launch barges- offshore Dredges- Floating Concrete Plant . **UNIT-II** Installation of Piles in marine and offshore Structures- Fabrication of tubular steel piles- Transportation- Installation- Methods of increasing penetration – Inserting and anchoring into rock and hardpan- Prestressed concrete piles for marine construction- Handling and Positioning of Piles Review of Basic Concepts. **UNIT-III** Offshore Platforms: Steel Jackets and Pin piles- Fabrication- Land out, tie down and transportation- Removal of jacket from transportation barge – Lifting – launching-Installation at Sea floor- Pile and conductor Installation- Deck Installation- Concrete Platforms- Construction stages- Sub base construction. **UNIT-IV** Submarine Pipelines- Types of barges- Controlled underwater floating- Bundles pipes- Directional drilling- protection of pipelines- burial and covering with rock- support of pipelines . Underwater repairs- Repairs to steel Jacket- type structures- Repairs to steel piling- Repairs to Concrete offshore structures- repairs to foundations- Fie damage- Pipeline repairs. **UNIT-V** Strengthening Existing structures- Strengthening of offshore Platforms and terminals, members or assembles- Increasing capacity of piles for axial loads- Increasing lateral capacity of piles and structures in interaction- seismic retrofitting. Constructability - Construction stages- Principles- Assembly and Jointing procedures- access- tolerances- survey control- quality control and assurance- safety- risk and reliability evaluation **REFERENCES:** 1. Construction of Marine and offshore Structures- 2e- Ben-C. Gerwick, Jr CRC press 2. Basic Coastal Engineering by R. M. Sorensen, published by Chapman & Hall, 1997 3. Port and Marine Structure Quin
4	**Principles and Applications of Remote Sensing & GIS**

	PRINCIPLES AND APPLICATIONS OF REMOTE SENSING & GIS UNIT I Introduction to aerial Photogrammetry: Principles of Optics, Types of Aerial Photographs, Stereoscopy, Photoscale, Map vs Mosaic, Mosaic-Kinds of Mosaic, Construction of Mosaic, Ground Control, Parallax measurements for height determinations. Remote Sensing: Basic Concepts and foundation of remote sensing, Elements involved in Remote Sensing, Electromagnetic spectrum, Remote Sensing terminology, Energy Sources, Energy interactions with Earth Surface features and atmosphere, Resolution, Sensors and Satellites, Visual Interpretation techniques-Basic elements. Interpretation for Terrain Evaluation, Spectral properties of water bodies, Introduction to digital data analysis. Unit II Geographic Information Systems: Introduction, GIS definition and Terminology, GIS categories, Components of GIS, Fundamental Operations of GIS, A theoretical Framework for GIS, GIS types of data representation, Raster Data Structures, Vector Data Structures, Comparisons between Data Structures. Unit III Data Acquisition and Data Input: Introduction, exisiting data sets, developing own data, digitization and scanning. Preprocessing: Format conversion, data reduction and generalisation, error detection and editing, merging, edge matching, rectification and registration, interpolation. Unit IV Data Management: Basic principles of data management: Efficiency, conventional database management systems, Spatial database management product generation: Types of output products, hardware components, Integrated analysis of Spectral and attribute data. Data Quality: Introduction, Components of data quality, Sources of error, Introduction to GPS Unit V Remote Sensing & GIS Applications: Land Use/Land cover in water resources, Rainfall-Runoff modelling, Flood plain zoning, Drought assessment and monitoring, Cropping patterns, condition of crops, irrigation system performance, Watershed

	Management for sustainable development, watershed characteristics, erosion and deposition, catchment area treatment, Estimation of Sediment load. TEXT BOOKS: 1. Elements of Photogrammetry by Paul Wolf 1. Remote Sensing and Image Interpretation by T.M. Lilles and R.W. Kifer. 2. Geographic Information Systems – A Management Perspective by Stan Aronoff 3. Elements of Photogrammetry by K.K. Rampal 4. Principles and Applications of Photogeology by R.W. Shiv Pandey 5. Remote Sensing in Hydrology by E.T. Engman and R.J. Curney 6. Geographic Information Systems by David Martin. 7. Remote sensing and Image Interpretation by LILESAND and KIEFER, Published by john Wiley and sons. 8. Fundamental of GIS by MICHAEL N DEMERS Published by John Wiley & Sons Inc.
5	**Foundation Engineering**
	FOUNDATION ENGINEERING **UNIT- I** Soil Exploration – Importance, Terminology, planning - Geophysical methods. Borings, location, spacing and depth, methods of boring including drilling, stabilization of boreholes, boring records. **UNIT- II** Soil sampling – Methods of sampling -Types of samples and samplers- cleaning of bore holes, preservation, labeling and shipment of samples - Design considerations of open drive samplers. **UNIT- III**

	Shallow Foundations –Bearing capacity – General bearing capacity equation, Meyerhof's, Hansen's and Vesic's bearing capacity factors - Bearing capacity of stratified soils - Bearing capacity based on penetration resistance- safe bearing capacity and allowable bearing pressure. (Ref: IS -2131 & IS 6403) **UNIT- IV** Types and choice of type. Design considerations including location and depth, Proportioning of shallow foundations- isolated and combined footings and mats - Design procedure for mats. Floating foundation- Fundamentals of beams on Elastic foundations. .(Ref: IS -456 & N.B.C. relevant volume) **UNIT- V** Pile foundations-Classification of piles-factors influencing choice-Load -carrying capacity of single piles in clays and sands using static pile formulae- α - β - and λ - methods –Dynamic pile formulae-limitations- Monotonic and cyclic pile load tests – Under reamed piles. Pile groups -Efficiency of pile groups- Different formulae-load carrying capacity of pile groups in clays and sands – settlement of pile groups in clays and sands – Computation of load on each pile in a group. **REFERENCES:** 1. Principles of Foundation Engineering by Braja M. Das. 2. Soil Mechanics in Engineering Practice by Terzagi and Peck 3. Foundation Design by Wayne C. Teng, John Wiley & Co., 4. Foundation Analysis and Design by J.E. Bowles McGraw Hill Publishing Co., 5. Analysis and Design of sub structures by Swami Saran 6. Design Aids in Soil Mechanics and Foundation Engineering by Shanbaga R. Kaniraj,Tata Mc. Graw Hill. 7. Foundation Design and Construction by MJ Tomlinson – Longman Scientific

	8. A short course in Foundation Engineering by Simmons and Menzes - ELBS
6	**Ground Improvement Techniques**
	GROUND IMPROVEMENT TECHNIQUES **UNIT – I** **Introduction to Ground Modification:** Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – suitability and feasibility, Emerging Trends in ground improvement. **UNIT –II** **Mechanical Modification:** Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro-floatation, Blasting, Dynamic consolidation, pre-compression and compaction piles, Field compaction control. **UNIT –III** **Hydraulic Modification:** Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains. **Physical and Chemical Modification:** Stabilization with admixtures like cement, lime, calcium chloride, fly ash and bitumen, Grouting: categories of grouting, Art of grouting, Gout materials, Grouting techniques and control. **UNIT –IV** **Reinforced Earth Technology:** Concept of soil reinforcement, Reinforcing materials, Backfill criteria, Art of reinforced earth technology, Design and construction of reinforced earth structures. **Soil Confinement Systems:** Concept of confinement, Gabbion walls, CRB walls, Sand bags, Evergreen systems and fabric formwork. **UNIT –V** **Miscellaneous Techniques:** Design, Construction and applications of stone columns lime columns and cofferdams. Types of Geo-textiles and their applications in various constructions. **References:** 1. Engineering, principles of ground modification – Manfred R.Hansmann Mc Graw-Hill pub. Co., New York.

	2. Construction and Geotechnical methods in Foundation Engineering – Robert M.Koerner McGraw-Hill Pub. Co., New York. 3. Foundation Engineering Hand book – Winterkorn and Fang Van Nostrand Reinhold Co., New York. 4. Aris C.Stamatopoulos & Panaghiotis C.Kotzios – Soil Improvement by Preloading – John Wiley & Sons Inc. Canada. 5. Ground Improvement Techniques – P. Purushothama Raj Laxmi Publications (P) Limited.
7	Traffic Engineering **and** Transportation Planning
	TRAFFIC ENGINEERING AND TRANSPORTATION PLANNING **UNIT – I** **TRAFFIC STUDIES:** Basic Traffic Parameters – Speed, Volume and Density – Definitions and their interrelationship – Traffic Volume Studies: Types, Methods and Analysis of Traffic Volume Data; Speed and Delay Studies: Types of Speeds, Speed Study Methods, Data Collection, analysis and Presentation; Use of Statistical Methods in Traffic Volume and Speed Data Analysis. **UNIT – II** **HIGHWAY CAPACITY**: Highway Capacity and Level of Service; Factors affecting Highway Capacity and Level of Service; Concept of PCU Factors; Capacity of Rural Highways and Basic freeways ; Capacity of Urban Roads; Capacity of Intersections and Factors influencing; Capacity of Rotary Intersections. **UNIT – III** **TRANSPORTATION PLANNING PROCESS**: Definition of Study Area; Zoning Principles; Types of Surveys: Home Interview Studies, Commercial Vehicle Surveys, Road Side Interview Methods, Public Transport Studies, Land Use Inventory; O-D Matrix and Desire Line Diagram. **TRIP GENERATION**: Four Stage UTP Process; Travel Demand Models; Sequential Models and Direct Demand Models; Factors affecting Travel Demand; Trip Generation; Multiple Regression Analysis; Category Analysis; Aggregate and Disaggregate Models. **UNIT- IV** **TRIP DISTRIBUTION**: Trip Distribution Models- Growth Factor Models: Uniform Growth Factor, Average Growth Factor, Fratar Method and Furness Method; Limitations of Growth factor Models; Gravity Model – Calibration of Gravity Model.;

	Opportunity Models. **TRAFFIC ASSIGNMENT**: Purpose of Traffic Assignment; Assignment Techniques-All-or-Nothing Assignment, Multiple Route Assignment, Capacity restraint assignment; Use of Diversion Curves in Assignment. **UNIT –V** **MODE SPLIT**: Factors affecting Mode Split; Pre–distribution Mode Split; Post-Distribution Mode Split; Advantages and Disadvantages; Probit, Logit and Discriminate Analysis in Mode Split. Syllabi for Pre-Ph.D/Civil (2009-2010) **ECONOMIC EVALUATION OF TRANSPORT PLANS**: Need for Economic Evaluation; Principles of Economic Evaluation; Costs and Benefits of Transportation Projects; Methods of Economic Analysis- Benefit Cost Ratio Method; Net Present Value Method; Internal Rate of Return Method; Comparison of various methods and their suitability. **REFERENCES:** 1. **Traffic Engineering and Transport Planning**, L.R.Kadiyali, Khanna Publishers,New Delhi. 2. **Fundamentals of Transportation Engineering**, C.S.Papacostas, Prentice Hall India Ltd 3. **Transportation Engineering**-An Introduction, C.J.Khisty and B.Kent Lall, Prentice Hall India Ltd
8	**Advanced Concrete Technology**
	ADVANCED CONCRETE TECHNOLOGY **UNIT-I** Materials- Cement, Aggregates, mixing water soundness of aggregate- Fresh and hardened concrete: Admixtures- types of admixtures- purposes of using admixtures- chemical composition- effect of admixtures on fresh and hardened concretes- Natural admixtures. Non destructive evaluation: Importance- Concrete behavior under corrosion, disintegrated mechanisms- moisture effects and thermal effects – Visual investigation- Acoustical emission methods- Corrosion activity measurement- chloride content – Depth of carbonation- Impact echo methods- Ultrasound pulse velocity methods- Pull out tests **UNIT-II** Repair and rehabilitation of structural elements: Analysis, strategy and design- Material requirement- Material selection- Surface preparation- Reinforcing steel cleaning, repair and protection- Bonding repair materials to existing concrete- placement methods-

	UNIT-III Strengthening and stabilization- Techniques- design considerations- Beam shear capacity strengthening- Shear Transfer strengthening- stress reduction techniques- Column strengthening-flexural strengthening- Connection stabilization and strengthening Crack stabilization **UNIT-IV** Fiber-reinforced concrete- Properties of constituent materials- Mix proportions, mixing and casting methods-Mechanical properties of fiber reinforced concrete- applications of fibre reinforced concretes. Light weight concrete- Introduction- properties of light weight concrete- No fines concrete- design of light weight concrete **UNIT-V** Fly ash concrete- Introduction- classification of flyash- properties and reaction mechanism of flyash- Properties of flyash concrete in fresh state and hardened state- Durability of flyash concretes. High performance concretes- Introduction- Development of high performance concretes- Materials of high performance concretes- Properties of high performance concretes. **REFERENCE:** 1. Concrete technology- Neville & Brooks 2. Special Structural concrete- Rafat Siddique 3. Concrete repair and maintenance illustrated- Peter H Emmons 4. Concrete technology-M S Shetty 5. Special Structural concretes by Rajat Siddique, Galgotia Publications. 6. Design of Concrete Mixes by N.Krishna Raju, CBS Publications. 7. Concrete: Micro Structure by P.K.Mehta, ICI, Chennai.
9	Theory of Elasticity and Plasticity
	THEORY OF ELASTICITY AND PLASTICITY 1. **Introduction:** Elasticity – Notation for Forces and Stresses – Components of Stresses – Components of Strain – Hooke's

	Law. Plane Stress and Plane Strain analysis – Plane Stress – Plane strain – Differential Equations of equilibrium – Boundary conditions – Compatibility equations - Stress function – Boundary Conditions. 2. **Two Dimensional Problems:** in Rectangular Co-Ordinates – Solution by polynomials – Saint – Venant's Principle – Determination of Displacements – Bending of Simple beams – Application of Fourier Series for two dimensional problems for gravity Loading. Two Dimensional problems in Polar Co-ordinates General Equations in polar Co-ordinates – Stress Distribution Symmetrical about an axis – Pure bending of curved bars - Strain Components in Polar Co-ordinates – Displacements for Symmetrical stress Distributions – Circular discs- Stresses on plates with circular holes 3. **Three Dimensional Problems:** Analysis of Stress and Strain in Three Dimension Principal Stress – Stress Ellipsoid and stress director surface – Determination of Principal stresses Maximum shear stresses – Homogeneous Deformation – Principle Axes of Strain. 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 –Reciprocal theorem. 4. **Torsion of Prismatic Bars:** Torsion of Prismatic Bars – Bars with Elliptical Cross Section – Other elementary Solution – Membrane Analogy – Torsion of Rectangular Bars – Solution of Torsional Problems by Energy method – use of soap Films in Solving Torsional problems – Hydro dynamical Analogies – Torsion of Bars. 5. **Theory of Plasticity:** Introduction – Concepts and Assumptions – Yield criteria. **References:** 1.Theory of Elasticity- Timoshenko & Goodier

	2.Theory of Elasticity – Sadhu Singh
10	Design of Masonry structures
	DESIGN OF MASONRY STRUCTURES **Unit I:** Properties of materials of masonry- Bricks, mortar, and factors influencing strength of masonry. **Unit II:** Properties of masonry, **Unit III** : Masonry under axial, flexure and shear, **Unit IV:** Theories of failure of masonry **Unit V:** Design of unreinforced masonry structures. **REFERENCES:** 1. Hendry, A.W., Structural Masonry, MacMillan Press, 1998. 2. Duggal, S.K., Earthquake resistant design of structures, Oxford University Press, 2007 3. Current literature.
11	Experimental Stress Analysis
	EXPERIMENTAL STRESS ANALYSIS **UNIT-I** **Strain measurement methods:** Definition of strain and its relation to experimental determinations - properties of strain – Gauge systems – Mechanical, Optical, Acoustic and Pneumatic types. **UNIT-II** **Electrical resistance strain gages:** Introduction – gauge construction – strain gauge adhesives - mounting methods – gauge sensitivities and gage factor – performance characteristics of wire and foil strain gauges – environmental effects. Analysis of strain gauge data: Introduction –

	the three element rectangular rosette – the delta rosette – correction for transverse sensitivity. **UNIT-III** **Non-Destructive Testing (NDT):** Introduction – objective of non destructive testing. Ultrasonic pulse velocity method – Rebound Hardness method (Concrete hammer) application to assessment of concrete quality. Brittle coating methods: Introduction – coating stresses – failure theories – brittle coating crack patterns – crack detection – types of brittle coatings – test procedures for brittle coating analysis – calibration procedures – analysis of brittle coating, data interpretation **UNIT-IV** **Theory of photo elasticity:** Introduction – temporary double refraction – Index ellipsoid and stress ellipsoid – the stress optic law – effects of stressed model in a polariscope for various arrangements - fringe sharpening. Two dimensional photo elasticity: iso-chromatic fringe patterns – isoclinic fringe patterns – compensation techniques – calibration methods – separation methods – materials for photo-elasticity – properties of photo-elastic materials. **UNIT-V** **Model design:** Introduction – Model & Prototype - Factors influencing model design – scale factors and Model material properties – Methods of model design. **REFERENCES:** 1. Experimental Stress Analysis- Riley and Dally 2. Experimental Stress Analysis – Lee 3. Experimental Stress Analysis- Sadhu Singh
12	**Structural Dynamics And Earthquake Resistant Design**
	STRUCTURAL DYNAMICS AND EARTHQUAKE RESISTANT DESIGN

	1. Introduction to Structural Dynamics: Fundamental objective of Dynamic analysis – Types of prescribed loadings – methods of Discretization – Formulation of the Equations of Motion. Theory of Vibrations: Introduction – Elements of a Vibratory system – Degrees of Freedom of continuous systems - Oscillatory motion – Simple Harmonic Motion – Free Vibrations of Single Degree of Freedom (SDOF) systems – Undamped and Damped – Critical damping – Logarithmic decrement – Forced vibrations of SDOF systems – Harmonic excitation – Dynamic magnification factor – Band width. 2. Single Degree of Freedom System: Formulation and Solution of the equation of Motion – Free vibration response – Response to Harmonic, Periodic, Impulsive and general dynamic loadings – Duhamel integral. 3. Multi Degree of Freedom System: Selection of the Degrees of Freedom – Evaluation of Structural Property Matrices – Formulation of the MDOF equations of motion - Undamped free vibrations – Solution of Eigen value problem for natural frequencies and mode shapes – Analysis of dynamic response - Normal coordinates – 4. Continuous Systems: Introduction – Flexural vibrations of beams – Elementary case – Equation of motion – Analysis of undamped free vibration of beams in flexure – Natural frequencies and mode shapes of simple beams with different end conditions. 5. Introduction to Earthquake Analysis: Introduction – Excitation by rigid base translation – Lumped mass approach of SDOF and MDOF systems – I.S. Code methods of analysis. Terminology- general principles of design criteria- Seismic coefficient method- Design criteria for various applications- Multistoried buildings- Bridges - Dams and Embankments- Retaining walls. Sesmic Evaluation of RC buildings – Condition assessment Field Evaluation Identification and assessment of concrete -. Sesmic retrofitting R.C.C and masonary building – Ductile detailing for earth quake resistant construction. I.S. Codal Provisions

	REFERENCES: 1. Dynamics of Structures by Claugh & Penzien. 2. Structural Dynamics A K Chopra 3. Earth quake resistant Design of Structure – P. Agarwal, M. Shikhande 4. IS:1983-1984 Code of Practice for Earthquake Resistant Design of Structure
13	**Pavement Analysis and Design**
	PAVEMENT ANALYSIS DESIGN AND EVALUATION 1. Pavement Types, Wheel Loads and Design Factors: Definition of Pavement Types, Comparison of Highway pavements, Wheel Loads, Tyre pressure, Contact pressure, Design Factors: Traffic and Loading, Environment, Materials, Failure criteria, Reliability. 2. Stresses in Pavements: Layered System Concepts: One Layer System: Boussinesq Theory. Two Layer Theory: Burmister's Theory. Three Layer System. Stresses in Rigid Pavements. Relative Stiffness of Slabs, Modulus of Subgrade Reaction, Stresses due to Warping, Stresses due to Friction, Stresses due to Load, IRC Recommendations. 3. Pavement Design: IRC Method of Flexible Pavement Design, AASHTO Method of Flexible Pavement Design, IRC Method for Rigid Pavements, use of Geosynthatics in pavements. 4. Pavement Inventories: Serviceability Concepts, Visual Rating, Pavement Serviceability Index, Roughness Measurements, Measurement of Distress Modes Cracking, Rutting, Rebound Deflection using Benkleman Beam Deflection Method, Load Man Concept, Skid Resistance Measurement. 5. Pavement EvaluationFunctional Pavement Performance Evaluation: AASHTO Method, Psycho Physical and Psycho Metric Scaling Techniques, Deduct Value Method. Structural Conditional Evaluation Technique: Benkelman Beam Deflection Method, Pavement Distress Rating Technique. Design of Overlays by Benkelmen Beam Deflection Methods as per IRC – 81 - 1997 – pavements on problematic soils. **REFERENCES:** 1. Yoder and Witzorack, "Principles of Pavement Design", John Willey and Sons. 2. Yang, H. Huang, "Pavement Analysis and Design", Prentice Hall Publication, Englewood Cliffs, New Jersy. 3. Sargious, M.A. Pavements and Surfacings for Highways and Airports – Applied science Publishers limited

	4. Ralps Hass and Hudson, W.R. " Pavement Management System" Mc-Graw Hill Book Company. 5. IRC codes of practice.
14	**Expansive Soil**
	EXPANSIVE SOILS **Unit-I** Origin and occurrence of expansive soils-problems associated with expansive clays-identification and classification based on mineralogical composition. X-Ray diffraction, differential thermal analysis and electron microscopy-identification by index properties . **Unit-II** Clay-water system – Ion distribution in clay –water systems-diffuse double layer-Gouy Chapman theory-cation exchange. Mechanisms of swelling-osmotic pressure concept-Importance of mineralogical details in swelling-soil suction-measurement in laboratory and field **Unit-III** Swell potential-swelling pressure-factors affecting-direct measurement from laboratory testing-stresses in an in-situ soil mass-factors affecting heave-methods of heave prediction **Unit-IV:** Shear strength of expansive clays-Katti's concept of bilinear stress- state variables-Fredlund's three dimensional approach to shear strength and swelling behaviour of expansive clays **Unit-V** Foundation practices in expansive clays-sand cushion-belled piers-under reamed piles-CNS layer technique. Expansive soil stabilization with lime-lime soil columns and lime slurry pressure injection-stabilization with admixtures. **REFERENCES:** 1. Foundations on expansive soils – F.H. Chen, Elsevier Publishing Co. 2. Search for solutions to problems in black cotton soils – R.K. Katti, Indian Goe.Tech.Journal, Volume 1, 1971 3. Fundamentals of soil behaviour – J.K. Mitchell, John Wiley&Sons

15	**Fracture Mechanics of Concrete Structures**

FRACTURE MECHANICS OF CONCRETE STRUCTURES

1. Introduction: Fundamentals of elastic and plastic behaviour of materials- stresses in a plate with a hole – Stress Concentration factor- modes of failure- Brittle fracture and ductile fracture- history of fracture mechanics-Griffiths criteria of cracks- mode I, mode II and mode III failure.

2. Principles of Linear Elastic Fracture Mechanics: SOM vs Fracture Mechanics -stressed based Criteria for fracture- Stress Intensity Factors- K_I K_{II} and K_{III} – Critical stress Intensity Factors, K_{Ic} K_{IIc} and K_{IIc} – crack tip plastic zone – Erwin's plastic zone correction -Critical crack length-Load carrying capacity of a cracked component- Design of components based on fracture mechanics.

3. Griffith's criteria- Criteria for crack propagation -Energy release rate , G_I G_{II} and G_{III} - Critical energy release rate G_{Ic} , G_{IIc} and G_{IIIc} – surface energy - R curves – compliance- J-Integrals:

4. Material characterisation by Crack Tip Opening Displacements (CTOD)- Crack Mouth Opening Displacement (CMOD)- Critical crack tip opening displacement ($CTOD_c$) –critical Crack Mouth Opening Displacement ($CMOD_c$)-Determination of fracture parameters. Experimental determination of fracture parameters- K_{Ic} , G_{Ic}, $CTOD_c$ and critical J-Integral.-for brittle and quasi brittle materials like concrete and rock- Specimen geometry .

5. Nonlinear Fracture Mechanics for mode I quasi- brittle fracture(Concrete): General quasi-brittle fracture-Ficticious crack approach - Hillerborg's Fictitious crack model-Bazanth's crack band model- Effective elastic crack approach-Two Parameter model- Bazanth' Size effect model-effective crack model-softening- Applications of Fracture Mechanics to Concrete structures: Size effect on nominal strength-Tension ,Bending, Shear and torsion of RRC members-Concrete dams- Interfacial fracture mechanics-

REFERENCES :

1. Engineering Fracture Mechanics- S.A. Meguid, Elsevier Applied Science Publications.
2. Elementary engineering fracture mechanics – David Broek – Sijthoff & Noordhoff – Alphenaan den Rijn – Netherlands.

	3. Elements of Fracture Mechanics – Prasanth Kumar, wiley Eastern Publications 4. Fracture Mechanics: Fundamentals and applications – T. L. Andrason, PhD, CRC publications 5. Fracture Mechanics of Concrete: Applications of fracture mechanics to concrete, Rock, and other quasi-brittle materials, Surendra P. Shah, Stuart E. Swartz, Chengsheng Ouyang, John Wiley & Son publications. 6. Fracture mechanics of concrete structures – Theory and applications – Rilem Report – Edited by L. Elfgreen – Chapman and Hall – 1989. 7. Fracture mechanics – applications to concrete – Edite
16	Repair & Rehabilitation of Concrete Structures
	REHABILITATION AND RETRO FITTING OF STRUCTURES **UNIT – I** **General:** Quality assurance for concrete construction, As built concrete properties, strength, permeability, volume changes, thermal properties, cracking. **UNIT – II** **Influence on serviceability and Durability:-** Effects due to climate, temperature, chemicals, wear and erosion, design and construction errors, corrosion mechanism, Effects of cover thickness and cracking methods of corrosion protection, inhibitors, resistant steels, coatings cathode protection. **UNIT – III** **Maintenance and Repair Strategies:-** Inspection, Structural Appraisal, Economic appraisal, components of quality assurance, conceptual bases for quality assurance schemes. **UNIT – IV** **Materials for Repair-1: -** Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement. Polymer concrete, sulphur infiltrated concrete, ferro-cement, Fibre reinforced concrete, Slurry Infiltrated Fibrous Concrete **UNIT – V** **Techniques for Repair**- Rust eliminators and polymers coating for re-bars during repair, foamed concrete, mortar and dry pack, vacuum concrete - Gunite and shotcrete - Epoxy injection, Mortar repair for cracks, shoring and underpinning. Examples of repairs to structures:- Repairs to overcome low member strength, Deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure. Syllabi for Pre-Ph.D/Civil (2009-2010)

	References: 1. Dension Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical, U.K, 1991. 2 Repair of concrete Structures, . RT. Allen and S.C. Edwards, Blakie and sons, UK, 1987. 3. Concrete Technology – Theory and practice, MS. Shetty S.Chand and company, New Delhi, 1992. 4. Training course notes on damage assessment and Repair in low cost housing Santhakumar, S.R. RHDC-NBO Anna University, Madras, July, 1992. 5. Raikar, R.N. learning from failures – deficiencies in Design, construction and service– R & D centre (SDCPL), Raikar Bhavan, Bombay, 1987. 6. Estate Management, N. Palaniappan, Anna Institute of Management, Madras Sep. 1992. 7. Structural Assessment, F.K. Garas, J.L. Clarke, GST Armer Butterworths, UK April 1987. 8. Concrete chemicals – Theory and applications, A.R. Santhakumar, Indian society for construction Engineering and Technology, Madras. 1993 (In press)
17	Computational And Statistical Methods
	COMPUTATIONAL AND STATISTICAL METHODS **Unit I** Numerical Solution of Ordinary: Differential Equations – Solution by Taylor's Series – Euler's Method- Runge Kutta Methods – Simultaneous and Higher Order Equations – Boundary Value Problems – Applications. **Unit II** Partial differential equations: Variable Separable Method – Wave, Heat and Laplace Equation (Two dimensions only) **Unit III** Regression Analysis – Simple Linear Regression, Evaluation of Regression – Confidence Intervals and Tests of Hypotheses – Multiple Linear Regression – Correlation and Regression Analysis. **Unit IV**

	Finite Difference Method : Construction of finite difference approximations – Taylor series, Forward, Backward and central difference approximations, Finite difference approximations of boundary value and initial value problems, One dimensional and two dimensional problems, Explicit, Implicit, and Crank – Nicolson Schemes, Convergence and stability, Alternating Direction Implicit (ADI) method for two space dimensions, simple examples. **Unit V** Finite Element Method: General Principles, types of elements, interpolation functions, Development of basis functions for one-dimensional and two dimensional elements, Linear interpolation, local co-ordinate system, variational formulation, Galerkin formulation, development of element matrices. Posting into Global locations, treatment of initial and boundary conditions, solution of Linear algebraic equations, simple examples. TEXT BOOKS: 1. Advanced Engineering Mathematics by B.S. Grewal 2 .Engineering Mathematics by Jaggi & Mathur 3. Calculus by Shantinarayan 4. GLEN. E. MYERS – Analytical Methods in Conduction Heat Transfer Mc Graw Hill, New York (1977) 5.REMSON. I. G.M. HORNBERGER AND F.J. MOLIZ – Numerical Methods in Subsurface Hydrology. 6. PINDER G.F. and GRAY – Finite Element Simulation in Sub Surface Hydrology, Academic Press, New York (1971).
18	Neuro-Fuzzy Techniques And Computer Programming
	NEURO-FUZZY TECHNIQUES AND COMPUTER PROGRAMMING **Unit I** Introduction: Basic concepts of Neural Networks and Fuzzy Logic, Differences between conventional computing and Neuro-

	Fuzzy computing, Characteristics of Neuro-Fuzzy computing. Fuzzy Set Theory: Basic definitions and terminology and membership functions – formulation and parameters, basic operations of fuzzy sets – complement, intersection, vision, T-norm and T-conorm **Unit II** Fuzzy Reasoning and Fuzzy Inference: Fuzzy relations, Fuzzy rules, Fuzzy reasoning, Fuzzy Inference Systems, Fuzzy modelling, Applications of Fuzzy reasoning and modelling in Water Resources Engineering Problems. **Unit III** Fundamental concepts of Artificial Neural Networks: Model of a neuron, activation functions, neural processing, Network architectures, learning methods. Neural Network Models: Feed forward Neural Networks, Back propagation algorithm, Applications of Feed forward networks, Recurrent networks, Hopfield networks, Hebbian learning, Self organising networks, Unsupervised learning, competitive learning. **Neuro-Fuzzy Techniques:** Hydrologic Modelling Time Series Analysis and Modelling, Remote Sensing , Environmental Modelling and Water Management, **Unit IV** Introduction to C and important Concepts. Beginning with C ++ : What is C ++., Applications of C ++, A S imple C ++ programme, More C ++ Statement, An Example with Class, Structure of C++ Program, Creating the Source File, Compiling and Linking. **Unit V** Tokens, Expressions and Control Structures in C ++ : Introduction, Tokens, Keywords, Identifiers, Basic Data Types, User-Defined Data Types, Symbolic Constants. Type Compatibility, Declaration of Variables, Dynamic Initialization of Variables, Reference Variables, Operators in C++ , Scope Resolution Operator, Member Dereferencing Operators, Memory Management Operators, Manipulators, Type Cast Operator, Expressions and Implicit Conversions, Operator Overloading, Operator Precedence, Control Structures

	TEXT BOOKS: 1. Jang, JSR, C.T. Sun and E. Mizutan (1997), "Neuro-Fuzzy and Soft Computing", Prentice Hall, NJ 2. Simon Haykin, (1994), "Neural Networks, A Comprehensive Foundation", Mc Millan College Publishing Company 3. Kosko, B. (1997), "Neural Networks and Fuzzy Systems", Prentice Hall of India Pvt. Ltd. , New Delhi. 4. Klir, George J., T.A. Forger, (1995), "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India, Pvt. Ltd., New Delhi. 5. Rao V and H. Rao , (1996), "C++ Neural Networks and Fuzzy Logic, BPB Publications, New Delhi.
19	**Solid & Hazardous Waste Management**
	SOLID & HAZARDOUS WASTE MANAGEMENT **Unit I Solid Waste Collection, Segregation and Transport:** Definition of solid wastes – types of solid wastes – Sources - Industrial, mining, agricultural and domestic – Characteristics. Solid waste Problems - impact on environmental health – Concepts of waste reduction, recycling and reuse. Handling and segregation of wastes at source. Collection and storage of municipal solid wastes; Analysis of Collection systems. Transfer stations. **Unit II Municipal Solid Waste Management:** Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery: composting, vermi-composting, termi-gradation, fermentation. Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; Leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation. Regulatory aspects of municipal solid waste management. **Unit III Hazardous Wastes:** Hazardous waste definition. Physical and biological routes of transport of hazardous substances – sources and characterization categories and control. Sampling and analysis of hazardous wastes – analytical approach for hazardous waste characterization – proximate analysis – survey analysis – directed analysis – analytical methods. **Unit IV Hazardous Wastes Management:**

	Sources and characteristics: handling, collection, storage and transport, TSDF concept. Hazardous Waste treatment technologies - Physical, chemical and thermal treatment of hazardous waste: solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste landfills - Site selections, design and operation. Hazardous waste reduction and Recycling - Regulatory aspects of HWM. **Unit V Biomedical, Radioactive and e-Waste Management:** Biomedical waste: Definition, sources, classification, collection, segregation Treatment and disposal. Radioactive waste: Definition, Sources, Low level and high level radioactive wastes and their management, Radiation standard by ICRP and AERB. Waste characteristics, generation, collection, transport and disposal. **Books:** Hazardous waste management by Prof. Y. Anjaneyulu. Hazardous waste management Charles A. Wentz. Second edition 1995. McGraw Hill International. Integrated solid waste management, George Tchobanoglous, Hilary Theisen & Sammuel A. Vigil. Criteria for hazardous waste landfills – CPCB guidelines 2000. Environmental Science by Daniel B. Botkin and Edward A. Keller, Wiley student, 6th edition-2009.
20	**Physico-Chemical Process For Water And Wastewater Treatment**
	PHYSICO-CHEMICAL PROCESS FOR WATER AND WASTEWATER TREATMENT UNIT-I Water Quality-Physical, chemical and biological parameters of water- Water Quality requirement - Potable water standards - Wastewater Effluent standards -Water quality indices. Water purification systems in natural systems-Physical processes chemical processes and biological processes-Primary, Secondary and tertiary treatment-Unit operations-unit processes. UNIT-II Mixing, Clarification - Sedimentation; Types; Aeration and gas transfer – Coagulation and flocculation, coagulation processes - stability of colloids - destabilization of colloidstransport of colloidal particles, Clariflocculation. UNIT-III Filtration - theory of granular media filtration; Classification of of filters; slow sand filter and rapid sand filter; mechanism of

	filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration. UNIT-IV Adsorption, adsorption equilibria- adsorption isotherms, Disinfection - chlorine dioxide; chloramines; ozonation; UV radiation. UNIT-V Ion Exchange-processes, Application Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis. **REFERENCE BOOKS** 1. Weber, W.J. *Physicochemical processes for water quality control*, John Wiley and sons, Newyork, 1983. 2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. *Environmental Engineering*, McGraw Hills, New York 1985. 3. Metcalf and Eddy, *Wastewater engineering, Treatment and Reuse*, Tata McGraw-Hill, New Delhi, 2003.
Pre-PhD Courses for Structural Engineering (Civil Engg)	
Structural Engineering Paper -I	
S.No.	**Structural Engineering**
1	Theory of Elasticity and Plasticity
	THEORY OF ELASTICITY AND PLASTICITY **UNIT-I** **Introduction:** Elasticity – Notation for Forces and Stresses – Components of Stresses – Components of Strain – Hooke's Law. Plane Stress and Plane Strain analysis – Plane Stress – Plane strain – Differential Equations of equilibrium – Boundary conditions – Compatibility equations - Stress function – Boundary Conditions. **UNIT-II**

	Two Dimensional Problems: in Rectangular Co-Ordinates – Solution by polynomials – Saint – Venant's Principle – Determination of Displacements – Bending of Simple beams – Application of Fourier Series for two dimensional problems for gravity Loading. Two Dimensional problems in Polar Co-ordinates General Equations in polar Co-ordinates – Stress Distribution Symmetrical about an axis – Pure bending of curved bars - Strain Components in Polar Co-ordinates – Displacements for Symmetrical stress Distributions – Circular discs- Stresses on plates with circular holes **UNIT-III** **Three Dimensional Problems:** Analysis of Stress and Strain in Three Dimension Principal Stress – Stress Ellipsoid and stress director surface – Determination of Principal stresses Maximum shear stresses – Homogeneous Deformation – Principle Axes of Strain. 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 – Reciprocal theorem. **UNIT-IV** **Torsion of Prismatic Bars:** Torsion of Prismatic Bars – Bars with Elliptical Cross Section – Other elementary Solution – Membrane Analogy – Torsion of Rectangular Bars – Solution of Torsional Problems by Energy method – use of soap Films in Solving Torsional problems – Hydro dynamical Analogies – Torsion of Bars. **UNIT-V** **Theory of Plasticity:** Introduction – Concepts and Assumptions – Yield criteria. **References:** 1. Theory of Elasticity- Timoshenko & Goodier. 2. Theory of Elasticity – Sadhu Singh
2	Experimental Stress Analysis

EXPERIMENTAL STRESS ANALYSIS

UNIT I

Basic equations and Plane Elasticity Theory: Introduction, Strain equations of Transformation, Compatibility, Stress-Strain Relations-Two dimensional State of Stress. The Plane-Elastic problem, The Plane-Strain Approach, Plane Stress, Airy's Stress function-Cartesian Co-ordinates-Two dimensional problems in Polar Co-ordinates, Polar Components of Stress in terms of Airy's Stress function, Forms. Principles of Experimental Approach: Merit of Experimental Analysis introduction, uses of experimental stress analysis-Advantages of experimental stress analysis, Different methods, Simplification of problems.

UNIT II

Strain Measurement using Strain Gauges: Definition of strain and its relation to Experimental Determinations, properties of strain-gauge systems, Types of strain gauges, Mechanical and Optical strain gauges. Electrical Strain Gauges- Introduction, LVDT - resistance strain gauge - various types - gauge factor, Materials for adhesion base, etc. Strain Rosettes: Introduction, The three element rectangular Rosette - The delta rosette - Corrections for Transverse strain effects.

UNIT III

Brittle Coating Method: Introduction, Coating stresses - Failure theories - Brittle coating Crack pattern - Crack detection - Types of Brittle coating - Test procedures for brittle coating analysis - Calibration procedures - Analysis of brittle coating data.

UNIT IV

Theory of Photo Elasticity: Introduction, Temporary double refraction - The stress optic law - Effects of stressed model in a Polaris cope for various arrangements – Fringe sharpening, Brewster stress optic law.

UNIT V

Two Dimensional Photo Elasticity: Introduction, Isochromatic Fringe patterns – Isoclinic fringe patterns, passage of light through plane Polaris cope and circular Polaris cope, Isoclinic fringe pattern - Compensation techniques - calibration methods, separation methods, scaling Model to Proto type stress- Materials for photo - elasticity, properties of photo elastic materials.

REFERENCES :

1. Experimental Stress Analysis by J.W.Dally and W.F.Riley

	2. Experimental Stress Analysis by Dr. Sadhu Singh 3. Experimental Stress Analysis by Dove and Adams 4. Experimental Stress Analysis - L.S. Srinath 5. Experimental Stress Analysis – Lee
3	Finite Element Method
	FINITE ELEMENT METHOD **Unit I:** Introduction: Review of stiffness method- displacement field - Integral form-differential form - "Rayleigh-Ritz method" of functional approximation - variational approaches -weighted residual methods- concept of FEM. Bar and torsional elements: Degree of freedom –simple element- higher order element-nodal displacement vector- shape functions- FE formulation-discrimination- stiffness matrix of element- element nodal load vector-assembling- total potential in terms of FEM formulation-boundary conditions- strain, stress and force in element-reaction- torsional element. trusses-Iso-parametric element. –natural coordinates. **Unit II:** Beam, frame and grid elements: Degree of freedom - displacement vector - simple element- higher order element-nodal displacement vector - shape functions- discrimination- stiffness matrix of element- element nodal load vector-assembling-total potential in terms of FE formulation- boundary conditions- strain, stress and forces in elements-reactions- frame element-Grid element-Beams - frames- Grid structures. Iso-parametric element –natural coordinates. **Unit III:** Membrane element: 2 Dimensional structures- Plane stress-plane strain- triangular elements-CST element-LST element-rectangular elements-Legrangian family of elements-Serendipity family of elements Shape functions – nodal displacement vector-FEM formulation-element stiffness matrix- element nodal load vector due to body forces, traction and concentrated loads- Iso-parametric element- Area coordinates- strain vector and stress vector in element. Axisymmetric solids: Modelling as 2D problem: stress-strain relations- material stiffness matrix-dof - Triangular element- rectangular element-shape functions-Displacement function- FE formulation -stiffness matrix of element- nodal loads- strain vector, stress vector in elements-reactions. Iso-parametric element-Area coordinates.

	Unit IV: 3 Dimensional stress analysis: dof – types of elements- simple elements – higher order elements-displacement function- shape functions- nodal displacement verctor- Nodal load vector- stiffness matrix of element- FE formulation – volume coordionates- isoparametric elements- strain vector and stress vector in element. Plate structures & shell structures: dof- displacement field – nodal displacement vector- shape function- Finite Element Formulation of plate structures- types elements- strain vector and stress vector in element-types of elements. **Unit V:** Introduction to Non-linear Finite Element Methods- types of nonlinear problems-Introduction to dynamic analysis using Finite Element Method - Development of simple programs for simple structures- Introductio of FEM package(only class work) **REFERENCES:** 1. Concepts and applications of Finite Element Analysis – Robert D. Cook, Michael E Plesha, John Wiley & sons Publications 2. A first course in the Finite Element Method – Daryl L. Logan, Thomson Publications. 3. Introduction to Finite Elements in Engineering- Tirupati R. Chandrupatla, Ashok D. Belgunda, PHI publications 4. Fundamentals of Finite Element Analysis- David V. Hutton, Tata McGraw-Hill 5. Finite element Analysis- Theory and programming – C.S. Krishna Murthy, Tata Mc Gra Hill. 6. Finite element Analysis – P.Seshu, PHI 7. Finite element method – O.C. Zeinkiewicz, Tata Mc Gra Hill, 2007
4	**Mechanics Of Composite Materials**
	MECHANICS OF COMPOSITE MATERIALS **UNIT-I** Classification of Composite materials. Introduction to composite materials, including fabrication processes, properties, design concepts, assembly, and applications. Polymer Matrix Composites (PMC's) Metal Matrix Composites (MMC's) Ceramic Matrix Composites (CMC's).

	UNIT-II Elastic properties and stress-strain relations –fracture behavior -Dispersion strengthened particle reinforced and fiber reinforced composite laminates - elastic anisotopic properties, the directional dependence of different properties, and the mechanical properties of thin laminates. **UNIT-III** Properties of matrix and reinforced materials-orthotropic coefficients needed for design activities, the Hill-Tsai failure criterion. Bending and torsion of composite beams, and the bending of thick composite plates. Micromechanics and principles of strengthening. **UNIT-IV** Fabrication methods and structural applications of different types of composite materials - thermo elastic properties **UNIT-V** Failure analysis and the bonding of cylinders, sandwich beam buckling and flexure shear, and vibrations in composite plates **REFERENCES:** 1. Engineering Mechanics of composite materials by Isaac M. Daniel and H. Thomas Hahn 2. An introduction to composite materials by by D. Hull and T.W. Clyne 3. The Theory of Composites - Graeme W. Milton- Cambridge.
5	**Advanced Structural Analysis**
	ADVANCED STRUCTURAL ANALYSIS **UNIT I** Analysis of Axially loaded bars, beams and portal frames by Rayleigh-Ritz method **UNIT II** Analysis of Axially loaded bars, beams and portal frames by Gelarkin’s method **UNIT – III**

	Analysis of beams and plates by Finite Difference Method **UNIT – IV** Analysis of Statically determinate and Indeterminate beams, Frames and Trusses by Stiffness method **UNIT –V** Analysis of Statically determinate and Indeterminate beams, Frames and Trusses by Flexibility method **UNIT – VI** Approximate methods of analysis of Multi-storey frames **UNIT – VII** Influence lines for indeterminate beams, Arches and Trusses **UNIT VIII** Cables and suspension bridges. **TEXT BOOKS** 1. Wang C. K., "Indeterminate Structural Analysis", McGraw-Hill, 2nd Edition, 2000. 2. Sinha, N. C. and Gayen, P. K., Advanced theory of structures, Dhanpat Rai & Sons, 4th Edition, 2002 **Reference Books** 1. Reddy C.S., Basic Structural Analysis, Tata McGraw Hill Publishing Co., 3rd edition, 2001 2. Hibbeler R.C, Structural Analysis, Macmillan Pub.Co., 2nd Edition, 2000 3. Au T and Christiano, P., Structural analysis, Prentice Hall, 1st Edition, 2002
6	Fracture Mechanics of concrete structures
	FRACTURE MECHANICS OF CONCRETE STRUCTURES UNIT-I Introduction: Fundamentals of elastic and plastic behaviour of materials- stresses in a plate with a hole – Stress Concentration factor- modes of failure- Brittle fracture and ductile fracture- history of fracture mechanics-Griffiths criteria of cracks- mode I, mode II and mode III failure. UNIT-I Principles of Linear Elastic Fracture Mechanics: SOM vs Fracture Mechanics -stressed based Criteria for fracture- Stress

	Intensity Factors- K_I K_{II} and K_{III} – Critical stress Intensity Factors, K_{Ic} K_{IIc} and K_{IIc} – crack tip plastic zone – Erwin's plastic zone correction -Critical crack length-Load carrying capacity of a cracked component- Design of components based on fracture mechanics. UNIT-I Griffith's criteria- Criteria for crack propagation -Energy release rate , G_I G_{II} and G_{III} - Critical energy release rate G_{Ic} , G_{IIc} and G_{IIIc} – surface energy - R curves – compliance- J-Integrals: UNIT-I Material characterisation by Crack Tip Opening Displacements (CTOD)- Crack Mouth Opening Displacement (CMOD)- Critical crack tip opening displacement ($CTOD_c$) –critical Crack Mouth Opening Displacement ($CMOD_c$)-Determination of fracture parameters. Experimental determination of fracture parameters- K_{Ic} , G_{Ic}, $CTOD_c$ and critical J-Integral.-for brittle and quasi brittle materials like concrete and rock- Specimen geometry . UNIT-I Nonlinear Fracture Mechanics for mode I quasi- brittle fracture(Concrete): General quasi-brittle fracture-Ficticious crack approach - Hillerborg's Fictitious crack model-Bazanth's crack band model- Effective elastic crack approach-Two Parameter model- Bazanth' Size effect model-effective crack model-softening- Applications of Fracture Mechanics to Concrete structures: Size effect on nominal strength-Tension ,Bending, Shear and torsion of RRC members-Concrete dams- Interfacial fracture mechanics- **REFERENCES :** 1. Engineering Fracture Mechanics- S.A. Meguid, Elsevier Applied Science Publications. 2. Elementary engineering fracture mechanics – David Broek – Sijthoff & Noordhoff – Alphenaan den Rijn – Netherlands. 3. Elements of Fracture Mechanics – Prasanth Kumar, wiley Eastern Publications 4. Fracture Mechanics: Fundamentals and applications – T. L. Andrason, PhD, CRC publications 5. Fracture Mechanics of Concrete: Applications of fracture mechanics to concrete, Rock, and other quasi-brittle materials, Surendra P. Shah, Stuart E. Swartz, Chengsheng Ouyang, John Wiley & Son publications. 6. Fracture mechanics of concrete structures – Theory and applications – Rilem Report – Edited by L. Elfgreen – Chapman

	and Hall – 1989. 7. Fracture Mechanics – Applications to Concrete – Edite
7	**Mechanical Vibrations**
	MECHANICAL VIBRATIONS **UNIT-I** **Single degree Freedom systems:** Undamped and damped free vibrations: forced vibrations – Viscous damper – Coulomb damper– Response to harmonic excitation, rotating unbalance and support excitation – Vibration isolation and transmissibility - Torsional vibrations. Vibration measuring instruments: Vibrometers, velocity meters & accelerometers. **UNIT-II** **Two degree freedom systems:** Principal modes – undamped and damped free and forced vibrations – undamped and damped vibration absorbers – Torsional vibrations. **UNIT**-III **Multi degree freedom systems:** Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by modal analysis; method of matrix inversion; Torsional vibrations of multi –rotor systems and geared systems. UNIT-IV **Continuous systems:** Beams and Beams on Elastic foundation- **Critical speeds of shafts:** Critical speeds without and with damping, secondary critical speed. UNIT-V **Numerical Methods:** Rayliegh's, stodola's, Matrix iteration and Holzer's methods. **Continuous systems:** Free vibration of strings – longitudinal oscillations of barstraverse vibrations of beams- Torsional vibrations of shafts. **TEXT BOOKS:** 1. Vibrations by W.T. Thomson. 2. Mechanical Vibrations by G.K. Groover.

	REFERENCES: 1. Elements of Vibration Analysis by Meirovitch. 2. Mechanical Vibrations by Den Hortog. 3. Mechanical Vibrations – Schaum series. 4. Vibration problems in Engineering by S.P. Timoshenko.
8	**Theory of plates and shells**
	THEORY OF PLATES AND SHELLS **UNIT-I** Derivation of governing differential equation for plate– in plane bending and transverse bending effects- Rectangular plates: Plates under various loading conditions like concentrated, uniformly distributed load and hydrostatic pressure. Navier and Levy's type of solutions for various boundary condition. UNIT-II **Circular plates:** Symmetrically loaded, circular plates under various loading conditions, Annular plates. UNIT-III **Introduction to Shells:-** Single and double curvature- Equations of Equilibrium of Shells: Derivation of stress resultants, Principles of membrane theory and bending theory. UNIT-IV **Cylindrical Shells:** Derivation of the governing DKJ equation for bending theory, details of Schorer's theory. Application to the analysis and design of short and long shells. Use of ASCE Manual coefficients for the design. UNIT-V **Beam theory of cylindrical shells:** Beam and arch action. Design of diaphragms - Geometry analysis and design of elliptic Paraboloid, Conoidal and Hyperbolic Paraboloid shapes by membrane theory. REFERENCES: 1. Theory of Plates and Shells – Timoshenko and Krieger, McGraw-Hill book company, INC, New york.

<table>
<tr><td></td><td>2. K. Chandra Sekhara
3. A Text Book of Plate Analysis – Bairagi, K, Khanna Publisher, New Delhi.
4. Design and Construction of Concrete Shell Roofs – Ramaswamy, G.S, Mc Graw – Hill, New York.
5. “Theory of Plates and Shells” by Timeshenko, S. and Wernewsky-Kriegar.
6. “Slressesin Shells” by Flugge.
7. “Design and Construction of Shells” by Ramaswamy, G.S.
8. Chandrashekhara, K., Theory of Plates, Universities Press, 2001.
9. Chandrashekhara, K., Analysis of thin concrete shells, New Age Intl, 1998.
10. Timshenko, S.P., and Woinowsky-Krieger, S., Theory of Plates and Shells, McGraw Hill, 1959.
11. Ugural, A.C., Stresses in Plates and Shells, John Wiley and Son, 1967.</td></tr>
<tr><td>9</td><td>Structural Reliability</td></tr>
<tr><td></td><td>STRUCTURAL RELIABILITY

UNIT-I
Concepts of Structural Safety: General, Design methods. Basic Statistics: Introduction, Data reduction, Histograms, Sample correlation. Probability Theory: Introduction, Random events, Random variables, Functions of random variables, Moments and expectation, Common probability distribution, Extremal distribution.

UNIT-II
Resistance Distributions and Parameters: Introduction, Statistics of properties of concrete, Statistics of properties of steel, Statistics of strength of bricks and mortar, Dimensional variations, Characterization of variables, Allowable stresses based on specified reliability. Probabilistic Analysis of Loads: Gravity loads, Wind load.

UNIT-III
Basic Structural Reliability: Introduction, Computation of structural reliability. Monte Carlo Study of Structural Safety: General, Monte Carlo method, Applications. Level 2 Reliability Methods: Introduction, Basic variables and failure surface, First-order second-moment methods (FOSM).

UNIT-IV</td></tr>
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	Reliability Based Design: Introduction, Determination of partial safety factors, Safety checking formats, Development of reliability based design criteria, optimal safety factors, Summary of results of study for Indian standard – RCC design. **UNIT-V** Reliability of Structural Systems: Preliminary concepts as applied to simple structures. References: 1. "Structural Reliability Analysis and Design" by Ranganatham, R. 2. "Structural Reliability" by Melchers, R.E.
10	Advanced Concrete Technology
	ADVANCED CONCRETE TECHNOLOGY **UNIT-I** Materials- Cement, Aggregates, mixing water soundness of aggregate- Fresh and hardened concrete: Admixtures- types of admixtures- purposes of using admixtures- chemical composition- effect of admixtures on fresh and hardened concretes- Natural admixtures. Non destructive evaluation: Importance- Concrete behavior under corrosion, disintegrated mechanisms- moisture effects and thermal effects – Visual investigation- Acoustical emission methods- Corrosion activity measurement- chloride content – Depth of carbonation- Impact echo methods- Ultrasound pulse velocity methods- Pull out tests **UNIT-II** Repair and rehabilitation of structural elements: Analysis, strategy and design- Material requirement- Material selection- Surface preparation- Reinforcing steel cleaning, repair and protection- Bonding repair materials to existing concrete- placement methods- **UNIT-III** Strengthening and stabilization- Techniques- design considerations- Beam shear capacity strengthening- Shear Transfer strengthening- stress reduction techniques- Column strengthening-flexural strengthening- Connection stabilization and strengthening Crack stabilization **UNIT-IV**

	Fiber-reinforced concrete- Properties of constituent materials- Mix proportions, mixing and casting methods-Mechanical properties of fiber reinforced concrete- applications of fibre reinforced concretes. Light weight concrete- Introduction- properties of light weight concrete- No fines concrete- design of light weight concrete **UNIT-V** Fly ash concrete- Introduction- classification of flyash- properties and reaction mechanism of flyash- Properties of flyash concrete in fresh state and hardened state- Durability of flyash concretes. High performance concretes- Introduction- Development of high performance concretes- Materials of high performance concretes- Properties of high performance concretes. **REFERENCE:** 1. Concrete technology- Neville & Brooks 2. Special Structural concrete- Rafat Siddique 3. Concrete repair and maintenance illustrated- Peter H Emmons
	Pre- PhD courses for Structural Engineering Paper -II
1	**Design of Masonry Structures**
	DESIGN OF MASONRY STRUCTURES **Unit I:** Properties of materials of masonry- Bricks, mortar, and factors influencing strength of masonry. **Unit II:** Properties of masonry, **Unit III** : Masonry under axial, flexure and shear, **Unit IV:** Theories of failure of masonry **Unit V:** Design of unreinforced masonry structures. **REFERENCES:** 1. Hendry, A.W., Structural Masonry, MacMillan Press, 1998.

	2. Duggal, S.K., Earthquake resistant design of structures, Oxford University Press, 2007 3. Current literature.
2	Structural Dynamics
	STRUCTURAL DYNAMICS **UNIT I:** **Theory of vibrations**: Introduction - 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. **UNIT II** **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. **UNIT III** **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. **UNIT IV** **Practical Vibration Analysis:** Introduction - Stodola method - Fundamental mode analysis - Analysis of second and higher modes - Holzer method - Basic procedure. **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.

	UNIT V **Introduction to Earthquake Analysis:** Introduction - 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. **REFERENCES:** 1. Dynamics of Structures by Clough & Penzien, McGraw Hill, New york 2. Structural Dynamics by Mario Paz, C.B.S Publishers, New Delhi. 3. Dynamics of Structures by Anil K. Chopra, Pearson Education (Singapore), Delhi. 4. I.S: 1893 - 1984, "Code of practice for Earthquake resistant design of Structures" and latest I.S: 1893 - 2002 (version) Part-1
3	**Earthquake Resistant Design of structures**
	EARTHQUAKE RESISTANT DESIGN OF BUILDINGS **UNIT - I** Engineering Seismology: Earthquake phenomenon cause 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. **UNIT - II** 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. 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. **UNIT - III**

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

UNIT - IV

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.

UNIT - V

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. Capacity Based Design: Introduction to Capacity Design, Capacity Design for Beams and Columns-Case studies.

REFERENCE BOOKS:

1. Earthquake Resistant Design of structures – S. K. Duggal, Oxford University Press
2. Earthquake Resistant Design of structures – Pankaj Agarwal and Manish Shrikhande, Prentice Hall of India Pvt. Ltd.
3. Seismic Design of Reinforced Concrete and Masonry Building – T. Paulay and M.J.N. Priestly, John Wiley & Sons
4. Masory and Timber structures including earthquake Resistant Design –Anand S.Arya, Nem chand & Bros
5. Earthquake –Resistant Design of Masonry Building –Miha Tomazevic, Imperial college Press.
6. Earthquake Tips – Learning Earthquake Design and Construction C.V.R. Murty.

REFERENCE CODES:

	1. IS: 1893 (Part-1) -2002. "Criteria for Earthquake Resistant – Design of structures." B.I.S., New Delhi. 2. IS:4326-1993, " Earthquake Resistant Design and Construction of Building", Code of Practice B.I.S., New Delhi. 3. IS:13920-1993, " Ductile detailing of concrete structures subjected to seismic force"– Guidelines, B.I.S., New Delhi.
4	**Low Cost Housing Techniques**
	LOWCOST HOUSING TECHNIQUES **UNIT-I** a) **Housing Scenario** Introducing- Status of urban housing- Status of Rural Housingb). **Housing Finance:** Introducing- Existing finance system in India- Government role as facilitator- Status at Rural Housing Finance- Impedimently in housing finance and related issues **b) Land use and physical planning for housing:** Introduction- Planning of urban land- Urban land ceiling and regulation act- Effectincey of building bye lans- Residential Densities **c) Housing the urban poor:** Introduction- Living conditions in slums- Approaches and strategies for housing urban poor. **UNIT-II** **Development and adopt on of low cost housing technology:** Introduction- Adoption of innovative cost effective construction techniques- Adoption of precast elements in partial prefabrication- Adopting of total prefabrication of mass housing in India- General remarks on pre cast rooting/flooring systems- Economical wall system- Single. Brick thick loading bearing wall- 19cm thick load bearing masonery walls- Half brick thick load bearing wall- Flyash grypsym thick for masonry- Stone Block masonery- Adoption of precast R.C. plank and join system for roof/floor in the building UNIT-III **Alternative building materials for low cost housing:** Introduction- Substitute for scarce materials- Ferrocement- Gypsum boards- Timber substitutions- Industrial wastes- Agricultural wastes. **UNIT-IV** **Low cost Infrastructure services:** Introducing- Present status- Technological options- Low cost sanitation's- Domestic wall- Water supply- energy. **Rural Housing:** Introduction- traditional practice of rural housing continuous- Mud Housing technology- Mud roofs- Characteristics of mud- Fire resistant treatment for

	thatched roof- Soil stabilization- Rural Housing programs **UNIT-V** **Housing in Disaster Prone areas:** Introduction- Earthquake- Damages to houses- Traditional Houses in disaster prone areas Type of Damages and Railways of non-engineered buildings- Repair and restore action of earthquake Damaged non-engineered buildings recommendations for future constructions- Requirement's of structural safety of thin precast roofing units against - Earthquake forces- Status of R& D in earthquake strengthening measures- Floods-cyclone- future safety. **TEXT / REFERENCE BOOKS:** 1. Building materials for low –income houses – International council for building research studies and documentation's. 2. Hand book of low cost housing by A.K.Lal – Newage international publishers. 3. Properties of Concrete – Neville A.M. Pitman publishing Limited- London. 4. Light weight concrete- Academic kiado- Rudhai .G – Publishing home of Hungarian Academy of Sciences 1963. 5. Low cost Housing – G.C. Mathur 6. Modern trends in housing in developing countries – A.G. Madhava Rao- D.S. Ramachandra Murthy & G.Annamalai
5	**Repair and Rehabilitation of Structures**
	REPAIR AND REHABILITATION OF STRUCTURES **UNIT-I** **Materials for Repair:** Materials: Construction chemicals, Mineral admixtures, Composites, Fibre reinforced concrete, High performance concrete, Polymer-impregnated concrete. Techniques to Test the Existing Strengths: Destructive and non-destructive tests on concrete. Special concretes and mortar, concrete chemicals, special elements for acclerated strength gain, Expansive cement , polymer concrete, sulphur infiltrated concrete, ferro cement, Fibre reinforced concrete. **UNIT-II** Repairs of Multistorey Structures: Cracks in concrete, Possible damages to the structural element beams, Slab, Column, Footing, etc., Repairing techniques like Jackchu, Grouting, External prestressing, Use of chemical admixtures, Repairs to the

	fire damaged structure. **UNIT-III** **Techniques for Repair;-** Rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, Gunite and shotcrete Epoxy injection, Mortar repair for cracks, shoring and underpinning. Repairs to Masonry Structures & Temples: Damages to masonry structures – Repairing techniques, Damages to temples – Repairing techniques. Foundation Problems: Settlement of soils – Repairs, Sinking of piles – Repairs. **UNIT-IV** Corrosion of Reinforcement: Preventive measures – Coatings – Use of SBR modified cementitious mortar, Epoxy resin mortar, Acrylic modified cementitious mortar, Flowing concrete. **UNIT-V** Temporary Structures: Need for temporary structures under any Hazard, Various temporary structures, Case studies. Case Studies: At least 10 case studies. References: 1. "Renovation of Structures" by Perkins. 2. "Repairs of Fire Damaged Structures" by Jagadish, R. 3. "Forensic Engineering" by Raikar, R.N. 4. "Deterioration, Maintenance and Repair of Structures" by Johnson, McGraw Hill. 5. "Concrete Structures: Repairs, Water Proofing and Protection" by Philip H. Perkins, Applied Sciences Publications Ltd., London, pp.302. 6. "Durability of Concrete Structure: Investigation, Repair, Protection" Edited by Geoffmangs, E. & FN SPON, An Imprint of Chapman & Hall, pp.270. 7. "Structural Failure" by Tomoss Weirzbicki, Norman Jones, Wiley Interscience, pp.551. 8. "Deterioration, Maintenance and Repair of Structures" by Johnson, McGraw Hill, pp.375. 9. "Design and Construction, Failures, Lessons from Forensic Investigation" by Dov Kaminetzky, McGraw Hill, pp.600.

<table>
<tr><td></td><td>10. Dension Campbell, Allen and Harold Roper, Concrete Structures, Materials,Maintenance and Repair, Longman Scientific and Technical, U.K, 1991.
11. RT. Allen and S.C. Edwards, Repair of concrete Structures, Blakie and sons, UK, 1987.
12. MS. Shetty, Concrete Technology – Theory and practice, S.Chand and company, New Delhi, 1992.
13. Santhakumar, S.R. Training course notes on damage assessment and Repair in low cost housing RHDC-NBO Anna University, Madras, July, 1992.
14. Raikar, R.N. learning from failures – deficiencies in Design, construction and service– R & D centre (SDCPL), Raikar Bhavan, Bombay, 1987.
15. N. Palaniappan, Estate Management, Anna Institute of Management, Madras Sep. 1992.
16. F.K. Garas, J.L. Clarke, GST Armer, Structural Assessment, Butterworths, UK April 1987.
17. A.R. Santhakumar, Concrete chemicals – Theory and applications, Indian society for construction Engineering and Technology, Madras. 1993 (In press)</td></tr>
<tr><td>6</td><td>Stability of Structures</td></tr>
<tr><td></td><td>STABILITY OF STRUCTURES

UNIT-I
Buckling of Columns: Method of neutral equilibrium, Critical load of the Euler column, Linear column theory – An eigen value problem, Effective length concept, Higher order differential equation for columns initially bent columns, Effect of shear stress on buckling, eccentrically loaded columns, beam columns (Beam columns with concreted lateral load, distributed, load end moment), Inelastic buckling of columns, Double modulus theory, Tangent modulus theory, Shanley theory of inelastic column behaviour.

UNIT-II
Approximate Methods of Analysis: Conservation of energy principles, Calculation of critical loads using approximate deflection curve, Principle of stationary potential energy, Raleigh-Ritz method, Buckling load of column with variable cross-section, Galerkin’s method, Calculation of critical load by finite differences, Unevenly spaced pivot points, Matrix stiffness method, Effect of axial load on bending stiffness-slope deflection equations, Buckling of column loaded along the length using energy methods.</td></tr>
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	UNIT-III a) Buckling of Frames: Modes of buckling, Critical load of a simple frame using neutral equilibrium, Slope deflection equations and matrix analysis. b) Lateral buckling of cantilever and simply supported beams of rectangular and I-sections and use of energy method and finite differences. **UNIT-IV** Buckling of Plates: Differential equation, Strain energy of bending, Critical load, Finite difference approach inelastic buckling of plates. **UNIT-V** Matrix approach for Frames: Criterion for determination of critical loads, Stiffness influence coefficients for members without axial load, Derivation of stability functions, Problem involving Non-sways, Modified stiffness of beams, Frames with sway, Multi-bar frames. **REFERENCES:** 1. "Principles of Structural Stability Theory" by Alexander Chajes. 2. "Theory of Elasticity Stability" by Timoshenko and Gere. 3. Stability of metalic structure by Blunch –Mc Graw hill 4. Theory of Beam columns Vol I by chem & Atsute Mc.Graw Hill. 5. Smitses, Elastic stability of structures, Prentice Hall, 1973. 6. Timoshenko, S., and Gere., theory of Elastic stability, Mc Graw Hill Book company,1973. 7. Brush and Almorth., Buckling of bars plates and shells, Mc Graw Hill book company, 1975. 8. Chajes, A., Principles of Structural Stability Theory, Prentice Hall, 1974 9. Ashwini Kumar, stability theory of Structures, TATA Mc Graw Hill publishing company Ltd, New Delhi, 1985. 10. Elastic stability by Bleaigh.
7	**Pre-Stressed Concrete and Steel Structures**

PRESTRESSED CONCRETE AND STEEL STRUCTURES

UNIT-I

INTRODUCTION: Development of prestressed concrete –Advantages and Disadvantages of PSC over RCC General principles of pre-stressing-pre tensioning and post tensioning –Materials used in PSC-high strength concrete –High tension steel- Different types /methods/systems of prestressing. **Losses of prestress**: Estimation of the loss of prestress due to various causes like elastic shortening of concrete ,creep of concrete, shrinkage of concrete, relaxation of steel, slip in anchorage, friction etc.

UNIT-II

a) **Flexure:** Analysis of sections for flexure in accordance with elastic theory-Allowable stresses-Design criteria as per I.S code of practice –Elastic design of Beams (rectangular, I and T sections) for Flexure –Introduction to partial prestressing.
b) **Shear, bond, Bearing and Anchorage:** shear in PSC beams –Principal stresses – Conventional elastic design for shear-transfer of prestress in pretensioned memberstransmission length –Bond stresses-bearing at anchorage –Anchorage zone stresses in post-tensioned members-Analysis and design of end blocks by Guyon, Magnel and approximate methods –Anchorage zone reinforcements.

UNIT-III

a) **Deflections:** Introduction-Factors influencing deflections-short term and long term time deflections of uncracked and cracked members.
b) **Composite Construction:** Types of composite construction-stress distribution in composite sections analysis of stresses-Differential shrinkage-Design of simple composite sections.

UNIT-IV

Statistically indeterminate structures: Introduction –advantages and disadvantages of continuity –Layouts for continuous beams-primary and secondary moments –Elastic analysis of continuous beams-Linear transformation-Concordant cable profile-Design of continuous beams.

	UNIT-V a) **Circular prestressing**: Introduction –Circumferential prestressing Design of Prestressed concrete tanks –vertical prestressing in tanks-Dome prestressing. b) **Introduction to pre-stressed of steel structures.** **REFERENCE BOOKS:** 1. Prestressed Concrete by Lin 2. Prestressed Concrete by S.Krishnam raju 3. Research materials on prestressing steel structures.
8	Artificial Neural Networks and Fuzzy Logic
	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC **UNIT-I** **Introduction to Neural Networks:** ANN definition, components, input, output and hidden layers, threshold value, weights. Relationship of ANN with other technologies. UNIT-II **Neural Networks Models:** Perceptron model, Feedforward network-back propagation, Hopfeild network, Adaline and Madaline models. UNIT-III **Learning and Training:** Objective of learning, Supervised and Unsupervised learning, Hebb's rule, Delta Rule. UN IT-IV **Fuzzy Logic:** Crispness, Uncertainty, Vagueness, Fuzzyness, Fuzzy sets, Fuzzy Relations, Fuzzy association memory, Fuzzy events, Means, Variances. **UNIT-V** **Applications:** Applications of fuzzylogic in neural networks, Applications of fuzzylogic and neural networks in Civil Engineering with case studies.

	REFERENCES: 1. Neural Networks and Fuzzy Systems by Bart. Kosko, pretence hall of India, 1994. 2. Artificial Neural Networks by Robert J. Schalokoff. 3. Fuzzysets Uncertainity an information by George.J.Klir and Tina, Pretence Hall of India, New Delhi.
9	Analysis And Design Of Tall Buildings
	ANALYSIS AND DESIGN OF TALL BUILDINGS Unit-I Design Criteria Philosophy, Materials – Modern concepts – High Performance Concrete, Fibre Reinforced Concrete, Light weight concrete, Self Compacting Concrete. UNIT-II Gravity Loading – Dead load, Live load, Impact load, Construction load, Sequential loading. Wind Loading – Static and Dynamic Approach, Analytical method, Wind Tunnel Experimental methods. Earthquake Loading – Equivalent lateral Load analysis, Response Spectrum Method, Combination of Loads. UNIT-III Behavior of Structural Systems- Factors affecting the growth, height and structural form, Behaviour of Braced frames, Rigid Frames, In-filled frames, Shear walls, Coupled Shear walls, Wall–Frames, Tubular, Outrigger braced, Hybrid systems. UNIT-IV Analysis and Design- Modeling for approximate analysis, Accurate analysis and reduction techniques, Analysis of structures as an integral unit, Analysis for member forces, drift and twist. Computerized 3D analysis. Design for differential movement, Creep and Shrinkage effects, Temperature Effects and Fire Resistance.

	UNIT-V Stability Analysis- Overall buckling analysis of frames, wall–frames, Approximate methods, Second order effect of gravity loading, P–Delta Effects, Simultaneous first order and P-Delta analysis, Translational instability, Torsional Instability, Out of plumb effects, Effect of stiffness of members and foundation rotation in stability of structures. **TEXT BOOKS:** 1. Bryan Stafford Smith and Alex Coull, "Tall Building Structures - Analysis and Design", John Wiley and Sons, Inc., 1991. 2. Taranath B.S, "Structural Analysis and Design of Tall Buildings", McGraw-Hill, 1988.
10	Optimization Techniques in Structural Engineering
	OPTIMIZATION TECHNIQUES IN STRUCTURAL ENGINEERING **UNIT I** **Introduction to Optimization:** Introduction - Historical developments – Engineering applications of Optimization - Statement of an Optimization problem - Classification of Optimization problems - Optimization Techniques. Optimization by calculus: Introduction - Unconstrained functions of a single variable - Problems involving simple constraints – Unconstrained functions of several variables - treatment of equality constraints - Extension to multiple equality constraints - Optimization with inequality constraints - The generalized Newton-Raphson method. **UNIT II** **Linear Programming:** Introduction - Applications of linear programming – standard form of a linear programming problem - Geometry of linear programming problems - Definitions and theorems - Solution of a system of Linear simultaneous equations - Pivotal reduction of a general system of equations - Motivation of the Simplex Method - Simplex Algorithm - Two phases of the simplex method. non-Linear Programming: Introduction - Unimodal Function - Unrestricted search - Exhaustive search Dichotomous search - Interval Halving method - Fibonacci method - Golden section method - Comparison of elimination methods - Unconstrained optimization techniques - Direct search methods - Random search methos - grid search method - Univariate method- Powell's method - Simplex method - Indirect search methods - Gradient of a function - Steepest descent method - Conjugate gradient - Newton's method. **UNIT III**

	Dynamic Programming: Introduction - Multistage decision processes - concept of sub-optimization and the principle of optimality - computational procedure in dynamic programming - example illustrating the Calculus method of solution – example illustrating the Tabular of solution - conversion of a final value problem into an initial value problem - continuous dynamic programming - Additional applications. **UNIT IV** **Network Analysis:** Introduction - Elementary graph theory - Network variables and problem types - Minimum-cost route - Network capacity problems - Modification of the directional sense of the network. **UNIT V** Application of Optimization techniques to trusses, Beams and Frames. **REFERENCES** 1. Optimization: Theory and Applications by S.S.Rao. 2. Numerical Optimization Techniques for Engineering Design with applications by G.N.Vanderplaats. 3. Elements of Structural Optimization by R.T.Haftka and Z.Gurdal. 4. Optimum Structural Design by U.Kirsch. 5. Optimum Design of Structures by K.I.Majid. 6. Introduction to Optimum Design by J.S.Arora.
Pre-PhD Courses for Geotechnical Engineering (Civil Engg)	
	Geotechnical Engineering Paper -I
1	**Ground Improvement Techniques**
	GROUND IMPROVEMENT TECHNIQUES **UNIT-I:** **Introduction to Ground Modification:** Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – suitability and feasibility, Emerging Trends in ground improvement. **UNIT-II:**

Mechanical and Hydraulics Modifications: Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro floatation, Blasting, Dynamic consolidation, pre-compression and compaction piles, Field compaction control. Hydraulic Modification - Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains.

UNIT-III:

Physical and Chemical modification: Stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen. Grouting: Categories of grouting, Art of grouting, Grout materials, Grouting techniques and control.

UNIT-IV:

Reinforced Earth Technology and Soil Confinement Systems: Concept of soil reinforcement, Reinforcing materials, Backfill criteria, Art of reinforced earth technology, Design and construction of reinforced earth structures. Soil Confinement Systems - Concept of confinement, Gabbion walls, Crib walls, Sand bags, Evergreen systems and fabric formwork.

UNIT-V:

Miscellaneous Techniques: Design, Construction and applications of stone columns, lime columns and Cofferdams.

REFERENCES:

1. Manfred R. Hansmann - Engineering principles of ground modification - Mc. Graw- Hill pub. Co., New York.
2. Robert M. Koerner - Construction and Geotechnical methods in Foundation Engineering – Mc.Graw-Hill Pub. Co., New York.
3. Winterkorn and Fang - Foundation Engineering Hand Book – Van Nostrand Reinhold Co., New York.
4. Aris C. Stamatopoulos & Panaghiotis C. Kotzios – Soil Improvement by Preloading –John Wiley & Sons Inc. Canada.
5. P. Purushothama Rao – Ground Improvement Techniques – Laxmi Publications (P) Limited.
6. Construction and Geotechnical Methods in Foundation Engineering By R.M. Koerner, McGraw – Hill Book Co.
7. Current Practices in Geotechnical Engineering Vol.1, Alam Singh and Joshi, International Book Traders, Delhi, & Geo-Environ Academia.

	8. Foundation Analysis and Design (1V Ed.) By J.E. Bowles, McGraw – Hill Book Co., 9. Ground Improvement Techniques by P. Purushotham Raj, Laxmi Publications (P) Ltd., New Delhi. 10. Ground Improvement – Edited by M.P. Moseley, Blackie Academic & Professional. 11. Soil Mechanics for Road Engineers, H.M.S.O, Londan. 12. Ground Improvement Techniques by Bergado et al.
2	Advanced Soil Mechanics
	ADVANCED SOIL MECHANICS **UNIT-I** Principles of Elasticity and Plasticity Concept of stress and strain – Principal stresses – Stress – strain relationships – Plane stress and plane strain – Mohr's diagram – Yield criteria – Theories of failure – Mohr – Coulomb failure condition. **UNIT-II** Clay Mineralogy -Nature of soils – atomic bonds - Clay mineral structure – clay water relation – electrical effects – clay mineral identification – Soil fabric and structure Water flow in Soils Flow equation – Darcy's Law – General equation – mathematical analysis – solution by sketching – electrical analogy – numerical solution **UNIT-III** Transient Flow Effective stress - change in degree of saturation – change in void ratio – compressibility of pore water – compressibility of soil solids – rate of storage equation – transient flow condition – one dimensional consolidation – mathematical analysis – approximate numerical analysis. **UNIT-IV** Consolidation: Mechanism of consolidation – Primary consolidation – Stress history – Pre-consolidation pressure – Terzaghi's one-dimensional consolidation theory and equation – Solution by Fourier series and finite difference methods – Determination of coefficient of consolidation including Scott's method – U versus T relationship for deferent forms of initial excess pore water pressure distribution – Degree of consolidation under time – dependent loading – secondary consolidation. **UNIT-V**

	Shear strength Principle of effective stress – Measurement of strength parameter – Strength tests based on drainage conditions – Skempton's pore pressure coefficients – Stress paths – Hvorslev' spacing parameters – Shear strength of cohesion-less sands – Strength and deformation behavior – Dilatancy – Critical. Void ratio Liquefaction – Shear strength of saturated cohesive soils – Triaxial testing – Normally and over consolidated clays – Partially saturated clays – Stress – state variables – Measurement of pore- water and pore – air pressure – Axis translation technique. REFERENCES: 1. "Foundations of theoretical soil mechanics" by M.E. Harr., McGraw Hill Co. 2. "Fundamentals of soil behaviour " by J.K. Mitchell., John Wiley & Sons. 3. " Advanced soil mechanics" by Braja M. Das., Mc Graw Hill Co., 4. "Introduction to Geotechnical engineering" by Holtz and Kovacs., Prentice Hall. 5. "Elements of soil mechanics" by G.N. Smith., B.S.P. Professional Books, Oxford, London.
3	**Earth & Rock fill Dams And Slope Stability**
	EARTH & ROCKFILL DAMS AND SLOPE STABILITY **Unit-I** **Earth and Rock fill Dams**: General features, Selection of site; Merits and demerits of the earth and rock fill dams, Classification of earth dams, Materials of construction and requirements, Causes of failure, Safe design criteria. Instrumentation in earth dams: Pore pressure measurements, Settlement gauges, Inclinometers, Stress measurements, Seismic measurements. UNIT-II **Failures, Damages and Protection of Earth Dams**: Nature and importance of failure, Piping through embankment and foundations, Methods of seepage control through embankments and foundations, Design Criteria for filters, Treatment of upstream and downstream of slopes, Drainage control, Filter design. UNIT-III **Slope Stability Analysis**: Types of Failure: Failure surfaces - Planar surfaces, Circular surfaces, Non-circular surfaces, Limit equilibrium methods, Total stress analysis versus effective Stress analysis, Use of Bishop's pore pressure parameters, Short term and Long term stability in slopes.

	UNIT-IV **Methods of Slope Stability**: Taylor Charts, Method of Slices, Effect of Tension Cracks, Vertical Cuts. Bishop's Analysis, Bishop and Morgenstern Analysis, Noncircular Failure Surfaces: Morgenstern and Price Analysis, Janbu Analysis, Spencer Analysis, Sliding Block Analysis, Seismic stability, Stabilization of slopes: Drainage measures, Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime/thermal treatment), surface protection (vegetation/erosion control mats/shotcrete). UNIT-V **Rockfill Dams**: Requirements of compacted rockfill, Shear strength of rockfill, Rockfill mixtures, Rockfill embankments, Earth-core Rockfill dams, Stability, Upstream & Downstream slopes. **REFERENCES:** 1. Sherard – Earth and Earth Rock Dams. 2. Sowers, G. F. and Salley, H. I. – Earth and Rockfill Dams 3. Bharat Singh and Sharma, H. D. – Earth and Rockfill Dams. 4. Abramson, L. W., Lee, T. S. and Sharma, S. - Slope Stability and Stabilisation methods – John Wiley & sons. 5. Bromhead, E. N. (1992). The Stability of Slopes, Blackie academic and professional, London. 6. Christian, Earth & Rockfill Dams – Principles of Design and Construction, Kutzner Published Oxford and IBH. 7. Ortiago, J. A. R. and Sayao, A. S. F. J. - Handbook of Slope Stabilisation, 2004.
4	Pavement Analysis and Design
	PAVEMENT ANALYSIS AND DESIGN **UNIT-I** 1. Pavement Types, Wheel Loads and Design Factors Definition of Pavement Types, Comparison of Highway pavements, Wheel Loads, Tyre pressure, Contact pressure, Design Factors: Traffic and Loading, Environment, Materials, Failure criteria, Reliability.

	UNIT-II Stresses in Pavements-Layered System Concepts: One Layer System: Boussinesq Theory. Two Layer Theory: Burmister's Theory. Three Layer System. Stresses in Rigid Pavements. Relative Stiffness of Slabs, Modulus of Subgrade Reaction, Stresses due to Warping, Stresses due to Friction, Stresses due to Load, IRC Recommendations. **UNIT-III** Pavement Design IRC Method of Flexible Pavement Design, AASHTO Method of Flexible Pavement Design, IRC Method for Rigid Pavements, use of Geosynthatics in pavements. **UNIT-IV** Pavement Inventories Serviceability Concepts, Visual Rating, Pavement Serviceability Index, Roughness Measurements, Measurement of Distress Modes Cracking, Rutting, Rebound Deflection using Benkleman Beam Deflection Method, Load Man Concept, Skid Resistance Measurement. **UNIT-V** Pavement Evaluation Functional Pavement Performance Evaluation: AASHTO Method, Psycho Physical and Psycho Metric Scaling Techniques, Deduct Value Method. Structural Conditional Evaluation Technique: Benkelman Beam Deflection Method, Pavement Distress Rating Technique. Design of Overlays by Benkelmen Beam Deflection Methods as per IRC – 81 - 1997 – pavements on problematic soils. **REFERENCES:** 1. Yoder and Witzorack, "Principles of Pavement Design", John Willey and Sons. 2. Yang, H. Huang, "Pavement Analysis and Design", Prentice Hall Publication, Englewood Cliffs, New Jersy. 3. Sargious, M.A. Pavements and Surfacings for Highways and Airports – Applied science Publishers limited 4. Ralps Hass and Hudson, W.R. " Pavement Management System" Mc-Graw Hill Book Company. 5. IRC codes of practice.
5	Expansive Soils

	EXPANSIVE SOILS **Unit-I** Origin and occurrence of expansive soils-problems associated with expansive clays-identification and classification based on mineralogical composition. X-Ray diffraction, differential thermal analysis and electron microscopy-identification by index properties . **Unit-II** Clay-water system – Ion distribution in clay –water systems-diffuse double layer-Gouy Chapman theory-cation exchange. Mechanisms of swelling-osmotic pressure concept-Importance of mineralogical details in swelling-soil suction-measurement in laboratory and field **Unit-III** Swell potential-swelling pressure-factors affecting-direct measurement from laboratory testing-stresses in an in-situ soil mass-factors affecting heave-methods of heave prediction **Unit-IV:** Shear strength of expansive clays-Katti's concept of bilinear stress- state variables-Fredlund's three dimensional approach to shear strength and swelling behaviour of expansive clays **Unit-V** Foundation practices in expansive clays-sand cushion-belled piers-under reamed piles-CNS layer technique. Expansive soil stabilization with lime-lime soil columns and lime slurry pressure injection-stabilization with admixtures. **REFERENCES:** 1. Foundations on expansive soils – F.H. Chen, Elsevier Publishing Co. 2. Search for solutions to problems in black cotton soils – R.K. Katti, Indian Goe.Tech.Journal, Volume 1, 1971 3. Fundamentals of soil behaviour – J.K. Mitchell, John Wiley&Sons
6	Foundation Engineering
	FOUNDATION ENGINEERING **UNIT-I** Soil Exploration – Importance, Terminology, Planning - Geophysical methods. Borings - Location, spacing and depth, Methods

	of Boring including Drilling, Stabilization of Boreholes, Boring records. Soil sampling – Methods of sampling -Types of Samples and Samplers- Cleaning of Bore holes, Preservation, Labeling and Shipment of Samples - Design Considerations of Open Drive Samplers. Field tests - The Standard Penetration Test – its limitations and Corrections – Cone Penetration Test – Field Vane Shear Test – Bore–Hole Shear Test – Dilatometer Test – Pressure Meter test – Preparation of Soil Report. UNIT-II Shallow Foundations – Types and choice of type. Design considerations of including location and depth, Bearing capacity – General bearing capacity equation, Meyerhof's Hnnsen's and Vesic's bearing capacity factors; Bearing capacity of stratified; soils; Bearing capacity based on penetration resistance, safe bearing capacity and allowable bearing pressure. UNIT-III Settlement Analysis – Elastic settlement in granular soils – Meyerhof's De beer and Marten's and schemertmann's equationsl; Elastic settlements of clays; Skempton and Bjerrum's psuedo – Three dimensional approach for consolidation settlement, settlement from in-situ tests. Tolerable settlements. Proportioning of shallow foundations- isolated and combined footings and mats, Design procedure for mats; floating foundation, fundamentals of beam on Elastic foundations. UNIT-IV Pile foundations – Classification methods – Factors influencing their choice – Load carrying Capacity of piles by static pile formulae in clays and granular soils - □□□and □□- methods for piles in clays; Meyerhof's, Vesic's equations and Coyle and Castello correlations for piles in sands; (Elastic settlement of piles)- Pull out resistance of piles – Load carrying capacity using Dynamic pile formula – Pile load tests – cyclic pile load tests. UNIT-IV Laterally loaded vertical piles Modulus of sub – grade reaction – Pile in granular sols and cohesive soils subjected t lateral loading, Matlock & Reese analysis, Davisson & Gill analysis, Broms' Analysis. Under – reamed pile foundations – construction techniques – design specifications – pile carrying capacity in compression and uplift of single and multi – under reamed piles in clays and sands. Negative skin friction in piles – typical field situations – Estimation of downdrag in single piles and pile groups – methods of minimizing downdrag .

	UNIT-V Drilled pier and Caisson Foundations – Types of Drilled piers – load carrying capacity of piers in clays and sands, uplift capacity of piers, caissons – Types – Pneumatic Caisson – Well Foundations – Design of components – Lateral stability of well foundations – Terzaghi's analysis. REFERENCES 1. Earth manual – Oxbord and IBH publishing company 2. Soil Mechanics in Engineeirng Practice by Terzagi and Peck 3. Foundation Design by Wayne C. Teng, John Wiley & co., 4. Foundation Analysis and Desing by F.E. Bowles Mc. Graw Hill publishing Co., 5. Analysis and Design of sub structures b. Swami saran, 6. Principles Foundation Engineering by Braja M. Das. 7. Design Aids in Soil Mechanics and Foundation Engineeirng by Shanbaga, R. Kaniraj 8. Foundation Design and construction by MJ Tmlinson – longman scientific
7	Numerical Methods In Geotechnical Engineering
	NUMERICAL METHODS IN GEOTECHNICAL ENGINEERING **UNIT-I** Introduction: Categories of Problems in Geo-technical Engineering, Finite Difference Method, Boundary Corrections for Grids. Accuracy, Convergence and Stability. Idealization of soil behaviour; Linear, Bilinear and multi-linear, Hyperbolic, Spline function, Ramberg – Osgood's Model, Polynomials, Higher order elastic models, perfect plasticity, frictional. Elastic models of soil behaviour – The winkler – Filenenko-boroditch – Pasternak – Ressiener models. **UNIT-II** **Seepage:** Finite Difference Solution to Laplace equation for Homogeneous and Layered Soils. **Consolidation:** Finite Difference Solution for One Dimensional, Two and three dimensional consolidations. Multi layered systems. Consolidation of Ground for Construction Load and Static Load. **UNIT-II**

	Shallow Foundations: Beams on Elastic foundations, solution by Finite Difference and – Finite Element Method (Direct Approach) Limit analysis, Lower Bound and Upper bound theories Method of Finite difference solution of Raft foundations. **UNIT-III** Pile Foundation: Pile Stresses – Static loading – Finite Element Method Solution (Direct approach) of the pile static pile capacity- wave equation. **Pile Group:** Finite Element Method (Direct Approach) method of Analysis for pile groups. Lateral Piles: Lateral piles by Finite Element Method – Finite Difference method – Soil modulus and Non-linearity – Pile length or partial embedment case – pile head fixity. **UNIT-IV** Sheet pile wall: Solution to sheet pile wall by Finite Element Method and FDM – Cohesion & Cohesion loss soils – Free – Fixed Anchored sheet pile walls. **UNIT-V** Mechanical Vibrations – Finite Difference Solution for Free and Forced, Undamped and damped single and two degree of freedom systems. **REFERENCE:** 1. Numerical methods in Geotechnical Engineering by C.S. Desai and J.T. Christian McGraw Hill publications. 2. Analytical and computer methods in foundation engineering, JE Bowles, McGraw Hill publications. 3. Foundation analysis and design, JE Bowles, McGraw Hill publications 4. Foundation analysis by RF Scott, Printice Hall 5. Hytenyi, Beams on Elastic Foundations – university of Michigan Press. 6. Elastic Analysis of Soil – Foundation Interaction, APS Selvadurai – Elsevier 7. Pile Foundation Analalysis & Design by Poulos and Davis.
8	Earth Retaining Structures

	EARTH RETAINING STRUCTURES **UNIT-I** Earth pressures – Different types and their coefficients- Classical Theories of Earth pressure – Rankine's and Coulomb's Theories for Active and Passive earth pressure- Computation of Lateral Earth Pressure in Homogeneous and Layered soils- Graphical solutions for Coulomb's Theory in active and passive conditions. UNIT-II Retaining walls – different types - Type of Failures of Retaining Walls – Stability requirements – Drainage behind Retaining walls – Provision of Joints – Relief Shells. UNIT-III Braced cuts – Lateral Pressure in Braced cuts – Design of Various Components of a Braced cut – Stability of Braced cuts – Bottom Heave in cuts. Sheet Pile Structures – Types of Sheet piles – Cantilever sheet piles in sands and clays – Anchored sheet piles – Free earth and Fixed earth support methods – Row's moment reduction method – Location of anchors, Forces in anchors. UNIT-IV Soil reinforcement – Reinforced earth - Different components – their functions – Mechanics of reinforced earth – Failure modes-Failure theories – Design of Embakments on problematic soils. UNIT-V Cofferdams – types, suitability, merits and demerits – Design of single – wall cofferdams and their stability aspects – TVA method and Cummins' methods.

	REFERENCES 1. Principles of Foundation Engineering by Braja M. Das. 2. Foundation analysis and design – Bowles, JE – McGraw Hill 3. Soil Mechanics in Engineering Practice – Terzaghi, K and Rolph, B. peck 2nd Edn. – John Wiley & Co., 4. Analysis and Design of Foundations and Retaining Structures, Prakash, S – Saritha Prakashan, Mearut.
	Geotechnical Engineering Paper -II
1	Design With Geosynthetics
	DESIGN WITH GEOSYNTHETICS **UNIT-I** Geosynthetics: Introduction to Geosynthetics – Basic description – History – Manufacturing methods – Uses and Applications. UNIT-II Properties and Testing Methods: Properties and Testing methods of Geotextiles – Geogrids – Geomembranes – Geocomposites. UNIT-III Geotextiles: Designing for Separation – Reinforcement – Stabilization – Filtration – Drainage and Moisture barriers. UNIT-IV Geogrids:Designing for Reinforcement – Stabilization – Designing Gabions – Construction methods – Design of retaining walls.Geomembranes: Survivability Requirements – Pond Liners – Covers for Reservoirs – Canal Liners – Landfill Liners – Caps and closures – Dams and Embankments. UNIT-V Geocomposites:Geocomposites – An added advantage – Geocomposites in Separation – Reinforcement – Filtration – Geocomposites as Geowebs and Geocells – Sheet drains – Strip drains and Moisture barriers. **REFERENCE:** 1. "Designing with Geosynthetics by Robert M. Koerner Prantice Hall, Eaglewood cliffs,

	NJ 07632. 2. "Construction and Geotechnical Engineering using Synthetic Fabries" by Robert M. Koerner and Josoph P. Welsh. John Willey and Sons, New York. 3. "Engineering with Geosynthetics", by G. Venkatappa Rao and GVS Suryanarayana Raju – Tata McGraw Hill Publishing Company Limited – New Delhi. 4. "Foundation Analysis and Design" by J.E. Bowles McGraw Hill Publications.
2	**Geo-Environmental Engineering**
	GEO-ENVIRONMENTAL ENGINEERING **UNIT I** Introduction to Ground water contamination, pollutant transport and ground water remediation. Sources and Types of ground water contamination – introduction – under ground storage tanks, Land fills, surface impoundments, waste disposal injection wells, Septic system, Agricultural wastes, Land application, radioactive contamination, other sources of contamination. **UNIT II** Data Collection methods: Introduction, Geological data acquisition – Drilling methods – Solid flight auger drilling – Hollow stem auger drilling – Wet rotating drilling – Hand auger soil boring – sample collection – Soil core logging – Cone penetration testing – Geophysical methods; Hydrologic data acquisition – monitoring well construction – well material – Screen interval selection – Installation procedure – Survey specification – Protective casing requirements – Well development procedures; Acquisition of soil and Ground water quality data. **UNIT III** Contaminant Transport Mechanisms: Introduction – Advection process – Diffusion – Dispersion process – Diffusion – Mass transport Equations : Derivation of advection dispersion equation for solute transport; One Dimensional Models – Continuous source in one dimension – Instantaneous source in one dimension – Adsorption effects – Transport in one dimensional with first order decay – Sorption: The concept of sorption, Factors influencing sorption – Contaminant characteristics, Soil characteristics, Fluid media characteristics. Sorption Isotherm: Linear sorption Isotherm – Freundlich Sorption isotherm – Langmuir Sorption Isotherm, Sorption effects on fate and transport of pollutants. **UNIT IV**

	Flow and Transport of Pollutants in Unsaturated zone: Capillarity, soil-water characteristic curves, Unsaturated Hydraulic conductivity, Governing equation for unsaturated flow, measurement of soil properties. **UNIT V** Non – Aqueous Phase Liquids (NAPLs): Introduction – Comparison of fate of dissolved mass versus NAPL mass- Types of NAPLs – LNAPL – DNAPL; NAPL Transport – general process – NAPL transport at the pore level - Downward Migration of DNAPLs in saturated zone – NAPL movement through Vadose zone – LNAPL behaviour at the water table – NAPL Transport at the site level – LNAPL conceptual models – DNAPL conceptual models, NAPL transport. **TEXT BOOKS:** 6. Ground water Contamination (Transport and Remediation) By Philip. B. Bedient, Hanadi, 7. S. Rifai & Charles. J. Newell, Prentice Hall PTR, Upper Saddle River, NJ07458. **REFERENCES:** 1. Geoenvironmental Engineering by R. Krishna Reddy - John Wiley & Sons, Inc. 2. Geotechnical Engineering by Gulahati, S.K. and Datta, M. – Tata Mc Graw Hill Publishing Company 3. Geotechnical Engineering Principles and Practices by Coduto – Pearson Education (PHI) 4. Geoenvironmental engineering by Reddy, L.N and Inyang, I.H. – Marcel Drekker, 2000. 5. Environmental geotechniques by Sarsby, R. – Thompson Telford, 2000. 6. Geotechnical Practices for Waste Disposal by Daniel, D.E., 1993.
3	**Finite Element Method**
	FINITE ELEMENT METHOD **Unit I:** Introduction: Review of stiffness method- displacement field - Integral form-differential form - "Rayleigh-Ritz method" of functional approximation - variational approaches -weighted residual methods- concept of FEM. Bar and torsional elements: Degree of freedom –simple element- higher order element-nodal displacement vector- shape functions- FE formulation-discrimination- stiffness matrix of element- element nodal load vector-assembling- total potential in terms of FEM formulation-boundary conditions- strain, stress and force in element-reaction- torsional element. trusses-Iso-parametric element. –natural

	coordinates. **Unit II:** Beam, frame and grid elements: Degree of freedom - displacement vector - simple element- higher order element-nodal displacement vector - shape functions- discrimination- stiffness matrix of element- element nodal load vector-assembling-total potential in terms of FE formulation- boundary conditions- strain, stress and forces in elements-reactions- frame element-Grid element-Beams - frames- Grid structures. Iso-parametric element –natural coordinates. **Unit III:** Membrane element: 2 Dimensional structures- Plane stress-plane strain- triangular elements-CST element-LST element-rectangular elements-Legrangian family of elements-Serendipity family of elements Shape functions – nodal displacement vector-FEM formulation-element stiffness matrix- element nodal load vector due to body forces, traction and concentrated loads- Iso-parametric element- Area coordinates- strain vector and stress vector in element. Axisymmetric solids: Modelling as 2D problem: stress-strain relations- material stiffness matrix-dof - Triangular element- rectangular element-shape functions-Displacement function- FE formulation -stiffness matrix of element- nodal loads- strain vector, stress vector in elements-reactions. Iso-parametric element-Area coordinates. **Unit IV:** 3 Dimensional stress analysis: dof – types of elements- simple elements – higher order elements-displacement function- shape functions- nodal displacement verctor- Nodal load vector- stiffness matrix of element- FE formulation – volume coordionates-isoparametric elements- strain vector and stress vector in element. Plate structures & shell structures: dof- displacement field – nodal displacement vector- shape function- Finite Element Formulation of plate structures- types elements- strain vector and stress vector in element-types of elements. **Unit V:** Introduction to Non-linear Finite Element Methods- types of nonlinear problems-Introduction to dynamic analysis using Finite Element Method - Development of simple programs for simple structures- Introductio of FEM package(only class work)

	REFERENCES: 1. Concepts and applications of Finite Element Analysis – Robert D. Cook, Michael E Plesha, John Wiley & sons Publications 2. A first course in the Finite Element Method – Daryl L. Logan, Thomson Publications. 3. Introduction to Finite Elements in Engineering- Tirupati R. Chandrupatla, Ashok D. Belgunda, PHI publications 4. Fundamentals of Finite Element Analysis- David V. Hutton, Tata McGraw-Hill 5. Finite element Analysis- Theory and programming – C.S. Krishna Murthy, Tata Mc Gra Hill. 6. Finite element Analysis – P.Seshu, PHI 7. Finite element method – O.C. Zeinkiewicz, Tata Mc Gra Hill, 2007
4	Rock Mechanics and Engineering
	ROCK MECHANICS AND ENGINEERING **UNIT-I** **Engineering Classification of Rocks**: Classification of intact rocks, Rock mass classifications, Rock Quality Designation (RQD), Rock Structure Rating (RSR), Rock Mass Rating (RMR), Norwegian Geotechnical Classification (Q-system), Strength and modulus from classifications, Classification based on strength & modulus and strength and fracture strain, Geoengineering classification. **UNIT-II** **Laboratory and In-Situ Testing of Rocks:** Physical properties, Compressive strength, Tensile strength, Direct shear test, Triaxial shear test, Slake durability test, Schmidt rebound hardness test, Sound velocity test, In-Situ Tests: Seismic methods, Electrical resistivity method, In situ stresses, Plate loading test, Goodman jack test, Plate jacking test, In-situ shear test, Field permeability test. **UNIT-III** **Strength, Modulus and Stresses-Strain Responses of Rocks**: Factors influencing rock response, Strength criteria for isotropic intact rocks, Modulus of intact rocks, effect of confining pressure, Uniaxial Compressive strength, Strength criteria for intact rocks, Strength due to induced anisotropy in rocks,. Stress Strain Models: Constitutive relationships, Elastic, Elasto-plastic, Viscoelastic, Elasto-viscoplastic stress-strain models.

	UNIT-IV **Stability of Rock Slopes and Foundations on Rocks:** Rock slopes, Modes of failure, Rotational failure, Plane failure, Design charts, Wedge method of analysis, Buckling failure, Toppling failure, Improvement of slope stability and protection. Foundations on Rock: Introduction, Estimation of bearing capacity, Stress distribution, Sliding stability of dam foundations, strengthening measures, Settlements in rocks, Bearing capacity of pile/pier in rock, Remedial measures, Foundations located on edge of jointed slope. **UNIT-V** **Underground and Open Excavations:** Blasting operational planning, Explosive products, Blast Design, Underground blast design, Controlled blasting techniques, blasting damage and control, Safe practice with explosives and shots. **REFERENCES:** 1. Goodman Introduction to Rock mechanics, Willey International (1980). 2. Ramamurthy, T. - Engineering in Rocks for slopes, foundations and tunnels, Prenice Hall of India. 3. Jaeger, J. C. and Cook, N. G. W. Fundamentals of Rock Mechanics, Chapman and Hall, London. 4. Hoek, E. and Brown, E. T. - Underground Excavation in Rock, Institution of Mining and Metallurgy, 1982. 5. Brady, B. H. G. and Brown, E. T. - Rock Mechanics for Underground Mining, Chapman & Hall, 1993.
5	Soil Dynamics and Machine Foundations
	SOIL DYNAMICS AND MACHINE FOUNDATIONS **Unit-I** **Fundamentals of Vibration**: Definitions, Simple harmonic motion, Response of SDOF systems of Free and Forced vibrations with and without viscous damping, Frequency dependent excitation, Systems under transient loads, Rayleigh's method of fundamental frequency, Logarithmic decrement, Determination of viscous damping, Transmissibility, Systems with Two and Multiple degrees of freedom, Vibration measuring instruments. UNIT- II **Wave Propagation and Dynamic Soil Properties**: Propagation of seismic waves in soil deposits - Attenuation of stress waves, Stress-strain behaviour of cyclically loaded soils, Strength of cyclically loaded soils, Dynamic soil properties - Laboratory and

	field testing techniques, Elastic constants of soils, Correlations for shear modulus and damping ratio in sand, gravels, clays and lightly cemented sand. Liquefaction of soils: An introduction and evaluation using simple methods. UNIT-III **Vibration Analyses**: Types, General Requirements, Permissible amplitude, Allowable soil pressure, Modes of vibration of a rigid foundation block, Methods of analysis, Lumped Mass models, elastic half space method, elasto-dynamics, effect of footing shape on vibratory response, dynamic response of embedded block foundation, Vibration isolation. UNIT-IV **Design of Machine Foundations**: Analysis and design of block foundations for reciprocating engines, Dynamic analysis and design procedure for a hammer foundation, IS code of practice design procedure for foundations of reciprocating and impact type machines. Vibration isolation and absorption techniques. UNIT-V **Machine Foundations on Piles**: Introduction, Analysis of piles under vertical vibrations, Analysis of piles under translation and rocking, Analysis of piles under torsion, Design procedure for a pile supported machine foundation. **REFERENCES:** 8. I.Chowdhary and S P Dasgupta - Dynamics of Structures and Foundation, 2009. 9. Arya, S. D, O'Neil, M. and Pincus, G.- Design of Structures and Foundations for Vibrating Machines, Gulf Publishing Co., 1979. 10. Prakash, S. and Puri, V. K. - Foundation for Machines: Analysis and Design, John Wiley & Sons, 1998. 11. Prakash, S. - Soil Dynamics, McGraw Hill, 1981. 12. Kameswara Rao, N. S. V. - Vibration Analysis and Foundation Dynamics, Wheeler Publication Ltd., 1998. 13. Richart, F. E. Hall J. R and Woods R. D. - Vibrations of Soils and Foundations, Prentice Hall Inc., 1970. 14. Swami Saran - Soil Dynamics and Machine Foundation, Galgotia Publishing, 1999. 15. Das, B. M. - Principles of Soil Dynamics, PWS KENT publishing Company, Boston.
6	**Soil-Structure Interaction**
	SOIL- STRUCTURE INTERACTION

	UNIT-I **Soil-Foundation Interaction**: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic-plastic behaviour, Time dependent behaviour. Idealized Soil Response Models for the Analysis of Soil – Foundation Interaction – Elastic Models for Soil Behaviour, Cointler model, Elastic Continuous Model, Two – Parametric Elastic Models – Elastic – Plastic and Time Dependent Behaviour of Soil Masses. UNIT-II **Beam on Elastic Foundation**- Soil Models: Infinite beam, Two-parameters models, Isotropic elastic half-space model, Analysis of beams of finite length, combined footings. Finite Beams on a Winkler Medium – Method of Initial Parameters – Method of Super Position – Strain Energy Method. **Plates on Elastic Continuum**: Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates. Analysis of finite plates – Axi Symmetric Leading of a Circular Plate – Circular Plate Resting on a Winkler Medium – Circular Plate Resting on a Two – parameter elastic. UNIT- III **Analysis of Axially and Laterally Loaded Piles and Pile Groups**: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap, Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system. **UNIT**-IV **Reinforcement – Backfill Interaction** in Reinforced Soil Structures **UNIT-V** **Ground-Foundation-Structure Interaction**: Effect of structure on ground-foundation interaction, Static and dynamic loads. **REFERENCES:**

	1. Selvadurai, A. P. S. - Elastic Analysis of Soil-Foundation Interaction 2. Poulos, H. G., and Davis, E. H. - Pile Foundation Analysis and Design 3. Scott, R. F. - Foundation Analysis 4. Bowles, J. E. - Foundation Design & Analyses 5. Das, B. M. - Advanced Foundation Engineering. 6. Soil mechanics by TW Lambe & Whitmen. 7. Analytical and computer methods in foundation engineering, JE Bowles, McGraw Hill publications. 8. Foundation analysis and design, JE Bowles, McGraw Hill Publications. 9. Foundation analysis by RF Scott, Printice Hall 10. Hytenyi, Beams on Elastic Foundations – university of Michigan Press. 11. Elastic Analysis of soil – Foundation Interaction. APS Selvadurai – Elsevier 12. Vibration Analysis and Foundation Dynamics, NSV Kameswara Rao, Wheeler Publishing, New Delhi.
7	Critical State Soil Mechanics
	CRITICAL STATE SOIL MECHANICS **Unit-I** Test paths in consolidation and shear testing. Stress and strain – Stress and Strain Paths and Invariants – Critical State line – families of Underained and Drained tests – Undrained and Drained planes – The Roscoe surface – Rosco surface as a state boundary surface. **Unit-II** Behaviour of Over Consolidated Samples – Hvorslev Surface – Critical State Line – Complete State Boundary surface – Volume Changes and Pore Pressure changes – Behaviour of Sands – Effect of Dilation. **Unit-III** Soil behaviour Before failure – Plasticity of Soils – Cam clay - Power in Cam – Clay – Critical States and Yielding of Cam –

	clay, Compression of Cam – Clay. **Unit-IV** Routine Soil Tests and the Critical State Model – Mohr – Coulomb Failure Criterion – One – dimensional compression – Undrained Shear Strength – General states of stress – Pore pressure Parameters – Interpretation of Index Test Data. **Unit-V** Soil Parameters for Design – Choice of Analysis – Methods – Choice of Strength Parameters. REFERENCES: 1. Atkinson, J. H., The Mechanics of Soils: An Introduction to Critical State Soil Mechanics, McGraw-Hill, 1978. 2. Ortigao, J. A. R., Soil Mechanics in the Light of critical State Theories, Taylor & Francis, 1995. 3. Roger Meier Andrew Abbo and Linbing Wang, Soil Behavior and Geo Micromechanics, ASCE Special Pub., 2010. 4. Schofield, P. and Wroth, P., Critical State Soil Mechanics, McGraw Hill, London. 1968. 5. The Mechanics of Soils by J.H. Atkinson and P.L. Bransby & ELBS McGraw – Hill Book Co., 6. Critical State Soil Mechanics – A. Sehofield and P. Wroth McGraw Hill Book Co. Guide to soil Mechanics – Bolton seed, Mac millan Press Ltd., London. 7. The Mechanics of Soils by J.H. Atkinson and P.L. Bransby & ELBS McGraw – Hill Book Co., 8. Critical State Soil Mechanics – A. Sehofield and P. Wroth McGraw Hill Book Co. 9. Guide to soil Mechanics – Bolton seed, Mac millan Press Ltd., London.
8	**Geotechnical Earthquake Engineering**
	GEOTECHNICAL EARTH QUAKE ENGINEERING **UNIT-I** **Earthquake Seismology:** Seismic waves - Causes of earth quake - Continual drift and Plate tectonics – Earthquake fault sources – Faults, fault geometry, fault movement - Elastic Rebound Theory – Location of Earth Quakes - Quantification of

	Earthquakes – Intensity and magnitude – Earthquake Energy. UNIT-II **Earthquake ground motion:** Seismograph - Characteristics of Ground motion: - Ground motion parameters – Amplitude Parameters – peak acceleration, peak velocity, peak displacement other amplitude parameters – Frequency content parameters – ground response spectra, Fourier spectra, Power spectra, response spectra – spectral parameters – duration. Local site Specification and Code based design. UNIT-III **Dynamic Soil Properties:** Representation of Stress conditions by the Mohr Circle – Measurement of Dynamic properties – field, laboratory, interpretation of observed ground response. **Ground Response Analysis:** One dimensional response analysis - linear approach, Equivalent linear approach. **Liquefaction and Lateral Spreading** – Liquefaction Related phenomena – Liquefaction susceptibility – Initiation of Liquefaction – Effect Liquefaction. UNIT-IV **Seismic Design of Foundation:** Seismic Design requirements for Foundation – Seismic Bearing capacity - Seismic Settlement. UNIT-V **Seismic Slope Stability Analysis:** Internal stability and weakened instability - Seismic design of retaining walls: Dynamic Response of Retaining walls - Seismic Displacement of Retaining walls -Seismic Design Considerations. **REFERENCE:** 1. *"Geotechnical Earth Quake Engineering"* by SL Kramer, Pearson Education. 2. *"Earth Quake"* W.H. Freeman, New York.
9	**Theory of Elasticity**
	THEORY OF ELASTICITY AND PLASTICITY 6. **Introduction:** Elasticity – Notation for Forces and Stresses – Components of Stresses – Components of Strain – Hooke's

	Law. Plane Stress and Plane Strain analysis – Plane Stress – Plane strain – Differential Equations of equilibrium – Boundary conditions – Compatibility equations - Stress function – Boundary Conditions. 7. **Two Dimensional Problems:** in Rectangular Co-Ordinates – Solution by polynomials – Saint – Venant's Principle – Determination of Displacements – Bending of Simple beams – Application of Fourier Series for two dimensional problems for gravity Loading. Two Dimensional problems in Polar Co-ordinates General Equations in polar Co-ordinates – Stress Distribution Symmetrical about an axis – Pure bending of curved bars - Strain Components in Polar Co-ordinates – Displacements for Symmetrical stress Distributions – Circular discs- Stresses on plates with circular holes 8. **Three Dimensional Problems:** Analysis of Stress and Strain in Three Dimension Principal Stress – Stress Ellipsoid and stress director surface – Determination of Principal stresses Maximum shear stresses – Homogeneous Deformation – Principle Axes of Strain. 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 –Reciprocal theorem. 9. **Torsion of Prismatic Bars:** Torsion of Prismatic Bars – Bars with Elliptical Cross Section – Other elementary Solution – Membrane Analogy – Torsion of Rectangular Bars – Solution of Torsional Problems by Energy method – use of soap Films in Solving Torsional problems – Hydro dynamical Analogies – Torsion of Bars. 10. **Theory of Plasticity:** Introduction – Concepts and Assumptions – Yield criteria. **References:** 1.Theory of Elasticity- Timoshenko & Goodier

	2.Theory of Elasticity – Sadhu Singh
	Pre-PhD Courses for Water Resources Engineering (Civil Engg)
S.No.	**Water Resources Engineering Paper -I**
1	**Computational And Statistical Methods**
	COMPUTATIONAL AND STATISTICAL METHODS **Unit I** Numerical Solution of Ordinary: Differential Equations – Solution by Taylor's Series – Euler's Method- Runge Kutta Methods – Simultaneous and Higher Order Equations – Boundary Value Problems – Applications. **Unit II** Partial differential equations: Variable Separable Method – Wave, Heat and Laplace Equation (Two dimensions only) **Unit III** Regression Analysis – Simple Linear Regression, Evaluation of Regression – Confidence Intervals and Tests of Hypotheses – Multiple Linear Regression – Correlation and Regression Analysis. **Unit IV** Finite Difference Method : Construction of finite difference approximations – Taylor series, Forward, Backward and central difference approximations, Finite difference approximations of boundary value and initial value problems, One dimensional and two dimensional problems, Explicit, Implicit, and Crank – Nicolson Schemes, Convergence and stability, Alternating Direction Implicit (ADI) method for two space dimensions, simple examples. **Unit V** Finite Element Method: General Principles, types of elements, interpolation functions, Development of basis functions for one-dimensional and two dimensional elements, Linear interpolation, local co-ordinate system, variational formulation, Galerkin

	formulation, development of element matrices. Posting into Global locations, treatment of initial and boundary conditions, solution of Linear algebraic equations, simple examples. TEXT BOOKS: 1. Advanced Engineering Mathematics by B.S. Grewal. 2. Engineering Mathematics by Jaggi & Mathur 3. Calculus by Shantinarayan 4. GLEN. E. MYERS – Analytical Methods in Conduction Heat Transfer McGraw Hill, New York (1977) 5. REMSON. I. G.M. HORNBERGER AND F.J. MOLIZ – Numerical Methods inSubsurface Hydrology. 6. PINDER G.F. and GRAY – Finite Element Simulation in Sub Surface Hydrology, Academic Press, New York (1971).
2	**Ground Water Exploration And Watershed Management**
	GROUND WATER EXPLORATION AND WATERSHED MANAGEMENT **UNIT I** Ground Water Exploration,: Internal Constitution of the earth. Basic concepts of geologic structures governing occurrence and movement of Ground water, Ground Water in igneous, metamorphic and sedimentary rocks, Hydrogeological methods of exploration. **UNIT II** Geophysical methods: Electrical methods, Expression for apparent resistivity in four electrode arrangements viz. – Wonner, Schlumberger, arrays. Field surveys interpretation techniques in sounding and profiling for ground water investigation. Seismic Refraction method – Principle and propagation of refracted energy in two and three media earth, Field procedure and interpretation techniques. Magnetic and Electromagnetic methods, principle and field practices VLF technique and its interpretation. **UNIT III**

Water Well Technology: Wells and their constructions, open wells and cavity wells, types and construction of Tube wells in alluvial soils and in hard rock areas. Methods of drilling tube wells: Hydraulic rotary method and reverse rotary method, DTH method. Well logging Techniques: Electrical – Long normal short normal SP and radioactive loggings. Completion of wells and development of wells: Various methods, design of strainer tube wells, pumping arrangements.

UNIT IV

Watershed Management I : Objectives of Planning watershed projects guidelines for project preparation, watershed delineation, codification and determination of priority, critical areas. Site selection, bench marks, resources survey, hydrological, soil, vegetative and land use surveys, socio-economic surveys and soil conservation works.

UNIT V

Watershed Management II :Peoples participation and constraints, Participatory Rural Appraisal in Watershed Programme, Community Mobilization & Participatory Management, Peoples Institutions, Capacity Building.

TEXT BOOKS:

1. Ground Water Hydrology by Raghunath
2. Principles and Applications of Ground Water geophysics by Murali, Sabnavis and N.S. Patangay.
3. Applied Geophysics by Telford, Geldard, Keys.
4. Hydrology and water resources Engineering by S.K. Garg.
5. Formation Evaluation by E.L. Lynch.
6. A Text book of geology by P.K. Mukerjee
7. Hydrogeology by Davis and Dewiest
8. Hydrogeology by K. R. Karanth
9. Integrated Watershed Management by Rajesh Rajora – Rawat Publications
10. Soil and Water Conservation by Seshagiri Rao – BS Publications Watershed

	Management in India by JVS Murthy- Wiley Eastern, Limited Publishers. 11. FAO Watershed Management Field Manuals, FAO Conservation Guide, UNO 12. Soil and Water Conservation Research in India by V.V.Dhruva Narayana published by ICAR, New Delhi.
3	**Hydraulic Structures**
	HYDRAULIC STRUCTURES **Unit I** Classification of dams, Selection of type of dam, Site investigations. Gravity dams – Forces acting, Causes of failures and design criteria – elementary profile and practical profile of a gravity dam, limiting height of a dam,Single and multiple step design. Method of zoning stability analysis. **Unit II** Earth & Rockfill dams : Types and general Principles of design, Methods of control of seepage through embankment and through foundation, Stability of earth dam slopes under different conditions – slip circle analysis. Horizontal shear, sudden drawdown condition, factors of safety. Rockfill dams – Types & Suitabilities. **Unit III** Arch and Buttress dams : Classification of arch dams, Cylinder theories, Principles of elastic theory and Elementary Principles of trial load analysis. Buttress dams – Types and relative merits of dams. Buttress Spacing, unit column design. **Unit IV** Spillways: Types, design principles of Ogee spillways, types of spillway crest gates. Energy dissipation below spillways-stilling basin and its aappurtenances. **Unit V** Cross Drainage works: Types, selection, design principles of aqueduct, siphon aqueduct and super passage. **TEXT BOOKS** 1. Irrigation and Water Power Engineering by B.C.Punmia and Lal

	2. Irrigation & Hydraulic Structures by S.K.Garg 3. Engineering of Dams by Creager, Justin and Hinds
4	**Irrigation Management**
	IRRIGATION MANAGEMENT **Unit I** Irrigation Development in India – Planning of Irrigation Projects, Command Area Development Programmes **Unit II** Physical and Chemical Properties of Soil, Soil Profile, Soil Aeration, Classification of Irrigable Soils, Soil Survey, Soil Management. **Unit III** Soil-Plant – Water Relationships, Capillary and Non Capillary Pores, Water Relation of Soils, Infiltration, Hydraulic Conductivity, Water Movement through Soils, Soil Water Potential, Soil Moisture Constant, Plant Water Relations, Rooting Characteristics, Evaporation and Evapotranspiration Measurements, Different Methods of Estimating Evapotranspiration, , Water Requirements of Crops, Irrigation Scheduling. **Unit IV** Irrigation water application methods: Basin, border, check, furrow, and sub irrigation methods, and their relative merits. Sprinkler and drip Irrigation systems, basic components and design. **Unit V** Land Grading and Field Layout, Cropping Patterns, Fertilizers, On-farm Developments, Diagnostic Analysis of Irrigation System, Water Application Methods, Rotational Water Distribution, Micro Irrigation, Water Logging and Salt Problems, Reclamation and Management of Salt Affected Soils, Drainage, Participatory Irrigation Management. TEXT BOOKS: 1. Murthy, V.V.N. (1999) , "Land and Water Management Engineering", Kalyani Publishers, Ludiana.

2. Scwabe G.O., Fangmeir, D.D. and Elliot W.J. (1996), "Soil and Water Management Systems", John Wiley and Sons, N. York.
3. Michael , B.A.M. (1990), "Irrigation", Vikas publishing House Pvt. Ltd. N Delhi.
4. Withers and Vipond, S. (1980), "Irrigation – Theory and Practice", Cornell University Press
5. Hutchinson (1973), "Irrigation, Drainage and Salinity", FAO/UNESCO Publications, Rome
6. Asawa,G.L(1996), "Irrigation Engineering", New Age International Pub. Co.N Delhi.
7. Hansen, V.E., Israelson O.S. and Stringham G.C. (1979) "Irrigation Principles and Practice", John Wiley and Sons, N York
8. Suresh R.L., (1999), "Soil and Water Conservation Engineering", Standard Publishing Co. Delhi.

5 **Stochastic Hydrology**

STOCHASTIC HYDROLOGY

UNIT I

Classification and Presentation of Data - Basic Concepts of Probability, Probability Axioms, Analysis and Treatment of Data, Population and Samples, Measures of Central Tendency, Measures of Dispersion, Measures of Symmetry, Measures of Peakedness.

UNIT II

Probability Distributions: Parameter Estimation, Methods of Moments, Methods of Maximum Likelihood, Weighted Moments and Least Square Method, Conditional Probability, Marginal Probability, Joint Probability Distributions.

UNIT III

Hydrologic Time Series Analysis - Independent and Auto-Correlated Data, Structure of Hydrologic Time Series, Trend, Jump and Seasonality, Stationarity and Ergodicity, Auto-Covariance and Auto-Correlation Function, Correlogaram Analysis, Spectral Analysis, Analysis of Multi-Variant Hydrologic Series.

	UNIT IV Modelling of Hydrologic Time Series I - Data Generation Techniques, Linear Stochastic Models, Auto-Regressive, Moving Average, ARMA Models, **UNIT V** Modelling of Hydrologic Time Series II- Modelling of Non-Stationary and Seasonal Series, Thomas-Fiering Model, ARIMA Models, Periodic Models, Multi-Site Modelling. TEXT BOOKS: 1. Haan C.T, Statistical Methods in Hydrology, EastWest Press, New Delhi. 2. McCueen R.H. and Snyder, W.M., Hydrological Modelling - Statistical Methods and Applications, Prentice Hall International, New York 3. Kottegoda, Stochastic Processes in Hydrology, Prentice Hall International, New Jersey. 4. Stochastic Hydrology by P. Jayarami Reddy 5. Stochastic Processes in Hydrology by Yevifievich
6	**Urban Drainage And Waste Water Treatment**
	URBAN DRAINAGE AND WASTE WATER TREATMENT **UNIT I** Urban Hydrological Cycle, Effects of Urbanization on Catchment Hydrology, Need for Urban Drainage System, Planning Objectives, Interaction of Urban and Surrounding Areas. Approaches to Urban Drainage, Urban Wastes and Urban Runoff Options for Waste Disposal, Separate and Combined System's, Open Channels and Closed Conduits, Wastewater and Storm water Reuse, Data Requirements, Master Drainage Plans.

UNIT II

Elements of Drainage System, Conveyance Elements, Appurtenances, Overflow Structures, Runoff Control, Pumping Stations. Design Parameters, Design Period, Catchment, Physical Parameters, Process Parameters, Rainfall, water Quality Parameters, Instrumentation for Data Collection. Hydraulic Design of Conveyance Elements, Sizing of Sewers and Drainage Channels, Design of Appurtenances, Layout of Road Drainage, Layout of Pumping Stations.

UNIT III

Operation and Maintenance of Urban Drainage Systems, Interaction of Urban Drainage and Solid Waste Management, Cleansing of Sewers and Drains, Repairs and Maintenance, Planning.

UNIT IV

Wastewater Treatment Technologies: Sedimentation, sedimentation with Coagulation, Filtration, Activated Sludge Process, trickling Filters. Tertiary Treatment Systems: Nitrogen removal, Phosphorous removal, biological phosphorus removal, advanced biological systems, aerobic ponds, facultative ponds, aerated ponds, anaerobic ponds, chemical oxidation.

UNIT V

Wetlands: Introduction, definition, classification, delineation, Identification methods, Importance of wetlands, Human impacts, wetland protection, mitigation. Wetland Management: Designed ecosystem, water recycling, soil filters, Constructed wetlands

TEXT BOOKS:

1. Industrial Wastewater Treatment, M.N. Rao, A.K. Dutta Oxford and IBH Publishing House, 1987.
2. Waste Water Treatment and Disposal by Metcalf Eddy & Co., Mc. Graw Hill Co., 1993
3. Water and wastewater Treatment by Hammer and Hammer: Prentice-Hall 1998
4. Hall, M.J. (1984), "Urban Hydrology ", Elsevier Applied Science Publishers.
5. Geiger, W.F., Marsalek, J. Zudima and Rawls, G. J. (1987 "Manual on Drainage in Urban Areas", 2 Volumes, UNESCO, Paris.
6. Geiger, W.F. and Jayakumar, K.V. (Ed.) (1996) "Lecture Notes of the V International Course on Urban Drainage in Developing Countries", Regional Engineering College, Warangal.

7	Water Resources Systems Planning And Management

WATER RESOURCES SYSTEMS PLANNING AND MANAGEMENT

Unit I

Introduction : General Principles of Systems Analysis to Problems in Water Resources Engineering, Objectives of Water Resources Planning and Development, Nature of Water Resources Systems, Socio-Economic Characteristics.

Economic Analysis of Water Resources Systems: Principles of Engineering Economy, Capital, Interest and Interest Rates, Time Value of Money, Depreciation, Benefit Cost Evaluation, Discounting Techniques, Economic and Financial Evaluation, Socio-Economic Analysis.

Unit II

Methods of Systems Analysis: Linear Programming Models, Simplex Method, Sensitivity Analysis, Dual Programming, Dynamic Programming Models, Classical Optimization Techniques, Non-Linear Programming, Gradient Techniques, Genetic Algorithm, Stochastic Programming, Simulation, Search Techniques, Multi Objective Optimization.

Unit III

Water Quantity Management: Surface Water Storage Requirements, Storage Capacity and Yield, Reservoir Design, Water Allocations for Water Supply, Irrigation, Hydropower and Flood Control, Reservoir Operations, Planning of an Irrigation System, Irrigation Scheduling, Groundwater Management, Conjunctive Use of Surface and Subsurface Water Resources, Design of Water Conveyance and Distribution Systems.

Unit IV

Water Quality Management: Water Quality Objectives and Standards, Water Quality control Models, Flow Augmentation, Wastewater Transport Systems, River Water Quality Models and Lake Quality Models.

Unit V

Legal Aspects of Water & Environment Systems: Principles of Law Applied to Water Rights and Water Allocation, Water Laws, Environmental Protection Law, Environmental Constraints on Water Resources Development.

	TEXT BOOKS: 1. Loucks, D.P., Stedinger, J.R. and Haith, D.A.(1982) "Water Resources Systems Planning and Analysis", Prentice Hall Inc. N York 2. Chaturvedi, M.C. (1987), "Water Resources Systems Planning and Manag;ement", Tata McGraw Hill Pub. Co., N Delhi 3. Hall. W.A. and Dracup, J.A. (1975), "Water Resources Systems", Tata Mc Graw Hill Pub. N Delhi 4. James, L.D. and Lee (1975) , "Economics of Water Resources Planning", M c Graw Hill Inc. N. York 5. Biswas, A.K. (1976) "Systems Approach to Water Mana;gement", Mc Graw Hill Inc. N York 6. Major, D.C. and Lenton, R.L., (1979), "Applied Water Resources System Planning", Prentice-Hall Inc., N. Jersey 7. Taha H A (1996), "Operations Research ", Prentice Hall of India, N Delhi.
	Water Resources Engineering Paper -II
1	Channel And River Hydraulics
	CHANNEL AND RIVER HYDRAULICS **Unit I** Basic Concepts of Free Surface Flow: Flow Regimes, Velocity and Pressure Distribution, Energy Principles and its applications, Specific Energy, Critical Flow Computations, Momentum Equation and its Applications, Specific force Diagram, theoretical Concepts of Surface Roughness, Velocity Equation, Uniform Flow Computation. **Unit II** Steady Gradually Varied Flow: Dynamic Equation, Characteristics of Flow Profile and Methods of Computation, Practical Problems, Gradually Varied Flow Analysis and Computation. **Unit III** Steady Rapidly Varied Flow: Hydraulic Jump Analysis and Location, Jump in Sloping Channels and Oblique Jump. Unsteady Rapidly Varied Flow: Dam Break Problem, Moving Hydraulic Jump, Positive and Negative Surges. **Unit IV** Hydraulic similitude: Dimensions and dimensional homogeneity, Buckingham's pi-terms evaluation. Froude's, Reynolds,

	Mach's and Weber's laws of similitude, simple applications to hydraulic models, Distorted models, Scale effect. **Unit V** Fluvial Hydraulics: Basic Characteristics of River Beds and Sediments, initiation of Motion, Regimes of Flow, Resistance to Flow in Alluvial Streams, Theories of Bed Load, Suspended Load and Total Load. Design of stable Channels: Regime and Tractive force Methods. **TEXT BOOKS:** 1. Chow, . V.T. (1979) "Open Channel Hydraulics", Mc Graw Hill Inc. N York. 2. Henderson. (1966): "Open Channel Flow", Mc Millan Pub. London. 3. Subramanya, K (1996) "Flow in Open Channels", Tata Mc Graw Hill Pub., 1995. 4. Garde and Ranga Raju, K.G. (1980): "Mechanics of Sediment Transportation and Alluvial Stream Problems", Wiley Eastern, N Delhi 5. Chaudhry M.H. (1994), "Open –Channel Flow", Prentice Hall of India, N Delhi 6. French, R.H.(1986), "Open Channel Hydraulics", Mc Graw Hill Pub Co., N York.
2	**Engineering Hydrology**
	ENGINEERING HYDROLOGY **Unit I** World's Water Resources: Hydrology and its scope, hydrologic cycle Precipitation Rainguage net work. Checks of rainfall data. Double mass curve. Depth intensity duration relationships. Infiltration: Factors affecting, Measurement of infiltration, Infiltration curve and infiltration indices. **Unit II** Runoff: The stream flow hydrograph, Hydrograph separation, Unit hydrograph and Synthetic unit hydrographs, S-Curve hydrograph, IUH models – Nash. Computation of reservoir capacity: Hydrology of Droughts: Definition : types of droughts, Effects of drought, Combating drought, reducing runoff losses, reducing evaporation and deep percolation, Efficient use of stored soil water.

	Unit III Hydrology of floods: Causes of floods, flood discharge formulae and envelope curves, Flood frequency analysis. **Unit IV** Probability distributions as applied to Hydrology: Discrete and Continuous Probability Distribution Functions – Binomial, Poisson, Normal, Lognormal , Exponential, gamma Distributions, Extreme Value Distributions, Gumbel and Log-pearson Type III distribution. **Unit V** Flood control: Flood control dams, detention basins, levees, diversion channels, flood channel improvement schemes. Flood routing: routing through a reservoir by I.S.D. method, channel routing by Muskingum method.. TEXT BOOKS: 1. A Text Book of Hydrology by P. Jayarami Reddy 2. H.M. Raghunath, Hydrology Wiley Eastern Ltd., 1986. 3. Engineering Hydrology by Subrahmanyam 4. Stochastic Hydrology by P. Jayarami Reddy.
3	**Geo-Environmental Engineering**
	GEO-ENVIRONMENTAL ENGINEERING **UNIT I** Introduction to Ground water contamination, pollutant transport and ground water remediation. Sources and Types of ground water contamination – introduction – under ground storage tanks, Land fills, surface impoundment's, waste disposal injection wells, Septic system, Agricultural wastes, and application, radioactive contamination, other sources of contamination. **UNIT II** Data Collection methods: Introduction, Geological data acquisition – Drilling methods – Solid flight auger drilling – Hollow stem auger drilling – Wet rotating drilling – Hand auger soil boring – sample collection – Soil core logging – Cone penetration testing – Geophysical methods; Hydrologic data acquisition – monitoring well construction – well material – Screen interval selection – Installation procedure – Survey specification – Protective casing requirements – Well development procedures;

	Acquisition loft soil and Ground water quality data. **UNIT III** Contaminant Transport Mechanisms: Introduction – Advection process – Diffusion – Dispersion process – Diffusion – Mass transport Equations : Derivation of advection dispersion equation for solute transport; One Dimensional Models – Continuous source in one dimension – Instantaneous source in one dimension – Adsorption effects – Transport in one dimensional with first order decay – Sorption: The concept of sorption, Factors influencing sorption – Contaminant characteristics, Soil characteristics, Fluid media characteristics. Sorption Isothers: Linear sorption Isotherm – Freundlich Sorption isotherm – Langmuir Sorption Isotherm Sorption effects on fate and transport of pollutants. **UNIT IV** Flow and Transport of Pollutants in Unsaturated zone: Capillarity, soil-water characteristic curves, Unsaturated Hydraulic conductivity, Governing equation for unsaturated flow, measurement of soil properties. **UNIT V** Non – Aqueous Phase Liquids (NAPLs): Introduction – Comparison of fate of dissolved mass versus NAPL mass- Types of NAPLs – LNAPL – DNAPL; NAPL Transport – general process – NAPL transport at the pore level p- Downward Migration of DNAPLs – in saturated zone – NAPL movement through Vadose zone – LNAPL behaviour at the water table – NAPL Transport at the site level – LNAPL conceptual models – DNAPL conceptual models. NAPL transport. **TEXT BOOKS:** Ground water Contamination (Transport and Remediation) By Philip. B.Bedient, Hanadi, S. Rifai & Charles. J.Newell, Prentice Hall Publishers.
4	**Ground Water Management & Modeling**
	GROUND WATER MANAGEMENT & MODELLING **Unit I** Fundamental concepts: Types of aquifers, Vertical distribution of soil water below the ground, Porosity specific yield, hydraulic conductivity and storage coefficient, their practical significance, Darcy's law and its validity. Derivation of basic differential equation and its solutions, Ground Water flow contour and their applications. Tracer techniques in ground water flow studies.

	Unit II Ground Water resources evaluation: Steady and unsteady radial flow of ground water towards a well in confined and unconfined aquifers, Analysis of pumping test data – Theis type curve method, Jacob's method for Time and Distance draw down tests, Theis recovery method – Estimation of well losses, Yield of open wells – methods of evaluation. Image wells. Geohydrologic boundaries **Unit III** Ground water Management: Water Balance Studies, Perennial Yield, Necessity of artificial recharge techniques. Conjunctive use of surface and ground water. Management of coastal aquifers – Ghyben Herzberg relation ,upcoming of Saline Water Methods of control of salt water intrusion. **Unit IV** Ground water Quality, Ground Water pollution, elements and source of pollution their effects and remedial measures. **Unit V** Aquifer Modelling – Electrical analog models – RC Network techniques. Principles of digital Modelling of aquifers, Numerical Modelling – Flow Modelling Using Finite Difference Methods and Finite Element Methods. Advection Process – Diffusion and Dispersion Process – Solute Transport Modelling. **TEXT BOOKS:** 1. Ground Water Hydrology by D.K. Todd. 2. Ground Water Hydrology by Raghunath. 3. Geohydrology by Davis and Dewiest 4. Geohydrology by K. R. Karanth 5. Development Evaluation and Monitoring of Ground Water by K.R.Karanth. 6. Domenice(1972) "Concepts and Models in Groundwater Hydrology" McGraw Hill Inc. N.York
5	Hydropower Development
	HYDROPOWER DEVELOPMENT **Unit I**

	Classification of Hydropower schemes, Load Studies and factors, Flow duration curve, Firm and secondary power pondage and storage. **Unit II** Low and high head intakes, forebay, trash rack, gates and their operation, air vent, Design of Penstocks, Pen stock anchorages. **Unit III** Water hammer analysis: Basic equations, solution for linearized equations, arithmetic method and graphical method. **Unit IV** Surge tanks: Different types, their working, Computation of Surges in simple surge tank, surge tank stability. **Unit V** Power Houses: General arrangement of overgrown lower houses component parts and their functions, Criteria for fixing power house dimensions, Selection of type and capa city of turbine . Underground power houses: types of layout their suitability and merits. TEXT BOOKS: 1. Hydropower structure by Varshney. 2. Water Power Engineering by Dandekar and Sharma. 3. Fluid Transients by V.L. Streeter.
6	**Neuro-Fuzzy Techniques And Computer Programming**
	NEURO-FUZZY TECHNIQUES AND COMPUTER PROGRAMMING **Unit I** Introduction: Basic concepts of Neural Networks and Fuzzy Logic, Differences between conventional computing and Neuro-Fuzzy computing, Characteristics of Neuro-Fuzzy computing. Fuzzy Set Theory: Basic definitions and terminology and membership functions – formulation and parameters, basic operations of fuzzy sets – complement, intersection, vision, T-norm

	and T-conorm **Unit II** Fuzzy Reasoning and Fuzzy Inference: Fuzzy relations, Fuzzy rules, Fuzzy reasoning, Fuzzy Inference Systems, Fuzzy modelling, Applications of Fuzzy reasoning and modelling in Water Resources Engineering Problems. **Unit III** Fundamental concepts of Artificial Neural Networks: Model of a neuron, activation functions, neural processing, Network architectures, learning methods. Neural Network Models: Feed forward Neural Networks, Back propagation algorithm, Applications of Feed forward networks, Recurrent networks, Hopfield networks, Hebbian learning, Self organising networks, Unsupervised learning, competitive learning. Neuro-Fuzzy Techniques: Hydrologic Modelling Time Series Analysis and Modelling, Remote Sensing , Environmental Modelling and Water Management, **Unit IV** Introduction to C and important Concepts. Beginning with C ++ : What is C ++., Applications of C ++, A S imple C ++ programme, More C ++ Statement, An Example with Class, Structure of C++ Program, Creating the Source File, Compiling and Linking. **Unit V** Tokens, Expressions and Control Structures in C ++ : Introduction, Tokens, Keywords, Identifiers, Basic Data Types, User-Defined Data Types, Symbolic Constants. Type Compatibility, Declaration of Variables, Dynamic Initialization of Variables, Reference Variables, Operators in C++ , Scope Resolution Operator, Member Dereferencing Operators, Memory Management Operators, Manipulators, Type Cast Operator, Expressions and Implicit Conversions, Operator Overloading, Operator Precedence, Control Structures **TEXT BOOKS:**

6. Jang, JSR, C.T. Sun and E. Mizutan (1997), "Neuro-Fuzzy and Soft Computing", Prentice Hall, NJ
7. Simon Haykin, (1994), "Neural Networks, A Comprehensive Foundation", Mc Millan College Publishing Company
8. Kosko, B. (1997), "Neural Networks and Fuzzy Systems", Prentice Hall of India Pvt. Ltd. , New Delhi.
9. Klir, George J., T.A. Forger, (1995), "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India, Pvt. Ltd., New Delhi.
10. Rao V and H. Rao , (1996), "C++ Neural Networks and Fuzzy Logic, BPB Publications, New Delhi.

7 **Principles and Applications of Remote Sensing And GIS**

PRINCIPLES AND APPLICATIONS OF REMOTE SENSING AND GIS

UNIT I

Introduction to aerial Photogrammetry: Principles of Optics, Types of Aerial Photographs, Stereoscopy, Photoscale, Map vs Mosaic, Mosaic-Kinds of Mosaic, Construction of Mosaic, Ground Control, Parallax measurements for height determinations.

Remote Sensing: Basic Concepts and foundation of remote sensing, Elements involved in Remote Sensing, Electromagnetic spectrum, Remote Sensing terminology, Energy Sources, Energy interactions with Earth Surface features and atmosphere, Resolution, Sensors and Satellites, Visual Interpretation techniques-Basic elements. Interpretation for Terrain Evaluation, Spectral properties of water bodies, Introduction to digital data analysis.

Unit II

Geographic Information Systems: Introduction, GIS definition and Terminology, GIS categories, Components of GIS, Fundamental Operations of GIS, A theoretical Framework for GIS, GIS types of data representation, Raster Data Structures, Vector Data Structures, Comparisons between Data Structures.

Unit III

Data Acquisition and Data Input: Introduction, existing data sets, developing own data, digitization and scanning. Preprocessing: Format conversion, data reduction and generalization, error detection and editing, merging, edge matching, rectification and registration, interpolation.

	Unit IV Data Management: Basic principles of data management: Efficiency, conventional database management systems, Spatial database management product generation: Types of output products, hardware components, Integrated analysis of Spectral and attribute data. Data Quality: Introduction, Components of data quality, Sources of error, Introduction to GPS **Unit V** Remote Sensing & GIS Applications: Land Use/Land cover in water resources, Rainfall-Runoff modeling, Flood plain zoning, Drought assessment and monitoring, Cropping patterns, condition of crops, irrigation system performance, Watershed Management for sustainable development, watershed characteristics, erosion and deposition, catchment area treatment, Estimation of Sediment load. **TEXT BOOKS:** 1. Elements of Photogrammetry by Paul Wolf 9. Remote Sensing and Image Interpretation by T.M. Lilles and R.W. Kifer. 10. Geographic Information Systems – A Management Perspective by Stan Aronoff 11. Elements of Photogrammetry by K.K. Rampal 12. Principles and Applications of Photogeology by R.W. Shiv Pandey 13. Remote Sensing in Hydrology by E.T. Engman and R.J. Curney 14. Geographic Information Systems by David Martin.
	Pre-PhD Courses for Transportation Engineering (Civil Engg)
S.No.	**Transportation Engineering Paper -I**
1	Traffic Engineering
	TRAFFIC ENGINEERING **UNIT-I** **Traffic Characteristics Measurement And Analysis:** Basic traffic Characteristics - Speed, Volume and Concentration. Relationship between Flow, Speed and Concentration. Traffic Measurement and Analysis - Volume Studies - Objectives,

	Methods; Speed studies – Objectives, Definition of Spot Speed, time mean speed and space mean speed; Methods of conducting speed studies; Presentation of speed study data; Head ways and Gaps; Critical Gap; Gap acceptance studies. **UNIT-II** **Highway Capacity And Level Of Service:** Basic definitions related to capacity; Level of service concept; Factors affecting capacity and level of service; Computation of capacity and level of service for two lane highways, Multilane highways and freeways. **UNIT-III** **Parking Analysis And Traffic Safety :** Types of parking facilities – On-street parking and Off-street Parking facilities; Parking studies and analysis- Parking Inventory Study, Parking Usage Study By Patrolling, Questionnaire Survey, Cordon Surveys; Evaluation of parking parameters; Parking accumulation, Parking Load, Parking Turnover, Parking Index, Parking Volume. Traffic Safety -Accident studies and analysis; Causes of accidents - The Road, The vehicle, The road user and the Environment; Engineering, Enforcement and Education measures for the prevention of accidents. **UNIT-IV** **Traffic Control, Regulation Signal Coordination:** Traffic Signals –Types of Signals; Principles of Phasing; Timing Diagram; Design of Isolated Traffic Signal by Webster method, Warrants for signalization. Signal Coordination - Signal Co-ordination methods, Simultaneous, Alternate, Simple progression and Flexible progression Systems. **UNIT-V** **Traffic And Environment:** Detrimental effects of Traffic on Environment , Air pollution; Noise Pollution; Measures to curtail environmental degradation due to traffic.

	REFERENCES: 1. Traffic Engineering and Transportation Planning – L.R. Kadiyali, Khanna Publishers. 2. Traffic Engineering - Theory & Practice - Louis J.Pignataro, Prentice Hall Publication. 3. Principles of Highways Engineering and Traffic Analysis - Fred Mannering & Walter Kilareski, John Wiley & Sons Publication. 4. Transportation Engineering - An Introduction - C.Jotin Khisty, Prentice Hall Publication *5.* Fundamentals of Transportation Engineering - C.S.Papacostas, Prentice Hall India. 6. I.T.E. Traffic Engineering Hand Book.
2	Pavement Analysis, Design and Evaluation
	PAVEMENT ANALYSIS, DESIGN AND EVALUATION **UNIT-I** **PAVEMENT TYPES, WHEEL LOADS AND DESIGN FACTORS:** Definition of Pavement Types, Comparison of Highway pavements, Wheel Loads, Tyre pressure, Contact pressure, Design Factors: Traffic and Loading, Environment, Materials, Failure criteria, Reliability. **UNIT-II** **STRESSES IN PAVEMENTS:** Layered System Concepts: One Layer System: Boussinesq Theory. Two Layer Theory: Burmister's Theory. Three Layer System. Stresses in Rigid Pavements. Relative Stiffness of Slabs, Modulus of Subgrade Reaction, Stresses due to Warping, Stresses due to Friction, Stresses due to Load, IRC Recommendations. **UNIT-III** **PAVEMENT DESIGN:** IRC Method of Flexible Pavement Design, AASHTO Method of Flexible Pavement Design, IRC Method for Rigid Pavements, use of Geosynthatics in pavements. **UNIT-IV** **PAVEMENT INVENTORIES:** Serviceability Concepts, Visual Rating, Pavement Serviceability Index, Roughness Measurements, Measurement of Distress Modes Cracking, Rutting, Rebound Deflection using Benkleman Beam Deflection Method, Load Man Concept, Skid Resistance Measurement.

	UNIT-V **PAVEMENT EVALUATION:** Functional Pavement Performance Evaluation: AASHTO Method, Psycho Physical and Psycho Metric Scaling Techniques, Deduct Value Method. Structural Conditional Evaluation Technique: Benkelman Beam Deflection Method, Pavement Distress Rating Technique. Design of Overlays by Benkelmen Beam Deflection Methods as per IRC – 81 - 1997 – pavements on problematic soils. **REFERENCES:** 1. Yoder and Witzorack, "Principles of Pavement Design", John Willey and Sons. 2. Yang, H. Huang, "Pavement Analysis and Design", Prentice Hall Publication, Englewood Cliffs, New Jersy. 3. Sargious, M.A. Pavements and Surfacings for Highways and Airports – Applied science Publishers limited 4. Ralps Hass and Hudson, W.R. " Pavement Management System" Mc-Graw Hill Book Company. 5. IRC codes of practice.
3	**Urban Transportation Planning**
	URBAN TRANSPORTATION PLANNING **UNIT-I: Urban Transportation Problem Travel Demand:** Urban Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach. Travel Demand: Trends, Overall Planning process, Long term Vs Short term planning, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques. **UNIT-II: Data Collection And Inventories:** Collection of data – Organisation of surveys and Analysis, Study Area, Zoning, Types and Sources of Data, Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data – Income – Population – Employment – Vehicle Owner Ship. **UNIT-III: Four Stage Demand Forecasting :** UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates. Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.

	UNIT-IV: Mode Choice and Traffic Assignment : Mode Choice Behaviour, Competing Modes, Mode Split Curves, Models and Probabilistic Approaches. Traffic Assignment: Basic Elements of Transport Networks, Coding, Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes, Equilibrium Assignment, Diversion Curves. **UNIT-V: Plan Preparation And Evaluation:** Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities. Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis. **REFERENCES:** 1. Introduction to Transportation Planning – M.J.Bruton; Hutchinson of London Ltd. 2. Introduction to Urban System Planning - B.G.Hutchinson; Mc Graw Hill. 3. Traffic Engineering and Transport Planning - Kadiyali L.R., Khanna Publishers. 4. Lecture notes on UTP - Prof. S. Raghavachari , R.E.C.Warangal.
4	Intelligent Transportation System
	INTELLIGENT TRANSPORTION SYSTEMS **(ELECTIVE- IV)** **UNIT-I** **FUNDAMENTALS OF ITS:** Definition of ITS s, The historical context of ITS from both public policy and market economic perspectives, Types of ITS; Historical Background, Benefits of ITS. **UNIT-II** SENSOR TECHNOLOGIES AND DATA REQUIREMENTS OF ITS**:** Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems; Data fusion at traffic management centres; Sensor plan and

	specification requirements; Elements of Vehicle Location and Route Navigation and Guidance concepts; ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), GIS, video data collection. **UNIT-III** **ITS functional areas:** Advanced Traffic Management systems (ATMS), Advanced Traveler Information systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control systems (AVCS), Advanced Public Transportation systems (APTS), Advanced Rural Transportation systems (ARTS). **ITS User Needs and Services** – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management. **UNIT-IV** **ITS ARCHITECTURE:** Regional and Project ITS architecture; Concept of operations; ITS Models and Evaluation Methods; Planning and human factor issues for ITS, Case studies on deployment planning and system design and operation; ITS and safety, ITS and security, ITS as a technology deployment program, research, development and business models, ITS planning **UNIT-V** **ITS applications:** Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing.; Transportation network operations; commercial vehicle operations and intermodal freight; public transportation applications; ITS and regional strategic transportation planning, including regional architectures: ITS and changing transportation institutions Automated Highway Systems- Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries. **REFERENCES:**

1. Fundamentals of intelligent transportation systems planning By Mashrur A. Chowdhury, Adel Wadid Sadek
2. Lawrence A. Klein , Sensor technologies and Data requirements of ITS
3. ITS Hand Book 2000: *Recommendations for World Road Association (PIARC)* by Kan Paul Chen, John Miles.
4. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.
5. National ITS Architecture Documentation, US Department of Transportation, 2007

S.No.	**Transportation Engineering Paper -II**
1	Environmental Impact Assessment

ENVIRONMENTAL IMPACT ASSESSMENT

Unit I

Conceptual Facts of EIA and Baseline Data Acquisition:

Introduction, Definition and Scope of EIA, Objectives in EIA, Basic EIA Principles, Classification of EIA: Strategic EIA (SEIA), Regional EIA, Sectoral EIA, Project Level EIA and Life Cycle Assessment, Project Cycle, Grouping of Environmental Impacts: Direct Impacts, Indirect Impacts, Cumulative Impacts and Induced Impacts. Significance of Impacts: Criteria/Methodology to determine the Significance of the Identified Impacts. Environmental Inventory, Data Products and Sources: thematic data, topographical data, collateral data and field data. Environmental Baseline Monitoring (EBM), Preliminary Study to determine impact significance, Environmental Monitoring Network Design, Monitoring Stations, Air and Water Quality, Soil, Socioeconomic and Biological data acquisition. Impact on Environmental Components: Significance and Criteria to determine the significance of the identified Impacts.

Unit II

Planning and Management of Impact Studies and Operational Aspects of EIA:

Conceptual Approach for Environmental Impact Studies, Proposal Development, Interdisciplinary Team Formations, Team Leader Selection and Duties, General Study Management, Fiscal Control.
Screening: Application for Prior Screening for Environmental Clearance, Screening Criteria; Category A Projects, Category B Projects, Criteria for Classification of Category B1 and B2 Projects, Consistency with other Requirements and Siting Guidelines. Scoping: Identification of Appropriate Valued Environmental Components (VEC), Identification of Impacts, Information in Form 1, Structure of a Pre-feasibility Report. Public consultation: Appraisal, Decision Making, Post-clearance Monitoring Protocol.

	Unit III **Methods for Impact Identification:** Background Information, Interaction - Matrix Methodologies: Simple matrices, stepped matrices, development of a simple matrix, other types of matrices, summary observations on matrices, Network Methodologies, Checklist methodologies, simple checklists, descriptive Checklists, summary observations on simple and descriptive Checklists. **Unit IV** **Prediction of Impacts (Air, Water, Noise, Soil, Biological and Socioeconomic):** Air Environment: Basic information on air quality, Sources of Pollutants, effects of pollutions, Conceptual approach for addressing air environment impacts, Air quality standards, Impact Prediction, Impact significance. Water Environment: Basic Information on surface-Water Quantity and Quality, Conceptual Approach for Addressing Surface-Water-Environment Impacts, Identification of Surface-Water Quantity or Quality Impacts, Procurement of Relevant Surface- Water Quantity-Quality Standards, Impact Predictions, Assessment of Impact Significance. Basic Information on Noise, Conceptual Approach for Addressing Noise-Environment Impacts, Identification of Noise Impacts, Procurement of Relevant Noise Standards and/or Guidelines, Impact Prediction, Assessment of Impact Significance, Soil Environment: Human Health and Society, Biological Environment: Basic Information on Biological Systems, Conceptual Approach for Addressing Biological Impacts, Identification of Biological Impacts, Description of Existing Biological Environment Conditions, Procurement of Relevant Legislation and Regulations, Impact Prediction, Assessment of Impact Significance. **Unit V** **Environmental Management Plan (EMP):** Case Study, identification of Impacts, EMP for Air Environment: Dust Control Plan, Procedural Changes, Diesel Generator Set Emission Control Measures, Vehicle Emission Controls and Alternatives, Greenbelt Development. EMP for Noise Environment, EMP for Water Environment: Water Source Development, Minimizing Water Consumption, Domestic and Commercial Usage, Horticulture, Storm Water Management. EMP for land Environment: Construction Debris, hazardous Waste, Waste from temporary Labour settlements. **Text Books:** 1. Environmental Impact Assessment by Prof. Y. Anjaneyulu.

	2. Technological guidance manuals of EIA. MoEF. 3. EIA by Canter
2	Pavement Construction, Evaluation and Management
	PAVEMENT CONSTRUCTION, EVALUATION AND MANAGEMENT **PAVEMENT CONSTRUCTION**: Preparation and Construction of Subgrade Soil, Subbase Courses,Base Courses, Bituminous Surface Courses, and Cement Concrete Surface Courses; MORTH specttlcations,Quality control. **PAVEMENT INVENTORIES AND EVALUATION**: Factors affecting Pavement Deterioration; Functional Condition Evaluation Techniques: Roughness Measurements, Identification of Uniform Sections,Serviceability Concepts: Visual & Ride Rating Techniques, Introduction to Psychometric and Psychophysical Scaling Techniques: Hutchinson's Tracking Task Device Structural Condition Evaluation Techniques: NDT Procedures, Rebound Deflection, Deflection Bowl Measurement and Analysis, Destructive Testing: Remaining Life Concept, Asphaltic Institute's Equivalency Factors. **EVALUATION OF PAVEMENT SAFETY**: Importance of Skid Resistance, Factors Affecting Skid Resistance, Skid Resistance Studies, Hydroplaning Reduction with Porous Overlays & Popcorn Friction Overlays;Deterioration Modelling Concepts: Factors Influencing Structural & Functional Condition Deterioration,Examples of Initiation and Progressing Deterioration Models, Use of Deterioration Models by HDM Software **PAVEMENT MAINTENANCE & QUALITY CONTROL**: Routine, Responsive Maintenance Programmes, Periodic Maintenance, Special Repairs, Rehabilitation and Reconstruction, Objectives & Components of Pavement Maintenance Management System (PMMS), Stages in Implementing PMMS, Total Quality Management (TQM): Quality Assurance/Quality Control Concepts, Sampling, Tolerances and Controls Related to Profile & Compaction, Role of ISO 9000 in TOM. **PAVEMENT MANAGEMENT SYSTEM (PMS)**: Phases and Components of System's Approach, Relationnhip Between System Approach and PMS, Components and Activities of PMS, Inter-relationshipsbetween the different components of PMS, Steps in Implementing PMS, Pavement Investment Planning Approaches: Index Ranking, Benefit Maximization & Cost Minimization Methods, Evaluating Alternative Strategies and Decision Criteria Using HDM Package. **REFERENCES:**

	1. RCC Haas, W. Ronald Hudson, et ai, Modern Pavement Management, Krieger Publishing Company 2. ISTE Summer School Report on PMSS by Bangalore University, ISTE, New Delhi. 3. Mohammed Y. Shahin, Pavement Management for Airports, Roads & Parking Lots, Chapman & Hall Publishers 4. Instructor's Guide-Asphalt Institute, Asphalt Technology and Construction Practices, Educational series 5. AF Stocks, Concrete Pavements, Elsevier Applied Science Publishers, New York 6. Harold N. Atkins, Highway Materials, Soils & Concrete 3rd Edition, Prentice Hall 7. MORTH, GOI, "SpeCifications for Roads & Bridge Works", New Delhi.
3	Principles & Applications of Remote Sensing and GIS
	PRINCIPLES AND APPLICATIONS OF REMOTE SENSING & GIS UNIT I Introduction to aerial Photogrammetry: Principles of Optics, Types of Aerial Photographs, Stereoscopy, Photoscale, Map vs Mosaic, Mosaic-Kinds of Mosaic, Construction of Mosaic, Ground Control, Parallax measurements for height determinations. Remote Sensing: Basic Concepts and foundation of remote sensing, Elements involved in Remote Sensing, Electromagnetic spectrum, Remote Sensing terminology, Energy Sources, Energy interactions with Earth Surface features and atmosphere, Resolution, Sensors and Satellites, Visual Interpretation techniques-Basic elements. Interpretation for Terrain Evaluation, Spectral properties of water bodies, Introduction to digital data analysis. Unit II Geographic Information Systems: Introduction, GIS definition and Terminology, GIS categories, Components of GIS, Fundamental Operations of GIS, A theoretical Framework for GIS, GIS types of data representation, Raster Data Structures, Vector Data Structures, Comparisons between Data Structures. Unit III Data Acquisition and Data Input: Introduction, exisiting data sets, developing own data, digitization and scanning.

	Preprocessing: Format conversion, data reduction and generalisation, error detection and editing, merging, edge matching, rectification and registration, interpolation. Unit IV Data Management: Basic principles of data management: Efficiency, conventional database management systems, Spatial database management product generation: Types of output products, hardware components, Integrated analysis of Spectral and attribute data. Data Quality: Introduction, Components of data quality, Sources of error, Introduction to GPS Unit V **Application of GIS in Transportation Engineering:** Intelligent information system for road accessibility study, GIS data base design for physical-facility planning, Decision support systems for land use planning. GIS applications in environment impact assessment, GIS based Highway alignment, GIS based road network planning, GIS based traffic congestion analysis and accident investigation**.** **REFERENCES:** 1. Elements of Photogrammetry by Paul Wolf 2. Remote Sensing and Image Interpretation by T.M. Lilles and R.W. Kifer. 3. Geographic Information Systems – A Management Perspective by Stan Aronoff 4. Elements of Photogrammetry by K.K. Rampal 5. Principles and Applications of Photogeology by R.W. Shiv Pandey 6. Remote Sensing in Hydrology by E.T. Engman and R.J. Curney 7. Geographic Information Systems by David Martin. 8. Remote sensing and Image Interpretation by LILESAND and KIEFER, Published by john Wiley and sons. **9.** Fundamental of GIS by MICHAEL N DEMERS Published by John Wiley & Sons Inc. GIS A Management, Perspenfi Stan Aronoff, WDL Publisher.
4	Urban Transportation Planning
	URBAN TRANSPORTATION PLANNING **UNIT-I**

Urban Transportation Problem Travel Demand: Urban Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach. Travel Demand: Trends, Overall Planning process, Long term Vs Short term planning, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential, and Simultaneous Approaches, Aggregate and Disaggregate Techniques.

UNIT-II

Data Collection And Inventories: Collection of data – Organisation of surveys and Analysis, Study Area, Zoning, Types and Sources of Data, Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data – Income – Population – Employment – Vehicle Owner Ship.

UNIT-III

Four Stage Demand Forecasting : UTPS Approach, Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction models, Commercial Trip Rates. Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.

UNIT-IV

Mode Choice and Traffic Assignment : Mode Choice Behaviour, Competing Modes, Mode Split Curves, Models and Probabilistic Approaches. Traffic Assignment: Basic Elements of Transport Networks, Coding, Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes, Equilibrium Assignment, Diversion Curves.

UNIT-V

Plan Preparation And Evaluation: Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities. Master plans, Selection of Corridor, Corridor Identification, Corridor deficiency Analysis.

REFERENCES:

1. Introduction to Transportation Planning – M.J.Bruton; Hutchinson of London Ltd.
2. Introduction to Urban System Planning - B.G.Hutchinson; Mc Graw Hill.
3. Traffic Engineering and Transport Planning - Kadiyali L.R., Khanna Publishers

	4. Lecture notes on UTP - Prof. S. Raghavachari , R.E.C.Warangal.
	Pre-PhD Courses for Environmental Engineering (Civil Engg)
S.No.	**Environmental Engineering Paper -I**
1	**Environmental Chemistry**
	ENVIRONMENTAL CHEMISTRY **Unit I** **Fundamentals of Environmental Chemistry:** Stoichiometry, chemical equilibria, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydro carbons, radio-nuclides. **Unit II** **Atmospheric and Water Chemistry:** Structure and composition of atmosphere - chemical reactions in the atmosphere - ozone chemistry - CFC's - Acid rain - photochemical smog - aerosols types- production and distribution - Aerosols and Radiation - temperature inversion - green house gases - global warming. Water resources, hydrological cycle, physical and chemical properties of water, complexation in natural and waste water, role of microorganisms – Water pollutants- Types – Sources – Heavy metals – Metalloids – Organic- Inorganic - Biological and Radioactive – Types of reactions in various water bodies including marine environment - Eutrophication- Groundwater – Potable water. **Unit III** **Soil Chemistry & Soil Composition:** Organic & Inorganic – soil, physical and chemical properties- cation exchange capacity- soil pH environmental properties of soils, leaching and erosion – reactions with acids and bases geochemical reactions that neutralize acidity- biological process that neutralize acidity – salt affected soils- trace metals in soils. **Unit IV** **Toxicological Chemistry:** Introduction to toxicology and toxicants- Toxicants - -Dose response relationship- Evaluation methods-LD_{50}, $LC_{-50,}$ impact of Toxic

	chemicals on Enzymes - Biochemical effects of arsenic, lead, mercury, carbon monoxide, Nitrogen oxides - sulphur dioxide - ozone and PAN - cyanide - pesticides and Carcinogens. **Unit V** **Green Chemistry and Green Environmental Issues:** Principles- tools of green chemistry- alternative feed stocks starting materials, alternative reagents, alternative solvents, alternative products and alternative catalysis. Introduction- ecological and carbon foot prints- carbon credits- carbon sequestration- clean development mechanism (CDM)- polluters pay- consumerism- sustainable mining- urban forestry- green buildings- green building practices- approaches to green computing, nanotechnology and environment. **Textbooks:** 1. Environmental chemistry, a global perspective by Gary W. Vanloon & tephen J. Duffy- Oxford University press. 2. Chemistry for environmental engineering and science- fifth edition by Clair N. Sawyer, Perry L. Me Carty. Gene F. Parkin, Tata McGraw Hill edition. 3. Environmental Chemistry, by A. K. de, 4th ed. New age internati9onal (P) Ltd., New Delhi, 2000. 4. Chemistry and the Environment, Johnson, D. O. Netterville, J. T., Wood, J. C., and James, M., 1973,W.B. Saunders company Philadelphia. 5. Toxic Chemistry, health and the Environment, Lave, L. B and Upton , A.C. 1987, The Hopkins Press Ltd., London. 6. Green Chemistry, Rashmi sanghi and Srivastava M. M, Narosa (2006). 7. Environmental Chemistry by Manhan, 7th ed., CRC press, Bo Co Raton, F. L., 2000. 8. Waste water engineering, treatment and reuse by Metcalf and eddy, fifth edition, Tata McGraw Hill.
2	**Environmental Impact Assessment**
	ENVIRONMENTAL IMPACT ASSESSMENT **Unit I** **Conceptual Facts of EIA and Baseline Data Acquisition:** Introduction, Definition and Scope of EIA, Objectives in EIA, Basic EIA Principles, Classification of EIA: Strategic EIA (SEIA), Regional EIA, Sectoral EIA, Project Level EIA and Life Cycle Assessment, Project Cycle, Grouping of Environmental Impacts: Direct Impacts, Indirect Impacts, Cumulative Impacts and Induced Impacts. Significance of Impacts: Criteria/Methodology to determine the Significance of the Identified Impacts. Environmental Inventory, Data Products and Sources: thematic data, topographical data, collateral data and field

	data. Environmental Baseline Monitoring (EBM), Preliminary Study to determine impact significance, Environmental Monitoring Network Design, Monitoring Stations, Air and Water Quality, Soil, Socioeconomic and Biological data acquisition. Impact on Environmental Components: Significance and Criteria to determine the significance of the identified Impacts. **Unit II** **Planning and Management of Impact Studies and Operational Aspects of EIA:** Conceptual Approach for Environmental Impact Studies, Proposal Development, Interdisciplinary Team Formations, Team Leader Selection and Duties, General Study Management, Fiscal Control. Screening: Application for Prior Screening for Environmental Clearance, Screening Criteria; Category A Projects, Category B Projects, Criteria for Classification of Category B1 and B2 Projects, Consistency with other Requirements and Siting Guidelines. Scoping: Identification of Appropriate Valued Environmental Components (VEC), Identification of Impacts, Information in Form 1, Structure of a Pre-feasibility Report. Public consultation: Appraisal, Decision Making, Post-clearance Monitoring Protocol. **Unit III** **Methods for Impact Identification:** Background Information, Interaction - Matrix Methodologies: Simple matrices, stepped matrices, development of a simple matrix, other types of matrices, summary observations on matrices, Network Methodologies, Checklist methodologies, simple checklists, descriptive Checklists, summary observations on simple and descriptive Checklists. **Unit IV** **Prediction of Impacts (Air, Water, Noise, Soil, Biological and Socioeconomic):** Air Environment: Basic information on air quality, Sources of Pollutants, effects of pollutions, Conceptual approach for addressing air environment impacts, Air quality standards, Impact Prediction, Impact significance. Water Environment: Basic Information on surface-Water Quantity and Quality, Conceptual Approach for Addressing Surface-Water-Environment Impacts, Identification of Surface-Water Quantity or Quality Impacts, Procurement of Relevant Surface- Water Quantity-Quality Standards, Impact Predictions, Assessment of Impact Significance. Basic Information on Noise, Conceptual Approach for Addressing Noise-Environment Impacts, Identification of Noise Impacts, Procurement of Relevant Noise Standards and/or Guidelines, Impact Prediction, Assessment of Impact Significance, Soil Environment: Human Health and Society, Biological Environment: Basic Information on Biological Systems, Conceptual Approach for Addressing Biological Impacts, Identification of Biological Impacts, Description of Existing Biological Environment Conditions, Procurement of Relevant Legislation and Regulations, Impact Prediction,

	Assessment of Impact Significance. **Unit V** **Environmental Management Plan (EMP):** Case Study, identification of Impacts, EMP for Air Environment: Dust Control Plan, Procedural Changes, Diesel Generator Set Emission Control Measures, Vehicle Emission Controls and Alternatives, Greenbelt Development. EMP for Noise Environment, EMP for Water Environment: Water Source Development, Minimizing Water Consumption, Domestic and Commercial Usage, Horticulture, Storm Water Management. EMP for land Environment: Construction Debris, hazardous Waste, Waste from temporary Labour settlements. **Text Books:** 2. Environmental Impact Assessment by Prof. Y. Anjaneyulu. 2. Technological guidance manuals of EIA. MoEF. 3. EIA by Canter
3	**Industrial Wastewater Management**
	INDUSTRIAL WASTEWATER MANAGEMENT UNIT-I Sources and types of industrial wastewater – Environmental impacts – Regulatory requirements – generation rates – characterization – Toxicity and Bioassay tests. Prevention vs Control of Industrial Pollution– Source reduction techniques – Waste Audit- Evaluation of pollution prevention options. UNIT-II Waste minimization - Equalization - Neutralization – Oil separation – Flotation –Precipitation – Heavy metal Removal – adsorption – Aerobic and anaerobic biological treatment – Sequencing batch reactors – High Rate reactors - Chemical oxidation – Ozonation– Photocatalysis – Wet Air Oxidation – Evaporation – Ion Exchange – Membrane Technologies – Nutrient removal. UNIT-III Individual and Common Effluent Treatment Plants – Zero effluent discharge systems -Wastewater reuse – Disposal of effluent

	on land – Quantification, characteristics and disposal of Sludge. UNIT-IV Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing. UNIT-V Petrochemical -Pharmaceuticals – Sugar and Distilleries – Food Processing – fertilizers – Thermal Power Plants and Industrial Estates, ISO 14000:2003 – Waste Audit. **REFERENCES:** 1. Eckenfelder, W.W., *Industrial Water Pollution Control*, McGraw-Hill, 1999. 2. Arceivala, S.J., *Wastewater Treatment for Pollution Control*, McGraw-Hill, 1998. 3. Frank Woodard, *Industrial waste treatment Handbook*, Butterworth Heinemann, New Delhi, 2001. *M. Tech. (Environmental Engineering)* *Department of Civil Engineering, National Institute of Technology, Tiruchirappalli – 620 015.*
	Environmental Engineering Paper -II
1	Air Pollution & Control Technologies
	AIR POLLUTION AND CONTROL TECHNOLOGIES **UNIT I** **Classification and properties of air pollutants:** Emission sources -major emissions from Global sources -importance of anthropogenic sources- behaviour and fate of air pollutants- photochemical smog-effects of air pollution-health, vegetation and materials damage in India-air pollution standards - Isolation and heat balance of the atmosphere – different types of terrain – effects of terrain features on atmosphere – mechanical and thermal turbulence- Indoor air pollution. **UNIT II** **Meteorological aspects of air pollution dispersions:**

	Temperature lapse Rates and Stability-wind velocity and turbulence-Plume behaviour dispersion of air pollutants- solutions to the atmospheric dispersion equation - the Gaussian Plume Model. **UNIT III** **Air pollution sampling and measurement:** Types of pollutant sampling and measurement - Ambient air sampling - collection of gaseous air pollutants - collection of particulate pollutants - stack sampling, analysis of air pollutants - sulfur dioxide - nitrogen dioxide, carbon monoxide, oxidants and ozone - hydrocarbons - particulate matter. **UNIT IV** **Control methods:** Sources- correction methods - particulate emission control - gravitational settling chambers -cyclone separators- fabric filters - electrostatic precipitators - wet scrubbers - control of gaseous emissions - adsorption by solids - absorption by liquids - combustion, condensation – control of SO_2 emission – desulphurization of flue gases – dry methods – wet scrubbing methods. Control of sulphur dioxide emission - desulphurization of flue gases - dry methods-wet scrubbing methods - control of nitrogen oxides - modification of operating conditions - modification of design conditions - effluent gas treatment methods - carbon monoxide control - control of hydrocarbons - mobile sources. **UNIT V** **Air pollution from specific industries:** Portland cement plants – steel mills – petroleum refineries **UNIT VI** **Vehicular air pollution:** Genesis of Vehicular emissions-Natural Pollution - Gasification of Vehicles - Point sources of Air Pollution from automobiles - Fuel tank, carburettor, crank case - Exhaust emissions -Mechanism of Origin of air pollution from automobiles. Automobile air pollution – Indian Scenario - Population and pollution loads of vehicles - Automobile Pollution Control - Control at sources - Exhaust gas treatment devices - Alternate fuels comparison - Thermal Reactor - Catalytic Converter - Automobile Emission Control - Legal measures. **Text books:**

	Air Pollution, H.C.V. Rao, 1990, McGraw Hill Co. Environmental Pollution Control, C.S.Rao, Wiley Eastern Ltd., 1993 Air Pollution, M.N. Rao McGraw Hill 1993. **Reference Books:** Fundamentals of Air Pollution, Samuel, J.W., 1971, Addison Wesley Publishing Co. Air Pollution, Kudesia, V.P. International Student Edition McGraw Hill - Kosakusha Ltd.,Tokyo. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand & Company Ltd., 1994 Air Pollution Control and Engineering, De Nevers, McGraw Hill, 1993.
2	**Solid & Hazardous Waste Management**
	SOLID & HAZARDOUS WASTE MANAGEMENT **Unit I Solid Waste Collection, Segregation and Transport:** Definition of solid wastes – types of solid wastes – Sources - Industrial, mining, agricultural and domestic – Characteristics. Solid waste Problems - impact on environmental health – Concepts of waste reduction, recycling and reuse. Handling and segregation of wastes at source. Collection and storage of municipal solid wastes; Analysis of Collection systems. Transfer stations. **Unit II Municipal Solid Waste Management:** Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery: composting, vermi-composting, termi-gradation, fermentation. Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; Leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation. Regulatory aspects of municipal solid waste management. **Unit III Hazardous Wastes:** Hazardous waste definition. Physical and biological routes of transport of hazardous substances – sources and characterization categories and control. Sampling and analysis of hazardous wastes –

	analytical approach for hazardous waste characterization – proximate analysis – survey analysis – directed analysis – analytical methods. **Unit IV Hazardous Wastes Management:** Sources and characteristics: handling, collection, storage and transport, TSDF concept. Hazardous Waste treatment technologies - Physical, chemical and thermal treatment of hazardous waste: solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste landfills - Site selections, design and operation. Hazardous waste reduction and Recycling - Regulatory aspects of HWM. **Unit V Biomedical, Radioactive and e-Waste Management:** Biomedical waste: Definition, sources, classification, collection, segregation Treatment and disposal. Radioactive waste: Definition, Sources, Low level and high level radioactive wastes and their management, Radiation standard by ICRP and AERB. Waste characteristics, generation, collection, transport and disposal. **Books:** Hazardous waste management by Prof. Y. Anjaneyulu. Hazardous waste management Charles A. Wentz. Second edition 1995. McGraw Hill International. Integrated solid waste management, George Tchobanoglous, Hilary Theisen & Sammuel A. Vigil. Criteria for hazardous waste landfills – CPCB guidelines 2000. Environmental Science by Daniel B. Botkin and Edward A. Keller, Wiley student, 6th edition- 2009.
3	Physico-Chemical process for water and waste water treatment
	PHYSICO-CHEMICAL PROCESS FOR WATER AND WASTEWATER TREATMENT UNIT-I Water Quality-Physical, chemical and biological parameters of water- Water Quality requirement - Potable water standards - Wastewater Effluent standards -Water quality indices. Water purification systems in natural systems-Physical processes chemical processes and biological processes-Primary, Secondary and tertiary treatment-Unit operations-unit processes. UNIT-II Mixing, Clarification - Sedimentation; Types; Aeration and gas transfer – Coagulation and flocculation, coagulation processes - stability of colloids - destabilization of colloidstransport of colloidal particles, Clariflocculation.

	UNIT-III Filtration - theory of granular media filtration; Classification of of filters; slow sand filter and rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration. UNIT-IV Adsorption, adsorption equilibria- adsorption isotherms, Disinfection - chlorine dioxide; chloramines; ozonation; UV radiation. UNIT-V Ion Exchange-processes, Application Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis. **REFERENCE BOOKS** 1. Weber, W.J. *Physicochemical processes for water quality control*, John Wiley and sons, Newyork, 1983. 2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. *Environmental Engineering*, McGraw Hills, New York 1985. 3. Metcalf and Eddy, *Wastewater engineering, Treatment and Reuse*, Tata McGraw-Hill, New Delhi, 2003.

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