CIVIL ENGINEERING

Syllabus for M Tech Civil Engineering and
M Tech Transportation and Infrastructure Engineering program August 2017

M Tech Program in Civil Engineering

Semester 1 Common to all students

Core: 18 Credits
CE 201 3:0 Basic Geomechanics
CE 202 3:0 Foundation Engineering
CE 203 3:0 Surface Water Hydrology
CE 204 3:0 Solid Mechanics
CE 205 3:0 Introduction to Finite Elements

MA --- 3:0 Math course

a) The 3:0 credits mathematics course will be identified by the Department at the beginning of the semester.
b) **To fulfill Major requirement in an Area,** students shall complete minimum 21 course credits (15 core + 6 elective on offer) and 22 Dissertation project credits in the said Area.
c) **For optional Minor in one of the other two Areas**, a student must complete minimum of 12 credits in the said Area.

Major in Geotechnical Engineering

Core: 9 Credits
CE 206 3:0 Earth and Earth Retaining Structures
CE 207 3:0 Geoenvironmental Engineering
CE 208 3:0 Ground Improvement and Geosynthetics
CE 299 0:22 Dissertation Project

Major in Structural Engineering

Core: 9 Credits
CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0 Structural Dynamics
CE 228 3:0 Introduction to the Theory of Plasticity
CE 299 0:22 Dissertation Project

Major in Water Resources and Environmental Engineering

Core: 12 Credits
CE 212 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 213 3:0 Systems Techniques in Water Resources & Environmental Engineering
CE 214 3:0 Ground Water Hydrology
CE 215 3:0 Stochastic Hydrology
CE 299 0:22 Dissertation Project

Electives in Geotechnical Engineering
CE 220 3:0 Design of Substructures
CE 222 3:0 Fundamentals of Soil Behaviour
CE 225 3:0 Engineering Rock Mechanics
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering

Electives in Structural Engineering
CE 235 3:0 Optimization Methods
CE 236 3:0 Fracture Mechanics
CE 238 3:0 Structural Masonry
CE 239 3:0 Stochastic Structural Dynamics
CE 240 3.0 Uncertainty Modeling and Analysis
CE 241 3:0 Advanced Structural Dynamics
CE 242 3:0 Fire structural Engineering
CE 243 3:0 Bridge Engineering

Electives in Water Resources and Environmental Engineering

CE 245 3:0 Design of Water Supply and Sewerage Systems
CE 246 3:0 Urban Hydrology
CE 247 3:0 Remote Sensing and GIS for Water Resources and Environmental Engineering
CE 248 3:0 Regionalization in Hydrology and Water Resources Engineering
CE 249 3:0 Water Quality Modelling
ME 201 3:0 Fluid Mechanics
AS 216 3:0 Introduction to Climate Systems

M Tech Program in Transportation and Infrastructure Engineering

Core: 24 Credits
CE 230 3:0 Pavement Engineering
CE 235 3:0 Optimization Methods
CE 240 3:0 Uncertainty Modelling and Analysis
CE 247 3:0 Remote Sensing and GIS for Water Resources and Environmental Engineering
CE 263 3:0 Modelling Transport and Traffic
CE 267 3:0 Transportation Statistics and Micro-simulation
MA 261 3:0 Probability Models
One 3:0 credit core course from either Geotechnical Engineering/ Structural Engineering/ Water Resources and Environmental Engineering streams
CE 299 0:22 Dissertation Project

Electives: 18 Credits of which at least 9 credits should be from among the electives listed below.

CE 202 3:0 Foundation Engineering
CE 205 3:0 An Introduction to Finite Elements
CE 208 3:0 Ground Improvement and Geosynthetics
CE 209 3:0 Mechanics of Structural Concrete
CE 238 3:0 Structural Masonry
CE 246 3:0 Urban Hydrology
CE 269 3:0 Principles of Traffic Engineering
CE 270 3:0 Travel Demand Modeling
CE 271 3:0 Discrete Choice Modeling Methods for Transportation Planning
ST 202 3:0 Renewable Energy - Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics
ST 211 3:0 Engineering Waste Management

Semester 1 (mandatory for all MTech Civil Engineering students)

CE 201 (AUG) 3:0
Basic Geo-mechanics

Introduction to genesis of soils, basic clay mineralogy; Principle of effective stress, permeability and flow; Fundamentals of Tensors, Introduction to stresses and deformation measures; Mohr-Coulomb failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

P Anbazhagan andTejas G Murthy

Wood, D.M., Soil Behaviour and Critical State Soil Mechanics, Cambridge University Press, 1991.
Bolton, M.D. A Guide to Soil Mechanics, Cambridge University Press, 1991.
Salgado, R., The Engineering of Foundations, McGraw Hill, 2008.

CE 202 (AUG) 3:0
Foundation Engineering

Bearing capacity of shallow foundations, penetration tests, plate load tests. Settlement of shallow foundations, elastic and consolidation settlements; settlement, estimates from penetration tests, settlement tolerance. Allowable bearing pressure. Foundations on problematic soils. Principles of foundation design. Introduction of deep foundations. Bearing capacity and settlement of piles and pile groups in soils. Machine foundations. Reinforced soil beds.

T G Sitharam

Bowles, J.W., Foundation Analysis and Design, 5th Edn., McGraw-Hill, 1996.
Das, M. B., Principles of Foundation Engineering, Brooks/Cale Engineering Division, 1984.

CE 203 (**AUG**) **3:0**
Surface Water Hydrology

Review of basic hydrology, hydrometeorology, infiltration, evapotranspiration, runoff and hydrograph analysis. Flood routing – lumped, distributed and dynamic approaches, hydrologic statistics, frequency analysis and probability, introduction to environmental hydrology, urban hydrology. Design issues in hydrology.

V V Srinivas

Bedient, P. B., and Huber, W. C., Hydrology and Floodplain Analysis, Prentice Hall, 2002.
Chow, V.T., Maidment, D.R. and Mays, L.W,. Applied Hydrology, McGraw-Hill 1988.
Linsley, R.K., Kohler, M.A. and Paulhus, J.L.H., Hydrology for Engineers, McGraw Hill, 1985.

CE 204 (AUG) 3:0
Solid Mechanics

Introduction to tensor algebra and calculus, indicial notation, matrices of tensor components, change of basis formulae, eigenvalues, Divergence theorem. Elementary measures of strain. Lagrangian and Eulerian description of deformation. Deformation gradient, Polar decomposition theorem, Cauchy-Green and Lagrangian strain tensors. Deformation of lines, areas and volumes. Infinitesimal strains. Infinitesimal strain-displacement relations in cylindrical and spherical coordinates. Compatibility. Tractions, body forces, stress at a point, Cauchy's theorem. Piola-Kirchhoff stress tensors. Momentum balance. Symmetry of the Cauchy stress tensor. St. Venant's Principle. Virtual Work. Green's solids, elastic strain energy, generalized Hooke's Law, material symmetry, isotropic linear elasticity in Cartesian, cylindrical and spherical coordinates, elastic moduli, plane stress, plane strain,. Navier's formulation. Airy stress functions. Selected problems in elasticity. Kirchhoff's uniqueness

theorem, Betti-Maxwell reciprocal theorem, Principle of stationary potential energy, Torsion in circular and non-circular shafts and thin-walled tubes, warping. Pure bending of thin rectangular and circular plates, small deflection problems in laterally loaded thin rectangular and circular plates. Outline of Mindlin plate theory.

Narayan K. Sundaram

Fung, Y. C. and Pin Tong, Classical and Computational Solid Mechanics, World Scientific, 2001
Boresi, A.P., and Lynn P.P., Elasticity in Engineering Mechanics, Prentice Hall 1974.
Malvern L., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969

CE 205 (AUG) 3:0

Introduction to Finite Elements

Elements of calculus of variations; normed function spaces and inner product spaces; Riesz representation theorem and weighted-residual/Galerkin/Rayleigh-Ritz methods; finite elements (FE) - weak formulations with continuous and piecewise smooth shape functions; isoparametric FE formulations; smooth, polynomial reproducing shape functions and moving least squares (MLS); virtual work/weak formulations with MLS methods; local error estimates; numerical integration – Gauss quadrature; applications to plane stress, plane strain and the general 3D linear elastostatic cases; enforcing essential and natural boundary conditions; dimensional descent and applications to beams; MATLAB-based simulation exercises.

Debasish Roy

Zienkiewicz, O.C. and Taylor, R. L., 2000, “The Finite Element Method: Vol. 1 (The Basis)”, Butterworth-Heinemann.
Chen, Y., Lee, J. and Eskandarian, A., 2006, “Meshless Methods in Solid Mechanics”; Springer.
Brenner, C. S. and Scott, L. R., 1994, “Mathematical Theory of Finite Element Methods”, Springer-Verlag.

Major in Geotechnical Engineering

CE 206 (JAN) 3:0
Earth and Earth Retaining Structures

Lateral earth pressure coefficients, Rankine and Coulomb theories. Graphical constructions, passive earth pressure with curved rupture surfaces, arching, stability of retaining walls, stability of vertical cuts. Braced excavations, anchored sheet piles, stability of infinite slopes, stability of finite slopes. Methods of slices - Swedish, Morgenstern and Price methods. Stability analysis of earth and rock-fill dams.

Jyant Kumar

Terzaghi, K., Theoretical Soil Mechanics, John Wiley, 1965.
Taylor, D.W., Fundamentals of Soil Mechanics, John Wiley, 1948.
Bowles, J.W., Analysis and Design of Foundations, 4th and 5th Ed., McGraw-Hill, 1988 & 1996.
Lambe, T.W. and Whitman, R.V., Soil Mechanics, Wiley Eastern Limited, 1976.

CE 207 (JAN) 3:0
Geo-environmental Engineering

Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

G L Sivakumar Babu

Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
Rowe, R. Kerry, Quigley, Robert M., Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities , 2nd edn 2004. Spon Press, Taylor & Francis Group, London.
Tchobanoglous, G., Theisen, H. and Vigil, S.A., Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill (1993).

CE 208 (JAN) 3:0
Ground Improvement and Geosynthetics

Principles of ground improvement, mechanical modification. Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures, stabilization using industrial wastes, grouting, soil reinforcement principles, properties of geo-synthetics, applications of geo-synthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements, filtration, drainage and seepage control with geo-synthetics, geo-synthetics in landfills, soil nailing and other applications of geo-synthetics.

G L Sivakumar Babu

Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill, 1990.
Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.
Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.

Major in Structural Engineering

CE 209 (JAN) 3:0
Mechanics of Structural Concrete

Introduction, Limit state design philosophy of reinforced concrete, Stress-strain behavior in multi-axial loading, failure theories, plasticity and fracture, ductility, deflections, creep and shrinkage, Strength of RC elements in axial, flexure, shear and torsion, RC columns under axial and eccentric loading, Beam-column joints, Strut and Tie modelling, Yield line theory of slabs, Seismic resistant design, Methods for predicting the behavior of pre-stressed concrete members and structures.

J M Chandra Kishen

Nilson, A. H., Darwin, D. and Dolan, C. W., Design of concrete structures, McGraw Hill, 2004
Lin and Burns, Design of Prestressed concrete structures, John Wiley and Sons, 2006
Agarwal and Shrikhande- Earthquake resistant design of structures, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006.

CE 210 (JAN) 3:0
Structural Dynamics

Equations of motion. Degrees of freedom. D' Alembert principle. SDOF approximation to vibrating systems. Energy storage elements: mass, stiffness and damper. Undamped free vibration. Natural frequency. Damped free vibration. Critical damping. Forced response under periodic and aperiodic excitations. Support motions. Resonance. Impulse response and complex frequency response functions. Duhamel integral. Vibration isolation: FTR and DTR. Multi-DOF systems. Normal modes and natural frequencies. Orthogonality of normal modes. Natural coordinates. Uncoupling of equations of motion. Repeated natural frequencies. Proportional and non proportional damping. Damped normal modes. Principle of vibration absorber. Continuous systems. Vibration of beams. Forced response analysis by eigenfunction expansion. Moving loads and support motions. Effect of axial loads. Approximate methods for vibration analysis. Rayleigh's quotient. Rayleigh-Ritz method. Method of weighted residual. Method of collocation. Galerkin's method.

C S Manohar

Meirovich, L., 1984, Elements of vibration analysis, McGraw-Hill, NY
Clough R W and J Penzien, 1993, Dynamics of structures, McGraw-Hill, NY
Rao,S S 2004, Mechanical Vibrations, 4th Edition, Pearson Education, New Delhi.

CE 228 (JAN) 3.0
Introduction to the Theory of Plasticity

1D plasticity and visco-plasticity; physical basis of plasticity; uniaxial tensile test & Bauschinger effect; structure of phenomenological plasticity theories; internal variables; yield criteria (Tresca, von Mises, Mohr-Coulomb, Drucker-Prager); geometry of yield surfaces; Levy-Mises equations; flow rules; plastic/ viscoplastic potentials; consistency condition; isotropic and kinematic hardening; Drucker's postulate; Principle of maximum plastic dissipation; associativity; convexity; normality; uniqueness; selected elastic-plastic boundary value problems (tension and torsion of tubes and rods, pressurized thin and thick spherical shells); collapse; advanced hardening models; introduction to computational plasticity; integration of plasticity models; return mapping; principle of virtual work; Finite elements for plasticity

Ananth Ramaswamy

Chakrabarty, J. Theory of Plasticity, Butterworth, 2006
Calladine, C.R., Plasticity for Engineers, Woodhead, 2000
Lubliner J., Plasticity Theory, Dover, 2008

Major in Water Resources and Environmental Engineering

CE 212 (JAN) 3:0
Computational Fluid Dynamics in Water Resources Engineering

Governing equations of fluid dynamics, numerical solution of ODEs, Classification of Quasi-Linear PDEs, classification of PDEs, Solution methods for Parabolic, Elliptic and Hyperbolic PDEs and their analysis. Curvilinear co-ordinates and grid generation. Introduction to finite difference, finite volume and finite elements method, Application of CFD to open channel flow, pipe flow, porous media and contaminant transport problems.

M S Mohan Kumar

Computational Fluid Dynamics: Applications in Environmental Hydraulics, edited by Paul D. Bates, Stuart N. Lane, Robert I. Ferguson, Wiley; 1st edition, 2007.
Computational Fluid Dynamics: A Practical Approach, by Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Elsevier, 2013.
Computational Fluid Dynamics in Drinking Water Treatment, by Bas Wols, IWA Publishing, 2011.
Computational Fluid Dynamics for Engineers, By Andersson et al, Cambridge University Press, New York, 2012.
Fundamentals of Computational Fluid Dynamics, by Tapan K Sinha, University Press, 2004.
Applied Numerical Analysis, by Curtis F. Gerald and Patrick O. Wheatley, Addison and Wesley, 1994

CE 213 (JAN) 3:0
Systems Techniques in Water Resources and Environmental Engineering

Optimization Techniques - constrained and unconstrained optimization, Kuhn-Tucker conditions, Linear Programming (LP), Dynamic Programming (DP), Multi-objective optimization, applications in water resources, water allocation, reservoir sizing, multipurpose reservoir operation for hydropower, flood control and irrigation. Review of probability theory, stochastic optimization. Chance constrained LP, stochastic DP. Surface water quality control. Simulation - reliability, resiliency and vulnerability of water resources systems.

D Nagesh Kumar

Loucks, D.P., Stedinger, J.R. and Haith, D.A., Water Resources Systems Planning and Analysis, Prentice Hall, Englewood Cliffs, N.J, 1981.
Vedula, S. and Mujumdar, P. P., Water Resources Systems: Modelling Techniques Tata-McGraw Hill, 2005.
Srinivasa Raju, K and Nagesh Kumar, D., Multicriterion Analysis in Engineering and Management, PHI Ltd., New Delhi, 2010.

CE 214 (JAN) 3:0
Ground Water Hydrology

Ground water and hydrological cycle. Ground water movement and balance. Ground water monitoring. Equations of flow. Well hydraulics - analysis of aquifer tests and models. Regional groundwater resource evaluation and numerical modeling. Groundwater recharge estimation. Base flow analysis and models. Ground water quality. Mass transport in ground water. Tracer tests and scale effects of dispersion. Solute transport modeling.

M Sekhar

Freeze, A. R. And Cherry, J. A. Groundwater, Prentice Hall, 1979.
Fetter, C. W. Applied Hydrogeology, Prentice Hall, 1988.
Domenico, P. A., and Schwartz, F. W. Physical and Chemical Hydrogeology, John Wiley, 1990.
Fetter, C. W. Contaminant Hydrogeology, Prentice Hall, 1993.

CE 215 (JAN) 3:0
Stochastic Hydrology

Introduction to random variables, statistical properties of random variables. Commonly used probability distributions in hydrology. Fitting probability distributions to hydrologic data. Probability plotting and frequency analysis. Data generation. Modeling of hydrologic uncertainty - purely stochastic models, first order Markov processes. Analysis of hydrologic time series - auto correlation and spectral density functions. Applications to hydrologic forecasting.

P P Mujumdar

Bras, R.L. and Rodriguez-Iturbe, Random Functions and Hydrology, Dover Publications, New York, USA, 1993.
Hann, C.T., Statistical Methods in Hydrology, First East-West Press Edition, New Delhi, 1995.
Ang, A.H.S. and Tang, W.H.,Probabilistic concepts in Engineering Planning Design, Vol. 1, Wiley, New York, 1975.
Clarke, R.T., Statistical Models in Hydrology, John Wiley, Chinchester, 1994

Electives in Geotechnical Engineering

CE 220 (AUG) 3:0
Design of Substructures

Design considerations, field tests for bearing capacity and settlement estimates, selection of design parameters. Structural design considerations. Codes of practice. Design of spread footings, combined footings, strap footings, ring footings, rafts, piles and pile caps and piers.

P Raghuveer Rao

Bowles, J.E. Foundation analysis and design. 5th Edn., McGraw Hill, 1996
Indian Standard Codes

CE 222 (JAN) 3:0
Fundamentals of Soil Behaviour

Identification and classification of clay minerals, expansive and collapsing soils; Concepts and measurements of matric and osmotic suction, Role of inter-particle forces and suction in effective stress, Role of clay mineralogy, inter-particle forces and suction in volume change, hydraulic conductivity and shear strength of soils

M Sudhakar Rao and P Raghuveer Rao

Mitchell, J. K. Fundamentals of Soil Behaviour, Wiley, 2005.
Yong, R. N. and Warkentin, B. P. Soil Properties and Behaviour, Elsevier, 1975,
Lu, N. and Likos, W.J. Unsaturated Soil Mechanics, Wiley, 2004
Fredlund, D.G. and Rahardjo, H., Fredlund, M.D. Unsaturated Soil Mechanics in Engineering Practice, Wiley, 2012
Nelson, J.D. and Miller, D.J. Expansive soils-Problems and Practice in Foundation and Pavement Engineering. Wiley- Interscience Pub., 1992

CE 225 (JAN) 3:0
Engineering Rock Mechanics

Rock as an engineering material, Geological factors affecting rocks, Stress, Strain and Strength of rocks, Insitu stresses in rock, Intact Rock - Elastic Deformation, Discontinuities and deformability and strength of rock masses, permeability, anisotropy and in homogeneity in rocks, Stereonet Analysis, testing techniques, rock mass classification, Failure criteria for rock and rock masses, Rock mechanics interactions and rock engineering systems, Excavation and stabilization principles, rock slope stability, foundations on rock, rock blasting support and reinforcement, Underground excavation and stability, Urban tunnels, Problematic Rocks - Rock Engineering, Modern modelling techniques & analyses in rocks.

T G Sitharam

Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford
Goodman, R.E. Introduction to Rock Mechanics, John Wiley & Sons.
Engineering in Rocks for Slopes, Foundation and Tunnels, Editor T. Ramamurthy, Prentice Hall India Pvt. Ltd.
Additional Readings: Literature, related codes and manuals from International Society of Rock Mechanics, ASTM and Bureau of Indian Standards

CE 227 (JAN) 3:0
Engineering Seismology

Introduction to earthquake hazards. Strong ground motions, tsunamis, landslides, liquefaction. Overview of plate tectonics and earthquake source mechanisms. Theory of wave propagation. Body waves and surface waves. Concepts of seismic magnitudes and intensity. Seismic station. Sensors and data loggers, mechanical and digital sensors. Interpretation of seismic records – acceleration, velocity and displacement. Regional seismicity and earthquakes in India. Seismic zonation – scales, macro and micro, attenuation, recurrence relation. Seismic hazard analysis - deterministic and probabilistic. Site characterization – different methods and experiments. Local site effects, ground motion amplifications. Development of response/design spectrum. Liquefaction hazard assessments. Integration of hazards using GIS. risk and vulnerability Studies.

P Anbazhagan

Earthquake Engineering – From Engineering Seismology to Performance Based Engineering, Edited by Bozorgnia, Y. and Bertero, V.V., CRC Press Washington 2004.
Leon Reiter, Earthquake hazard Analysis – Issues and Insights, Columbia University Press New York 1990.
Steven L Kramer, Geotechnical Earthquake Engineering Pearson Education, 2003.

CE 231 (Aug) 3:0
Forensic Geotechnical Engineering

Introduction, Definition of a Forensic Engineer, Types of Damage, Planning the Investigation, investigation methodology, Collection of Data, Distress Characterization, Development of Failure, Hypothesis, Diagnostic Tests, Back Analysis, Technical Shortcomings, Legal Issues Reliability Aspects, Observation Method of Performance Evaluation, Case Histories related to settlement of Structures, lateral movement, backfill settlements, causes due to soil types such as collapsible soil, expansive soil, soluble soils, slope Failures and landslides, debris flow, slope softening and creep, trench collapses, dam failures, foundation due to earthquakes, erosion, deterioration, tree roots, groundwater and moisture problems, groundwater problems, retaining failures problems, pavement failures and issues, failures in soil reinforcement and geosynthetics, development of codal provisions and performance based analysis procedures.

G L Sivakumar Babu

Bolton M (1991) A Guide to Soil Mechanics, Universities Press
Robert W. Day (2011) Forensic Geotechnical and Foundation Engineering, Second Edition, McGraw-Hill Companies, Inc.
Rao, V.V.S. and Sivakumar Babu, G.L (2016) Forensic Geotechnical Engineering, Springer Nature.

CE 232 (Jan 3:0)
Geotechnical Engineering and Rehabilitation of Dams

Geotechnical and geological aspects of the investigations for dams. Phases of geotechnical investigations. Review and assessment of existing dams in India and History of dams. Design and construction of embankment dams including their zoning and selection of type of dams. Shear strength, compressibility and permeability of embankment materials and soil foundations. Design methods with the theoretical basis. Design, specifications and construction of filters. Foundation preparation and grouting. Seepage analyses and control. Stability analyses and deformation with and without earthquakes. Internal erosion and piping. Embankment dam details like freeboard slope protection, crest details, dimensioning and tolerances. Construction methods. Flood control structures and conduits/pipes through dams. Rockfill dams. Mine and Industrial Tailing dams. Ground motions and soil liquefaction during earthquakes. Geosynthetics in earth dams. Monitoring and surveillance of earth dams. Assessment, safety and management of dams. Dam rehabilitation plans. Foundations for gravity dams and Geotechnical engineering aspects for concrete gravity and arch dams.

T G Sitharam

Robin Fell, Patrick MacGregor, David Stapledon and Graeme Bell (2005) Geotechnical Engineering of dams, 2nd Edition, Taylor and Francis Group Plc, London, UK
Sherard J L., Woodward, R J., Gizienski, S F., and Clevenger W.A. (1963) Earth and rockfill dams, John Wiley & Sons.
International Committee on Large dams (ICOLD) reports and manuscripts

Electives in Structural Engineering

CE 235 (JAN) 3:0
Optimization Methods

Basic concepts, Kuhn-Tucker conditions, linear and nonlinear programming, treatment of discrete variables, stochastic programming, Genetic algorithm, simulated annealing, Ant Colony and Particle Swarm Optimization, Evolutionary algorithms, Applications to various engineering problems.

Ananth Ramaswamy

Arora, J.S. Introduction to Optimization, McGraw-Hill (Int. edition)1989.
Rao, S.S., Optimization: Theory and Applications. Wiley Eastern, 1992
Current Literature.

CE 236 (AUG) 3:0
Fracture Mechanics

Definition of stress intensity factor. Fracture toughness. Energy release rate, critical energy release rate. Crack mouth opening displacement, R-curve. Elasto-plastic fracture mechanics and J-integral. Mixed-mode crack propagation, fatigue crack propagation. Computational fracture mechanics. Introduction to fracture of quasi-brittle materials like concrete, Non-linear fracture models with softening, Size effect in fracture of concrete.

J M Chandra Kishen

David Broek, Elementary Engineering Fracture Mechanics, Sijthoff and Noordhaff, Alphen Aan Den Rijn, The Netherlands.
Anderson, T.L., Fracture Mechanics : Fundamentals and Applications, CRC Press, USA, Second Edition.
Shah, S.P., Swartz, S.E. and Quyang, C., Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi-Brittle Materials, John Wiley and Sons, USA.

CE238 (JAN) 3:0
Structural Masonry

Masonry materials, Masonry characteristics, Compression failure theories, masonry in tension, shear and biaxial stress, laterally loaded un-reinforced walls, Strength of masonry arches, Design of reinforced and un-reinforced masonry structures.

B V VENKATARAMA REDDY

Hendry, A. W., Structural Masonry, MacMillan Press, 1998
Current literature

CE 239 (JAN) 3:0
Stochastic Structural Dynamics

Introduction to random variables and processes: probability, random variables. Transformations of random variables. Stationary, ergodic and non-stationary stochastic processes. Linear transformation of stationary-ergodic stochastic processes. Normal Gaussian Stochastic processes. PSD functions. Wiener processes and an introduction to Ito calculus. Response of SDOF and MDOF oscillators under random inputs. Oscillators subject to white noise excitations. Input-output relations in time and frequency domains under the assumption of response stationarity. Handling non-stationarity in the response. level crossing and first passage problems. Nonlinear oscillators under random inputs: sources of non-linearity. Equivalent linearization and perturbation methods. Numerical integration and Monte Carlo simulations: Ito-Taylor expansions. Stochastic Euler and Heun methods. Higher order implicit and explicit methods. Errors in Monte-Carlo simulations. Variance reduction techniques.

D Roy

Lin, Y K, Probabilistic Structural Dynamics, McGraw-Hill
Kloeden, P.E. and Platen, E., Numerical Solutions of Stochastic Differential Equations, Springer
Ghanem, R.G and Spanos, P D, Stochastic Finite Elements: A Spectral Approach, Springer-Verlag.

CE 240 (JAN) 3:0
Uncertainty Modeling and analysis

Deterministic vs nondeterministic perspectives. Sources of uncertainty. Epistemic vs. aleatoric uncertainty. Data driven vs. physics driven uncertainty modelling. Different approaches such as probabilistic, interval, fuzzy. Introductory probability and statistics, point estimation, hypothesis testing, time series. Modelling: connecting data to the probabilistic models. Discretization of random fields. Tools for uncertainty propagation. Computational aspects of uncertainty propagation.

Debraj Ghosh

Applied Statistics and Probability for Engineers by Douglas C. Montgomery & George C. Runger, John Wiley and Sons, 2010
Current literature

CE 241 (AUG) 3:0
Advanced Structural Dynamics

FE models for dynamics of built-up structures. Integration of equations of equilibrium. Explicit and implicit methods. Treatment of uncertainty in vibration problems. Random process models for loads. Simulation based approaches. Reduction of sampling variance. FE model updating. Bayesian framework for system identification. MCMC samplers. Kalman and particle filters.

C S Manohar

Pre-requisites: CE 210 [Structural Dynamics] or equivalent, and background in probability models.

Yuen, Ka-Veng. Bayesian methods for structural dynamics and civil engineering. John Wiley & Sons, NY, 2010.
Petyt, Maurice. Introduction to finite element vibration analysis. Cambridge University Press, 2010 Cambridge.
Bathe, Klaus-Jürgen. Finite element procedures. PHI, New Delhi, 2006.

CE 242 (AUG) 3:0
Fire structural engineering

Role of structural engineering in fire safety. Introduction to fire dynamics. Models for enclosure fire dynamics. Review of heat transfer and thermo elasticity. Material properties at elevated temperature. Behavior of beams, columns, walls, and slabs at elevated temperature. Thermal buckling. Finite element modeling of structures under fire. Treatment of material and geometric nonlinearities. Joint behavior. Modeling of building frames under fire. Review of fire resistant design. Treatment of uncertainties and concepts of performance based design.

C S Manohar and H S Mukunda

Buchanan, A H 2002, Structural design for fire safety, Wiley, Chichester.
Wang,Y., I Burgess, F Wald, and M Gillie, 2013, Performance-based fire engineering of structures, CRC Press.
Drysdale, D 1998, An introduction to fire dynamics, 2nd Edition, Wiley.
Karlsson, B and J Quintiere. 1999, Enclosure fire dynamics. CRC press, Boca Raton
Quintere, J G 2006, Fundamentals of fire phenomenon. John Wiley.

CE 243 (AUG) 3:0
Bridge Engineering

Bridge types, aesthetics, general design considerations and preliminary design, IRC/ AASHTO design loads, concrete bridge design - reinforced and prestressed girder bridges, steel bridge design Composite bridges, design of bridge bearings, Pier, Abutment and foundation; seismic and wind load analysis, analysis of cable supported bridge systems, bridge inspection and maintenance.

Ananth Ramaswamy

Barker and Puckett Design of Highway Bridges, John Wiley and Sons 2007

Electives in Water Resources and Environmental Engineering

CE 245 (AUG) 3:0
Design of Water Supply and Sewerage Systems

Basics of hydraulics and hydrology. Introductory chemistry and biology. Water distribution systems, water processing, and operation of networks. Design of water supply units, wastewater flows and collection systems, wastewater processing. Advanced wastewater treatment and water reuse.

M S Mohan Kumar

Mark J Hammer & Mark J Hammer Jr., Water and Wastewater Technology, Fifth Edition, Pearson Prentice Hall, Columbus, USA, 2004.

CE 246 (AUG) 3:0
Urban Hydrology

Review of basic hydrology. Storm water runoff generation; return period; hydrologic risk; frequency analysis – IDF relationships; open channel flow in urban watersheds; interception storage, infiltration, depression storage; combined loss models; estimation of runoff rates from urban watersheds; flow routing; storm water drainage structures; storm water detention; structural and non-structural control measures; Source control techniques; urban storm water models. Introduction to urban ground water systems.

P P Mujumdar

Butler, D. & Davies, J.W., Urban Drainage, Spon Press, 2nd Edn., 2004.
Akan A.O and Hioughtalen R.J., Urban Hydrology, Hydraulics and Storm Water Quality – Engineering Applications and Computer Modeling, John Wiley & Sons 2003.
Hall, M.J., Urban Hydrology. Elsevier, 1984.
Shaw, E.M., Hydrology in Practice, 3rd Edn., Chapman & Hall, 1994.

CE 247 (AUG) 3:0
Remote Sensing and GIS for Water Resources & Environmental Engineering

Basic concepts of remote sensing. Airborne and space borne sensors. Digital image processing. Geographic Information System.

Applications to rainfall - runoff modeling. Watershed management. Irrigation management. Vegetation monitoring. Drought and flood monitoring. Environment and ecology. Introduction to digital elevation modeling and Global Positioning System (GPS). Use of relevant software for remote sensing and GIS applications.

D Nagesh Kumar

Lillesand T.M. and Kiefer R.W. Remote Sensing and Image Interpretation, John Wiley & Sons, 2000.
Sabins, F.F. Remote Sensing - Principles and Interpretation, Freeman & Co., New York, 1986.
Heywood, I., Cornelius, S., and Carver, S. An Introduction to Geographical Information Systems, Pearson Education, 1998.

CE 248 (JAN) 3:0
Regionalization in Hydrology and Water Resources Engineering

Prediction in ungauged basins. Regional frequency analysis- probability weighted moments and its variations, stationary and non-stationary distributions, regional goodness-of-fit test. Approaches to regionalization of hydro-meteorological variables and extreme events. Regional homogeneity tests. Prediction of hydro-meteorological variables in gauged and ungauged basins, Estimation of probable maximum precipitation and probable maximum flood, and their use in hydrologic design.

V V Srinivas

Prerequisite : CE 203

Diekkrüger, B., Schröder, U., Kirkby, M. J., Regionalization in Hydrology, IAHS Publication no. 254, 1999.
Hosking, J. R. M., and Wallis, J. R., Regional Frequency Analysis: An Approach Based on L-Moments, Cambridge University Press, 1997.
Rao, A.R. and Srinivas, V.V., Regionalization of Watersheds - An Approach Based on Cluster Analysis, Series: Water Science and Technology Library, Vol. 58, Springer Publishers, 2008.

CE 249 (AUG) 3:0
Water Quality Modeling

Basic characteristics of water quality, stoichiometry and reaction kinetics. Mathematical models of physical systems, completely and incompletely mixed systems. Movement of contaminants in the environment. Water quality modeling in rivers and estuaries - dissolved oxygen and pathogens. Water quality modeling in lakes and ground water systems.

M Sekhar

Chapra, S.C., Surface Water Quality Modeling, McGraw Hill, 1997.
Tchobanoglous, G., and Schroeder, E.D., Water Quality, Addison Wesley, 1987.

M Tech Program in Transportation and Infrastructure Engineering

CE 230 (AUG) 3:0
Pavement Engineering

Introduction to pavement engineering: Design of flexible and rigid pavements; selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria: pavement design of overlays and drainage system: pavement performance evaluation: non-destructive tests for pavement: IRC, AASHTO design codes: maintenance and rehabilitation of pavements

Faculty

Rajib B Mallick and Tahar El-Korchi, Pavement Engineering, Principles and Practice, CRC Press, 2009
Huang, Y.H, Pavement Analysis and Design, Prentice-Hall, New Jersey, 1993.
E. J. Yoder, M. W. Witczak, Principles of Pavement Design, Wiley New York, 1975

CE 263 (AUG) 3:0
Modelling Transport and Traffic

Approaches to travel demand modelling; trip-based modelling approach, activity based travel demand modelling, land use-transport models; traffic flow theory; deterministic and stochastic models of traffic flows; delay and saturation flow models; pedestrian flow modeling; optimization of public transport system

Ashish verma

Ortuzar J. de D. and L.G. Willumsen, Modelling Transport, John Wiley and Sons, 2001.
May, A.D. Traffic Flow Fundamentals, Prentice Hall, 1990

Vuchic Vukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005.

CE 267 (JAN) 3:0
Transportation Statistics and Micro-simulation

Role of statistics in transportation engineering; graphical methods for displaying transportation data; numerical summary measures; random variables in transportation; common probability distributions in transportation; use of sampling and hypothesis testing in transportation; use of ANOVA; regression models for transportation; Bayesian approaches to transportation data analysis; traffic micro-simulation models, analysing micro-simulation outputs, performance measures.

Ashish Verma

Spiegelman,C.H., Park, E.S. and Rilett, L.R. Transportation Statistics and Microsimulation, CRC Press, 2011.
Benjamin J.R. and Cornell, C. A. Probability, Statistics, and Decisions for Civil Engineers, McGraw-Hill Book Company, 1970

CE 269 (AUG) 3:0
Principles of Traffic Engineering

Traffic flow elements and its characterization: vehicle characteristics, human factors, infrastructure elements, capacity and LoS concepts, Highway Capacity Manual (HCM) methods. Uninterrupted Traffic Flow: speed-flow-density relationships, multi-regime models, car-following, lane-changing, simulation framework. Interrupted Traffic Flow: signal design, shock-wave theory, gap-acceptance behavior, delay and queue analysis. Design of traffic facilities: expressways, signalized and un-signalized intersections, interchanges, parking, signs and markings.

Caleb Ronald & Ashish Varma

Roess, R.P., Prassas E.S. & McShane, W.R. (2010), Traffic Engineering, Prentice Hall, USA.
May, A. D. (1990), Traffic Flow Fundamentals, Prentice Hall, USA.
Highway Capacity Manual (2010), Transportation Research Board, USA.
Kadiyali, L. R. (2000), Traffic Engineering and Transport Planning, Khanna Publishers, India.
Salter, R J. & Hounsell, N. B. (1996), Highway Traffic Analysis and Design, Macmillan Education, UK.

CE 270 (AUG) 3:0
Travel Demand Modeling

Individual travel behavior and aggregate-level travel demand analysis; Alternative approaches to modeling travel demand (aggregate, trip-based approaches and disaggregate, activity-based approaches); Econometric methods for modeling travel demand (development, estimation, and application of statistical models for travel behavior analysis); Linear regression for activity and trip generation (specification, interpretation, estimation, hypothesis testing, market segmentation, non-linear specification, tests on assumptions); Mode choice and destination choice using discrete choice methods (introduction to binary logit and multinomial logit models, contrast with gravity methods); Traffic assignment/route choice (network equilibrium, system optimum); Model transferability; Microsimulation for activity-based models; Recent advances.

Abdul R. Pinjari

J. de D. Ortuzar and L.G. Willumsen, Modelling Transport (4th edition), John Wiley and Sons, 2011.
F. Koppelman and C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006.
S. Washington, M. Karlaftis, F. Mannering. Statistical and econometric methods for transportation data analysis (2nd edition), CRC Press, 2010.

CE 271 (Jan) 3:0
Discrete Choice Modeling Methods for Transportation Planning

Individual choice theories; Binary choice models; Unordered multinomial choice models (multinomial logit and multinomial probit); Ordered response models (ordered logit, ordered probit, generalized ordered response); Maximum likelihood estimation; Sampling based estimation (choice-based samples and sampling of alternatives); Multivariate extreme value models (nested logit, cross-nested logit); Mixture models (mixed logit and latent class models); Mixed multinomial probit; Integrated choice and latent variable models; Discrete-

continuous choice models with corner solutions; Applications to travel demand analysis and transportation planning; Recent advances.

Abdul R. Pinjari

Prerequisites: Travel Demand Modeling

F. Koppelman & C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006.
K. Train. Discrete Choice Methods with Simulation (2nd edition), Cambridge University Press, 2009.
M. Ben-Akiva & S.R. Lerman. Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 1985.

CE 272 (JAN) 3:0
Traffic Network Equilibrium

Traffic assignment; Fixed points and Variational inequalities; Fundamentals of convex optimization; Shortest path algorithms; Wardrop user equilibrium; System optimum and Price of Anarchy; Link-based algorithms (Method of successive averages, Frank-Wolfe); Potential games; Variants of the traffic assignment problem (Multiple-classes, Elastic demand); Path-based algorithms; Origin-based methods; Sensitivity analysis.

Tarun Rambha

Sheffi, Y. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods. Prentice Hall, 1985.
Patriksson, M. The traffic assignment problem: models and methods. Courier Dover Publications, 2015.

CE 299 0:22 Dissertation Project

The project work is aimed at training the students to analyze independently problems in geotechnical engineering, water resources and environmental engineering, structural engineering and transportation and infrastructural engineering. The nature of the project could be analytical, computational, experimental, or a combination of the three. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature, and analytical, computational, experimental aptitudes of the student.