CIVIL ENGINEERING

Scheme of Instruction for M Tech Civil Engineering program (2020-21)

M Tech Program in Civil Engineering

Semester 1 Common to all students
Core: 18 Credits
CE 201 3:0 Basic Geomechanics
CE 275 3:0 Transportation Systems Modelling
CE 217 3:0 Fluid Mechanics
CE 204 3:0 Solid Mechanics
CE 205 3:0 Finite Element Method (For the year 2020-21, this course is shifted to the February semester. It remains a core course for all MTech students, irrespective of their major)
CE 211 3:0 Mathematics for Engineers

a) **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.
b) **For optional Minor in one of the other three Areas**, a student must complete minimum of 12 credits in the said Area.

Major in Geotechnical Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE 202 3:0 Foundation Engineering
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 (+ 6 credits from term 1)
CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0 Structural Dynamics
CE 228 3:0 Continuum Plasticity
CE 299 0:22 Dissertation Project

Major in Water Resources Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE 203 3:0 Surface Water Hydrology
CE 213 3:0 Systems Techniques in Water Resources and Environmental Engineering
CE 214 3:0 Ground Water Hydrology
CE 215 3:0 Stochastic Hydrology
CE 299 0:22 Dissertation Project

Major in Transportation Systems Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE 269 3:0 Traffic Engineering
CE 262 3:0 Public Transportation Systems Planning
CE 272 3:0 Traffic Network Equilibrium
CE 235 3:0 Optimization Methods
CE 299 0:22 Dissertation Project

Electives in Geotechnical Engineering

CE 220 3:0 Design of Substructures
CE 221 3:0 Earthquake Geotechnical Engineering
CE 222 3:0 Fundamentals of Soil Behaviour
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering
CE 279 3:0 Computational Geotechnics

Electives in Structural Engineering

CE 216 3:0 Random Vibration and Reliability Analyses
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 234 3:0 Nonlinear analysis in earthquake engineering
CE 235 3:0 Optimization Methods
CE 236 3:0 Fracture Mechanics
CE 239 3:0 Stochastic Structural Dynamics
CE 243 3:0 Bridge Engineering
CE 297 3:0 Problems in the Mathematical Theory of Elasticity
CE 298 3:0 Parallel computing in mechanics problems

Electives in Water Resources Engineering

CE 226 3:0 Open-channel Flow
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 248 3:0 Regionalization in Hydrology and Water Resources Engineering
CE 249 3:0 Water Quality Modelling
CE 277 3:0 Remote Sensing in Ecohydrology
AS 216 3:0 Introduction to Climate Systems

Electives in Transportation Systems Engineering

CE 271 3:0 Choice Modelling
CE 273 3:0 Markov Decision Processes
DS 290 3:0 Modelling and Simulation
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics

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

Tejas 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 275 3:0
Transportation Systems Modelling

Methods – Statistical and econometric methods for transportation data analysis; linear regression for analysis of continuous variable data (assumptions, estimation, specification, interpretation, hypothesis testing, segmentation, non-linear specification, testing of assumptions); discrete outcome models for analysis of categorical data (binary and multinomial choice models, maximum likelihood estimation); entropy methods for analysis of spatial flows; Demand-supply equilibrium; Models of traffic flow; Optimization models to predict traffic volumes;
Applications – analysis of user behaviour in infrastructure systems; travel behaviour, travel demand and supply analysis (modelling the generation, spatial and temporal distribution, modal split, and route choice of travel); analysis of vehicular traffic streams; tools for data analysis and transport modelling.

Abdul R. Pinjari & Tarun Rambha

J. de D. Ortuzar and L.G. Willumsen. Modelling Transport (4th edition), John Wiley and Sons, 2011.
P. Chakroborty and A. Das. Principles of Transportation Engineering (2nd Edition), PHI Learning Private, Ltd., 2017
F. Koppelman and C.R. Bhat. A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006.

CE 217 (AUG) 3:0
Fluid Mechanics

Vectors and tensors, divergence theorem, pressure, Archimedes principle, fluid mass conservation, heat and contaminant conservation, momentum conservation and Cauchy equation, stress tensor, constitutive relation for Newtonian fluids, Navier-Stokes equations, vorticity, laminar plane couette and open channel flow, Euler equations, potential flow approximation, simple solutions of potential flows, laminar flow in pipes and channels, transition to turbulence Reynolds stress and fluxes, laminar boundary layer, laminar bottom dense flows.

Debsunder Dutta

Kundu, Cohen and Dowling Fluid Mechanics, Sixth Ed., Academic Press, 2016.White, F.M. Fluid Mechanics, F.M., Eighth Edition, McGraw Hill, 2016.

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 (FEB) 3:0

Finite Element Method

Concepts of the stiffness method. Energy principles. Continuum BVP and their integral formulation. Variational methods: Raleigh-Ritz, weighted residual methods, virtual work and weak formulations. Finite element formulation of one, two and three dimensional problems, Isoparametric formulation. Computational aspects and applications, Introduction to non-linear problems.

J M Chandra Kishen

Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method: Vol. 1 (The Basis), Butterworth-Heinemann, 2000.
Cook R.D.. Malkus, D. S., Plesha and Witt, R.J., Concepts and Applications of Finite Element Analysis, Fourth edition, John
Wiley and Sons.
J N Reddy, An Introduction to the Finite Element Method, Second Edition, McGraw Hill Inc, 1993.

CE 211 (AUG) 3:0

Mathematics for Engineers

Revision of ordinary linear ODEs, Formal operators, Adjoint operator, Sturm-Liouville theory, eigenvalue problems, Classification of PDEs, Characteristics / first order PDEs, Laplace equation / potential theory, Separation of variables (cartesian, polar), Eigenfunction expansions, Green's functions, Introduction to boundary value problems
Probability space and axioms of probability. Conditional probability. Total probability and Bayes theorems. Scalar and vector random variables. Probability distribution and density functions. Expectation operator. Functions of random variables.
Vector spaces and subspaces, solution of linear systems, Linear independence, basis, and dimension, The four fundamental subspaces, Linear transformations, Orthogonal vectors and subspaces, Cosines and projections onto lines, Projections and least squares, The fast Fourier transform, Eigenvalues and eigenvectors, Diagonalization of a matrix, Difference equations and powers of matrices, Similarity transformations.

Debraj Ghosh & Tarun Rambha

Michael Stone, Paul Goldbart, 2009, Mathematics for Physics: A Guided Tour for Graduate Students, Cambridge University Press
Papoulis A and Pillai, S U., 2002, Probability, random variables and stochastic processes, Mc Graw-Hill, Boston
Strang Gilbert, 2013, Linear Algebra and Its Applications, India Edition (4th), CENGAGE LEARNING

<u>Major in Geotechnical Engineering</u>

CE 202 (JAN) 3:0
Foundation Engineering

Subsurface investigations, 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.

Tejas G Murthy

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 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 Madhavi Latha

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.

<u>Major in Structural Engineering</u>

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.

Ananth Ramaswamy

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
Continuum Plasticity

Brief reviews of finite deformation kinematics and constitutive closure; introduction to rational thermodynamics and formulation of constitutive theories; internal variables; dissipation inequality; physics of yielding; plastic flow and hardening; notion of yield surface; classical models for yielding; plastic flow and hardening; additive and multiplicative splitting of kinematic quantities; solutions of simple BVPs; FEM for small deformation plasticity; yield free plasticity models; linearization and computational schemes; introduction to damage mechanics.

Prerequisites: A graduate level course in solid mechanics or continuum mechanics.

Debasish Roy

A S Khan, S Huang, 1995, Continuum Theory of Plasticity, John Wiley, NY
J Lubliner, 2008. Plasticity theory. Courier Corporation.
M E Gurtin, L Anand, 2012, The Mechanics and Thermodynamics of Continua, Cambridge University Press, UK
Simo, J. C., & Hughes, T. J., 2006, Computational inelasticity, Springer Science & Business Media.

Major in Water Resources Engineering

CE 203 (JAN) 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 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

Major in Transportation Systems Engineering

CE 269 (Jan) 3:0
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.

Tarun Rambha

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 262 (Jan) 3:0
Public Transportation Systems Planning

Modes of public transportation and application of each to urban travel needs; comparison of transit modes and selection of technology for transit service; transit planning, estimating demand in transit planning studies, demand modeling, development of generalized cost, RP & SP data and analysis techniques; functional design and costing of transit routes, models for planning of transit routes, scheduling; management and operations of transit systems; integrated public transport planning; operational, institutional, and physical integration; models for integrated planning; case studies.

Ashish Verma

A. Verma and T. V. Ramanayya, Public Transport Planning and Management in Developing Countries, CRC Press, 2014
VuchicVukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005.
Gray G. E., and Hoel L. A., Public Transportation, Prentice Hall, 1992.

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 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.

<u>Electives in Geotechnical Engineering</u>

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 221 (Aug) 3:0
Earthquake Geotechnical Engineering

Introduction to engineering seismology. Plate tectonics. Earthquake magnitude. Ground motion. Effect of local soil conditions on ground motion. Dynamic behaviour of soils. Analysis of seismic site response. Liquefaction phenomena and analysis of pore pressure development. Laboratory and in-situ testing for seismic loading. Analysis and design of slopes, embankments, foundations and earth retaining structures for seismic loading. Case histories. Mitigation techniques and computer-aided analysis

G Madhavi Latha

Geotechnical Earthquake Engineering By Steven L. Kramer, Pearson Education, 2003. Geotechnical Earthquake Engineering Handbook, Robert W. Day, McGraw-Hill, 2002.

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 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 279 (JAN) 3:0
Computational Geotechnics

Introduce governing equations for geotechnical engineering problems, basics of solving governing equations using frequency and time domain numerical methods including finite element and finite difference methods, soil constitutive modeling, examples of coding/solving geotechnical engineering problems using the above methods/tools.

Swetha Veeraraghavan

Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1982.
Wood, D.M., Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, New York, 1990.
Hai-Sui Yu, Plasticity and Geotechnics, Springer, 2006
Desai, C.S. and Christian, J.T. Eds. Numerical Methods in Geotechnical Engineering, McGraw-Hill, 1977.

<u>Electives in Structural Engineering</u>

CE 216 (Aug) 3:0
Random Vibration and Reliability Analyses

Review of probability: probability space and random variables. Review of random processes: stationarity, ergodictiy, power spectrum and autocovariance. Calculus of random processes. Input-output relations for linear systems. Stochastic steady state. Level crossing and first passage problems. Extreme value distributions. Reliability index based analyses: FORM and SORM. Monte Carlo simulations and variance reduction. Reliability of existing structures.

C S Manohar

Prerequisites: Background in structural dynamics and theory of probability

A Papoulis, 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York
N C Nigam, 1983, Introduction to random vibrations, MIT press, Cambridge
R E Melchers, 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley, Chichester.

CE 229 (JAN) 3:0
Non-Destructive Evaluation Methods for Concrete Structures

Planning and interpretation of in-situ testing of concrete structures; Surface hardness methods; Fundamental bases and methodologies of non-destructive evaluation (NDE) techniques related to concrete structures; NDE methods for concrete testing based on sounding: Acoustic emission (AE) testing of concrete structures; NDE methods for concrete testing based on sounding: Ultrasonic pulse velocity (UPV) methods; Partially destructive strength tests related to concrete; cores; Examples of UPV corrections for reinforcement; examples of evaluation of core results

R Vidya Sagar

J. H. Bungey and S. G. Millard (1996) Testing of concrete in structures. Blackie Academic & Professional, 1996, chapman & Hall publishers.
V. M. Malhotra and N. J. Carino (2005) Handbook on Nondestructive Testing of Concrete Ed. by V.M. Malhotra and N.J. Carino., CRC publishers.
C. V. Subramanian (2016) Practical Ultrasonics., Narosa publishers
C. U. Gross and M. Ohtsu (2008) Acoustic Emission Testing., Springer-Verlag Berlin Heidelberg
JSNDI (2016) Practical Acoustic Emission testing. Springer Japan 2016.

CE 234 (Aug) 3:0
Nonlinear Analysis in Earthquake Engineering

Earthquake load specification via time histories and response spectra. Seismic hazard. Spectrum compatible accelerograms. Numerical integration of equations of motion. Geometric and material nonlinear behaviour. Characterization of hysteresis, strength and stiffness degradations, pinching, and residual deformations. Oscillator models for inelastic behaviour. Internal variables. Energy dissipation characteristics. Models for seismic demands and capacities. Inelastic response spectrum. Ductility demand and yield capacity. P- □ effects. Global damage indices. Oscillator and FE based models for buildings and bridges under earthquake loads. Vibration isolation. Soil-structure interactions. Seismic collapse capacity using nonlinear static and incremental dynamic analyses. Capacity spectrum. Seismic fragility and vulnerability analyses. Performance based earthquake engineering formats.

Prerequisites: Background in linear structural dynamics and FEM

C S Manohar

Chopra, A K, 1996, Dynamics of structures, Prentice Hall, New Dehli.
Villaverde, R, 2009, Fundamental concepts of earthquake engineering, CRC Press, Boca Raton.
Elnashai A S, and L D Sarno, 2008, Fundamentals of earthquake engineering, Wiley, Chichester.
Current literature

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

Introduction; Linear Elastic Fracture Mechanics; Design based on LEFM; Elasto-Plastic Fracture Mechanics; Mixed Mode Crack Propagation; Fatigue Crack Propagation; Finite Elements in Fracture Mechanics.

R Vidya Sagar

T. L. Anderson, Fracture Mechanics, CRC press, Fourth Edition, 2017, Boca Raton, Florida
David Broek, Elementary Fracture Mechanics, Sijthoff and Noordhoff, The Netherlands.
Prashanth Kumar, Elements of Fracture Mechanics, Wheeler Publishing, New Delhi.
J. F. Knott, Fundamentals of Fracture Mechanics, Butterworths, London.

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.

Debasish 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 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

CE 297 (**JAN**) **3:0**
Problems in the Mathematical Theory of Elasticity

Introduction: Review of linear elasticity, equilibrium, compatibility, statements of 2D (plane strain / plane stress) and 3D elastic BVPs, Review of Airy stress functions. Functions of a complex variable: Introduction to holomorphic and sectionally holomorphic functions. Laurent series, contour integrals, generalized Cauchy integral formulae. Bi-harmonic equation in the complex plane. Kolosov-Muskhelishvili formulation for planar elasticity. Conformal mapping. The Riemann-Hilbert problem. Analysis of selected problems using complex variable methods: Plate with an elliptic hole. The slit infinite plane. Singular and distributed solutions for halfplanes, disks, and plates with holes. Contact of a rigid punch and halfplane. Multivalued displacements and disloca-tions. 3D linear elasticity problems: Papkovich-Neuber formulation. Boussinesq potentials. Kel-vin's problem. The Boussinesq solution. The Hertz contact problem. Galin's theorem. Introduction to micromechanics: Eshelby's ellipsoidal inclusion problem. Planar inclusions. Other topics as time permits (e.g. anisotropic elasticity)

Prerequisites : Graduate-level solid mechanics (CE-204 / ME-242 or equivalent) with a grade of B or higher, or instructor consent.

Narayan K Sundaram

Current and historic literature

CE 298 (JAN) 3:0
Parallel computing in mechanics problems

Introduction to parallel computing. Parallelization using MPI. Parallel operations on vectors and matrices; linear systems solving and eigenvalue problems. Substructuring and domain decomposition. Parallelization in statistical simulation.

Prerequisites: Programming experience using one of the languages among C/C++/Fortran. Familiarity with Linux/Unix.

Debraj Ghosh

Karniadakis, G E and Kirby II, (2003) R M, Parallel Scientific Computing in C++ and MPI, Cambridge.

Electives in Water Resources Engineering

CE 226 (AUG) 3:0
Open-channel Flow

Basic Concepts of Fluid Mechanics, Introduction to Open-channel Flow, Uniform Flow, Non-uniform Flow: Gradually Varied, Non-uniform Flow: Rapidly Varied, Spatially Varied Flow, Unsteady Flow, Pollutant Transport in Open Channels.

P P Mujumdar

Chow, V. T., Open-channel hydraulics. Vol. 1. New York: McGraw-Hill, 1959.
Chaudhry, M. Hanif. Open-channel flow. Springer Science & Business Media, 2007.
Srivastava, Rajesh. Flow through open channels. Oxford Higher Education, 2008.

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

Prerequisites: : 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.

CE 277 (JAN) 3:0

Remote Sensing in Ecohydrology

Introduction to ecohydrology, fundamentals of exchange of energy and water in terrestrial ecosystems, soil temperature and moisture, surface energy fluxes, modeling leaf photosynthesis and stomatal conductance, introduction to plant canopies and radiation regime, soil, plant atmosphere continuum, fundamentals of optical remote sensing, remote sensing of vegetation composition, structure and function, applications of remote sensing to coupled water and carbon cycles in terrestrial ecosystems.

Debsunder Dutta

Ecological Climatology, 3rd Edition, Gordon Bonan, Cambridge University Press. An Introduction to Environmental Biophysics, 1998, G.S. Campbell, J. Norman, Springer. Remote Sensing and Image Interpretation, 2015, Lilliesand, Thomas and Chipman, John Wiley &

Sons. Some current and previous literature on remote sensing and modeling.

Electives in Transportation Systems Engineering

CE 271 (Jan) 3:0
Choice Modeling

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; rank-ordered data models); 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; Alternative estimation methods (EM, analytic approximations, simulation); Applications to travel demand analysis.

Abdul R. Pinjari

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 273 (Aug) 3-0

Markov Decision Processes

Discrete time Markov chains; Transient and limiting behavior; Finite horizon MDPs; Backward induction; Infinite horizon models; Discounted, average, and total cost MDPs; Value and policy iteration; Linear programming methods; Approximate dynamic programming; Reinforcement learning; Inverse models; Applications such as shortest paths, airline ticketing, dynamic pricing, adaptive signal control, and demand estimation.

Tarun Rambha

Puterman, M. L. (2014). Markov decision processes: discrete stochastic dynamic programming. John Wiley & Sons.
Bertsekas, D. P. (1995). Dynamic programming and optimal control (Vol. 1, No. 2). Belmont, MA: Athena scientific.
Kulkarni, V. G. (2016). Modeling and analysis of stochastic systems. CRC Press.