MTech Course Structure for Structural Engineering (July 2011 onwards)

1. First Semester

CE 501 Continuum Mechanics	3	0	0	6
CE 502 Finite Element Method	3	0	0	6
CE 503 Structural Dynamics	3	0	0	6
CE 512 Structural Engineering Laboratory	0	0	3	3
Elective I*	3	0	0	6
Total	**12**	**0**	**3**	**27**

*Open Elective

2. Second Semester

CE 504 Advanced Structural Design	3	0	0	6
CE 511 Analysis and Design of Bridges	3	0	0	6
Elective II**	3	0	0	6
Elective III**	3	0	0	6
Elective IV**	3	0	0	6
Total	**15**	**0**	**0**	**30**

**Open Elective

3. Third Semester

CE 698 Project & thesis phase I	0	0	24	24

4. Fourth Semester

CE 699 Project & thesis phase II	0	0	24	24
Total credits	**27**	**0**	**51**	**105**

Open Elective (Electives I, II, III and IV)

Students can opt any masters-level elective course within the department or outside the department.

Courses for Elective I

- CE 601 Numerical Methods 3 0 0 6
- CE 602 Optimization Methods 3 0 0 6
- CE 669 Advanced Mathematics for Engineers 3 0 0 6
- CE 513 Statistical Methods in Civil Engineering 3 0 0 6
- CE 514 Plates, Shells and Elastic Stability 3 0 0 6

Courses for Electives II, III and IV

- CE 603 Fuzzy Logic and Artificial Intelligence in Civil Engg. Applications 3 0 0 6
- CE 604 Mechanics of Composite Materials 3 0 0 6
- CE 605 Computer Aided Design 3 0 0 6
- CE 606 Earthquake Engineering 3 0 0 6
- CE 607 Random Vibration 3 0 0 6
- CE 608 Reliability based Structural Design 3 0 0 6
- CE 609 Computation Plasticity 3 0 0 6
- CE 610 Computational Structural Mechanics 3 0 0 6
- CE 611 Dynamics of Bridges 3 0 0 6
- CE 612 Advanced Concrete Technology 3 0 0 6
- CE 613 Engineering Fracture and Fatigue Mechanics 3 0 0 6
- CE 614 Financing Infrastructure Projects 3 0 0 6

CE 501 Continuum Mechanics (3-0-0-6)

Pre-requisite: Nil

Basic concepts of the theory of continuous media; introduction to tensor algebra; theory of stresses; infinitesimal and finite strains; strain-displacement relationships; compatibility; stress-strain relationships; boundary value problem in elasticity; plane stress and plane strain case; stress function approaches; plane problems in Cartesian and polar coordinates; elements of plasticity; yield criteria; flow rule and hardening. Plastic stress-strain relationships; variational methods; Introduction to Hamilton's principles; Rayleigh-Ritz and Weighted residual methods; Introduction to thin plates; stability theory; torsion of non-circular sections.

Texts

1. D.S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Prism Books Pvt. Ltd., Bangalore, 1994.
2. S. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw Hill Book Company, International Ed, 1970.

References

1. I. H. Shames and F. A. Cozzarellie, Elastic and Inelastic Stress Analysis, Prentice Hall New Jersey 1992.
2. S.P. Timoshenko and S.W. Krieger, Theory of Plates and Shells, McGraw Hill International Ed, 1959.

CE 502 Finite Element Method (3-0-0-6)

Pre-requisite: Nil

Introduction to FEM; governing equation and its solution approximations (e.g. Collocation, Least Squares, Galerkin's method, the Ritz method); introduction to calculus of variations; concept of discretization of structures and shape functions; Lagrangian and serendipity elements; isoparametric formulation. Analysis of framed structures: plane stress and plane strain problems; axisymmetric problems; 3D stress analysis; analysis of plate and shell. Numerical integration and order of integration: error analysis and convergence; computer implementations of algorithms. Application of FEM in dynamics: eigenvalues and orthogonality.

Texts

1. J.N. Reddy, An Introduction to the Finite Element Method, Tata McGraw Hill, 2nd Ed, 2003.
2. C.S. Krishnamoorthy, Finite Elements Analysis: Theory and Programming, Tata McGraw Hill, 2nd Ed, 1994.

References

1. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 4th Ed, 2002.
2. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, Finite Element Method Its Basis and Fundamentals, Elsevier, 6th Ed, 2005.
3. S.S. Rao, Finite Element Method in Engineering, Butterworth Heinemann, 3rd Ed, 1999.
4. M.B. Kanchi, Matrix Method of Structural Analysis, Wiley Eastern Limited, 2nd Ed, 1993.
5. K.J. Bathe, Finite Element Procedures, Prentice Hall of India Pvt. Ltd., 2002.

CE 503 Structural Dynamics (3-0-0-6)

Pre-requisite: Nil

SDOF systems: Equations of Motion, Free vibration, damping, Forced vibrations under harmonic, impulse and general loadings, Response spectrum Generalized SDOF systems: Rigid body distributed mass and stiffness systems; MDOF Systems: Dynamic properties, modal damping, classical damping, modal superposition methods; Numerical methods in dynamics: Eigen value analysis, direct integration scheme: Continuous systems: Equations of motion, Hamilton's principle, Lagrangian formulation, Free and force vibration scheme, Wave propagation; Introduction to Random vibration: Random variables, Random process, moment and characteristic function, spectral analysis, response to random excitation; Application of structural dynamics in the design of block and frame foundation.

Texts/References

1. R.W. Clough and J. Penzien, Dynamics of Structures, Second edition, McGraw Hill international edition, 1993.
2. Mario Paz, Structural dynamics, CBS Publishers 1987.
3. Anil K. Chopra, Dynamics of structures: Theory and applications to earthquake engineering, PHI Ltd., 1997.
4. K. Rao, Vibration analysis and foundation dynamics, Wheeler, 1998.
5. E. Siniu and R. H. Scanlan, Wind effects on structures: fundamentals and applications to design, John Wiley and Sons, 1997.

CE 504 Advanced Structural Design (3-0-0-6)

Pre-requisite: Nil

Design philosophy, modeling of loads, material characteristics.
Reinforced Concrete -- P-M, M-phi relationships; strut-and-tie method; design of deep beam and corbel; design of shear walls; compression field theory for shear design; design against torsion; Indian and ACI Standards; Eurocode.
Steel structures -- stability design; torsional buckling (pure, flexural and lateral); design of beam-columns; fatigue resistant design; Indian and AISC Standards; Eurocode.

Texts

1. S.U. Pillai and D. Menon, Reinforced Concrete Design, Tata McGraw-Hill, 3rd Ed, 1999.
2. N. Subramaniam, Design of Steel Structures, Oxford University Press, 2008.

References

1. S. Chandrasekaran, L. Nunziante, G. Serino and F. Carannante, Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures, Taylor and Francis, 2010.
2. R. Ranganathan, Structural Reliability: Analysis and Design, Jaico Publishers, 1999.
3. R. Park and T. Paulay, Reinforced Concrete Structures, John Wiley & Sons, 1995.
4. P.C. Varghese, Advanced Reinforced Concrete Design, Prentice Hall of India, 2nd Ed, 2005.
5. C-K Wang, C.H. Solomon and J. A. Pincheira, Reinforced Concrete Design, John Wiley and Sons, 7th Ed, 2007.
6. J.G. MacGregor and J.K. Wight, Reinforced Concrete: Mechanics and Design, Pearson Education, 5th Ed, 2008.
7. T.T.C. Hsu and Y.L. Mo, Unified Theory of Concrete Structures, John Wiley & Sons, 2010.
8. C.G. Salmon, J.E. Johnson and F.A. Malhas, Steel Structures Design and Behavior Emphasizing Load and Resistance Factor Design, Pearson Education, 5th Ed, 2009.
9. IS 456: 2000 – Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standards, 2000.

10. SP 34: 1987 – Handbook of Concrete reinforcement and Detailing, Bureau of Indian Standards, 1987.
11. IS 800: 2007 – General Construction in Steel - Code of Practice, Bureau of Indian Standards, 2007.
12. ACI 318:2008 – Building Code Requirements for Structural Concrete, American Concrete Institute, 2008.
13. Specification for Structural Steel Buildings, American Institute of Steel Construction, 2005.
14. Eurocode 2 Part 1-1, BS EN 1992-1-1 Common Rules for Buildings and Civil Engineering Structures, The Institution of Structural Engineers, 2004.
15. Eurocode 3 Part 1-1, BS EN 1993-1-1 Design of Steel Structures General Rules and Rules for Buildings, The Institution of Structural Engineers, 2004.

CE 511 Analysis and Design of Bridges (3-0-0-6)

Pre-requisite: CE 503 Structural Dynamics

Types of bridges; structural configurations; bridge loading standards in India and other countries (IRC, IRS and AASHTO guidelines); Impact effect; Standard specifications for road and railway bridges; analysis of bridge deck.
Reinforced concrete bridges -- design of deck slab; T-beam bridge; balanced cantilever type; design and details of articulation.
Prestressed concrete bridges -- Pretensioned and post tensioned concrete bridges; analysis of section for flexure, shear and bond; losses in prestress, deflection of girder; partial prestressing; analysis and design of anchorage block; box girder bridge.
Steel bridges -- steel-concrete composite constructions, shear connectors and their design; types of bearings and layout.
Abutment and piers -- scour at abutment and piers; types of foundations; analysis for stresses and design; introduction to soil-structure interaction.
Numerical modeling and analysis; introduction to earthquake resistant design of bridges.

Texts

1. D. J. Victor, Essentials of Bridge Engineering, Oxford IBH, 1980.
2. V. K. Raina, Concrete Bridge Practice Analysis Design and Economics, Tata McGraw Hill, 2nd Ed, 1994.

References

1. N. Rajagopalan, Bridge Superstructure, Narosa Publishing House, 2006.
2. W. F. Chen and L. Duan, Bridge Engineering Handbook, CRC press, 2003.
3. B. Bakht and L.G. Jaeger, Bridge Analysis Simplified, McGraw Hill, 1987.
4. E. J. O'Brien, and D. L. Keogh, Bridge Deck Analysis, Taylor and Francis, 1999.
5. H. Eggert and W. Kauschke, Structural Bearings, Ernst & Sohn, 2002.
6. T. Y. Lin and N. H. Burns, Design of Prestressed Concrete Structures, John Wiley and Sons, 1981.
7. L. Fryba, Dynamics of Railway Bridges, Thomas Telford, 1996.

CE 512 Structural Engineering Laboratory (0-0-3-3)

Pre-requisite: Nil

List of experiments: (a) Mix design for high strength concrete, use of admixture/plasticizer; (b) Non destructive evaluation of strength of concrete/steel specimens; (c) Study of loading and response measuring systems; (d) Testing of beams subjected to transverse (static/dynamic) loading; (e) Testing of prestressed concrete beams; (f) Testing of slab – study of flexural and punching failure; (g) Free and forced vibration studies using FFT analyser; (h) Loading and deflection measurement in a space truss system; (i) Natural frequencies and mode shapes of structures; (j) Evaluation of structural damping.

Texts/References

1. H.G. Harris and G.M. Sabnis, Structural Modeling and Experimental Techniques, 2nd Ed, CRC Press, 1999.
2. E. Bray and R. K. Stanley, Non Destructive Evaluation, CRC Press, 2002.
3. J.W. Dally and W.F. Riley, Experimental Stress Analysis, McGraw Hill, 3rd Ed, 1991.
4. J.F. Doyle, Modern Experimental Stress Analysis, John Wiley and Sons, 2004.
5. P.C. Aitcin, High-Performance Concrete, E & FN SPON, 1998.

CE 513 Statistical Methods in Civil Engineering (3-0-0-6)

Pre-requisite: Nil

Charts & Diagrams; Measures of Central Tendency & Measures of Dispersions and their applications in Civil Engineering; Percentile Ranks and Percentiles; Concept of Standardization; Applications of Scatter Plots; Covariance; Correlation Coefficients and their Properties in field data; Curve Fitting & Least Square Techniques and their use in the experimental methods in Civil Engineering; Concept of Regressions; Regression curve in Bivariate Frequency Distributions; Introduction to probability and set theory; Probabilistic measures; Conditional probability and Bayes' theorem; Discrete and continuous random variables; Probability Density Functions; Probability Distributions of Single and Multiple Random Variables; Discrete & continuous distributions; Chi-Square Test; Kolmogorov-Smirnov Test; Analysis of Variance; Conditional distributions and independence; Expectations and Moments and their applications in Random Vibrations and other fields of Civil Engineering; Random Processes and their properties; Some important Random Processes and their applications in Civil Engineering.

Texts

1. Applied Statistics and Probability for Engineers by Douglas C. Montgomery and George C. Runger, Wiley India Pvt. Ltd, 2009.
2. David Asquith, Statistics: From Concept to Practice, Lynne Rienner Publishers Inc., 2010.

References

1. S. Bendat and A. G. Piersol, Random Data: Measurements and Analysis, John Wiley and Sons, 2010.
2. 3.W. Mendenhall and T. Sincich, Statistics for Engineering and the Sciences, Prentice-Hall, 2000.
4. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, Brooke & Cole, 2009.

CE 514 Plates, Shells and Elastic Stability (3-0-0-6)

Pre-requisite: CE 202 Solid Mechanics

Bending of thin plates --- assumptions; governing differential equations in Cartesian coordinate system; boundary conditions; analytical solutions for rectangular plates by Navier and Levy's methods; distributed and concentrated loads; Circular plates: governing differential equations in polar coordinate system, annular plate, rotationally symmetric loading, eccentric concentrated load; simultaneous bending and stretching of thin plates; introduction to large deflection theory of plates.

Shells --- geometry and classifications; stress resultants; membrane theory and its applications to shells of surface of revolutions; membrane theory for cylindrical shell; general theory in bending of cylindrical shell; simplified method for cylindrical shell.
Elastic stability of columns --- eigenvalue problem; buckling modes and critical load; beam-columns; beam-columns with elastic restraints; effect of initial curvature; buckling of bar on elastic foundation; buckling of frames; inelastic stability; lateral buckling of beams in pure bending; torsional buckling; combined flexural-torsional buckling.
Buckling of thin plates; rectangular plates under uniaxial and biaxial compression; combined bending and compression; shear bucking; application of energy methods for calculation of buckling loads and modes.

Texts/References

1. G. S. Ramaswami, Design and Construction of Concrete Shell Roofs, CBS Publishers, New Delhi, 2004.
2. M. L. Gambhir, Stability Analysis and Design of Structure, Springer, 2009.
3. S. P. Timoshenko and W. W. Krieger, Theory of Plates and Shells, McGraw Hill, 2nd Ed, 1964.
4. R. Szilard, Theory and Analysis of Plates - Classical and Numerical Methods, John Wiley and Sons, 2004.
5. A. Zingoni, Shell Structures in Civil and Mechanical Engineering, Thomas Telford, 1997.
6. S. P. Timoshenko and J. M. Gere, Theory of Elastic Stability, Dover Publications, 2nd Ed, 2009.
7. A. Chajes, Principles of Structural Stability Theory, Pearson Education Limited, 1993.

CE 601 Numerical methods (3-0-0-6)

Pre-requisite: Nil

Linear equations and eigenvalue problems, Accuracy of approximate calculations, Nonlinear equations, interpolation, differentiation and evaluation of single and multiple integrals, initial and boundary value problems by finite difference method, Newton’s method, variation and weighted residual methods, introduction to finite element methods, fundamental of statistical distribution.

Texts/References

1. J. B. Scarborough, Numerical Mathematical Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., 2000.
2. K. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical Methods - Problem and Solutions, Wiley India Pvt. Ltd, 2001.
3. R.W. Hamming, Numerical Methods for Scientist and Engineers, McGraw Hill, 1998.
4. J. H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Education, 2004.
5. A. J. Hayter, Probability and Statistics, Duxbury, 2002.

CE 602 Optimization Methods (3-0-0-6)

Pre-requisite: Nil

Basics of engineering analysis and design, Need for optimal design, formulation of optimal design problems, basic difficulties associated with solution of optimal problems, Classical optimization methods, necessary and sufficient optimality criteria for unconstrained and constrained problems, Kuhn-Tucker conditions, Global optimality and convex analysis, Linear optimal problems, Simplex method, Introduction to Karmarkar’s algorithm. Numerical methods for nonlinear unconstrained and constrained problems, sensitivity analysis, Linear post optimal analysis, sensitivity analysis of discrete and distributed systems. Introduction to variational methods of sensitivity analysis, shape sensitivity, Introduction to integer programming, dynamic programming, stochastic programming and geometric programming, Introduction to genetic algorithm and simulated annealing.

Texts/References

1. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and examples, Prentice Hall India Pvt. Ltd, 1998.
2. J.S. Arora, Introduction to Optimum Design, McGraw Hill International Ed., 1989.
3. R.T. Hafta and Z. Gurdal, Elements of Structural Optimization, 3rd Ed., Kluwer academic publishers, 1996.

CE 603 Fuzzy Logic and Artificial Intelligence in Civil Engineering Applications (3-0-0-6)

Pre-requisite: Nil

Introduction - Classification of artificial intelligence-expert systems-artificial neural networks-basic concepts, uses in functional approximation and optimization-applications in the design and analysis, building construction. Fuzzy logic - basic concepts - problem formulation using fuzzy logic - applications.

Texts/References

1. D.E. Rumelhart and J.L. McClelland, Parallel Distributed Processing, Vol. 1, MIT Press, 1986.
2. M.J. Patyra and D.J. Mlynek, Fuzzy Logic Implementation and Applications, Wiley Teubner, 1996.

CE 604 Mechanics of Composite Materials (3-0-0-6)

Pre-requisite: Nil

Composites, Various reinforcements and matrix materials, Strength and stiffness properties, Effective moduli, spherical inclusions, cylindrical and lamellar systems, Laminates: Laminated plates, analysis, strength and design with composites, Fibre reinforced pressure vessels, Dynamic inelastic and nonlinear effects, Technological applications.

Texts/References

1. R. M. Jones, Mechanics of Composite Materials, McGraw Hill, 1988.
2. J.N. Reddy, Mechanics of Laminated Composite Plates, CRC Press, 1999.
3. B.D. Agrawal and Broutman, Analysis of Performance of Fibre Composites, John Wiley and Sons, 1990.

CE 605 Computer Aided Design (3-0-0-6)

Pre-requisite: Nil

Principles of computer aided design, computer configuration for CAD applications, Computer peripherals for CAD. Computer graphics fundamentals, points and lines, Three dimensional transformations and projections, plane curve, space curves surface descriptions and generation, Hidden line algorithms for wireframe modeling, Surface modeling, Solid modeling, Representation of 3D objects. B-rep solid modelers and constructive solid geometry, CAD system utilization and application Hidden surface algorithms and Shading, Finite element systems, Computer aided drafting system.

Texts/References

1. David F. Rogers. Mathematical Elements for Computer Graphics, Mcgraw Hill, 1990.
2. David F. Rogers, Elements of Computer Graphics, McGraw Hill Int. Ed., 1988.
3. Michael E. Mortenson, Geometric Modeling, John Wiley and Sons, 1989.

CE 606 Earthquake Engineering (3-0-0-6)

Pre-requisite: CE 503 Structural Dynamics

Earthquakes: Causes, Magnitude and Intensity, Ground Motions, Site effects, Sensors; Response spectrum: Construction, Characteristics, Design Response spectrum; Linear Earthquake analysis: Idealization of structures, Response spectrum analysis, Torsionally coupled systems, Frequency domain analysis, Time domain analysis; Nonlinear Earthquake analysis : Force-deformation relationships, Equation of motion, Controlling parameters, Ductility demand, Allowable ductility; Earthquake resistance design: philosophy ductility based design, Detailing provisions, Codal Provisions, Concepts of passive controls; Geotechnical aspects: Dynamic properties of soil, dynamic earth pressures, Liquefaction and ground improvement techniques; Retrofitting and strengthening of Buildings and Bridges.

Text/ References

1. R.W. Clough and J. Penzien, Dynamics of Structures, McGraw Hill, 2nd Ed., 1993.
2. M. Paz, Dynamics of Structures, CBS Pub., 1987.
3. A. K. Chopra, Dynamics of Structures - Theory and application to earthquake engineering, Pearson Education, 3rd edition, 2007.
4. T. Paulay and M.S.N. Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1992.
5. M. N. S. Priestley, F. Seible and G.M. Calvi, Seismic Design and Retrofit of Bridges, John Wiley and Sons, 1996.
6. D. J. Dowrick, Earthquake Resistant Design for Engineers and Architects, John Wiley and Sons, 1987.

CE 607 Random Vibration (3-0-0-6)

Pre-requisite: CE 503 Structural Dynamics

Concepts of probability, random variables, theory of random process, stationary and non-stationary process, Expected values, moments, spectral properties of random process, Response of linear systems to random excitations, SDF and MDF discrete systems, Continuous systems, Response of nonlinear systems to random excitations. Fokker-plank equations, Markov vector approach, statistical linearization and perturbation techniques. Level crossing, Peaks envelops and first passage time, Monte-Carlo simulation.

Texts/References

1. N.C. Nigam, Introduction to Random Vibration, MIT Cambridge, 1983.
2. Y.K. Lin, Probabilistic Theory of Structural Dynamics, McGraw Hill, New York, 1967.
3. D.E. Newland, Random Vibration and Spectral Analysis, Longman New York, 1984.

CE 608 Reliability based structural design (3-0-0-6)

Pre-requisite: Nil

Concepts of structural safety, basic statistics and probability, resistance parameters and distributions, probabilistic analysis of loads, live load and wind load determination of reliability, Monte-Carlo study of structural safety, Level 2 reliability methods including advanced level 2 method, reliability analysis of components, Reliability based design determination of partial safety factors, code calibration, reliability structural systems, applications to steel and concrete structures, Offshore structures etc.

Texts/References

1. P. Thoft-Christensen and M.J. Baker, Structural Reliability Theory and its Applications, Springer Verlag, 1982.
2. R.E. Melchers and Ellis Horwood, Structural Reliability and Prediction, John Wiley and Sons Ltd., 1987.
3. A.H.S. Ang and W. H. Tang, Probability Concepts in Engineering Planning and Design, Vol. II, John Wiley and Sons, New York, 1984.
4. P. Thoft-Christensen and Y. Murotsu, Applications of Structural Systems Reliability Theory, Springer Verlag, 1986.

CE 609 Computational Plasticity (3-0-0-6)

Pre-requisite: CE 501 Continuum Mechanics, CE 502 Finite Element Method

Experimental behaviour of metals and other materials under monotonic and cyclic loading, One dimensional mathematical modeling and its computational implementation, Yield criteria for different materials in multiaxial conditions, Elastoplastic boundary value problem. Finite element analysis of elastoplastic boundary value problems, Integration of constitutive relations. Consistent tangent modulus, Kinematics of plastic deformation at finite strain. Finite element formulation at large strain, Recent development in cyclic plasticity and its computational implementation.

Texts/References

1. J. C. Simo and T.J.R. Hughes, Computational Inelasticity, Springer, 1998.
2. J. Lemaitre and J.L. Chaboche, Mechanics of Solid Materials, Cambridge University Press, Cambridge 1990.
3. Akhatar S. Khan and Sujian Huang, Continuum theory of plasticity, John Wiley & sons Inc 1995.
4. I. H. Shames and F.A. Cozzarelli, Elastic and inelastic stress analsis, Prentice hall, Englewood Cliffs, New Jersey 1992.

CE 610 Computational Structural Mechanics (3-0-0-6)

Pre-requisite: CE 502 Finite Element Method

Energy principles in mechanics: Weak form and variational principles. Isoparametric finite element formulation and its properties. Concepts of locking in finite element and constrained minimal problems. Shear locking, membrane locking and incompressible locking in solid and structural problems. Locking free finite element methods: Field consistent formulation, Assumed strain and assumed stress methods, Incompatible modes and the enhanced strain formulation. Mixed finite element methods. Introduction to nonlinear continuum mechanics, Eulerian and Lagrangian formulation. Solution techniques for nonlinear equations, Newton-Raphson method and quasi-Newton schemes. Equilibrium path tracing strategies, Arc length schemes, Formulations of contact problems, Error analysis in linear and nonlinear FEM.

Texts/References

1. O. C. Zienkiewicz, R. L. Taylor and J.Z. Zhu, The Finite Element Methods Its Basis and Fundamentals, Butterworth-Heinemann, 6^{th} Ed., 2005.
2. G. Prathap, Finite Element Methods in Structural Mechanics, Kluwer Academic Press, 1993.
3. T. J. R. Hughes, The Finite Element Method Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
4. J. Bonnet and R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 1997.
5. R. H. MacNeal, Finite Elements, Their Design and Performance, Marcel Dekker Inc., 1994.

CE 611 Dynamics of Bridges (3-0-0-6)

Pre-requisite: CE 503 Structural dynamics

Objectives of dynamic analysis of bridges, vibration of structures under moving load : deterministic and random vibration theory. Theoretical bridge models: Highway and railway bridges, discrete and continuous systems, Modeling of vehicles: lumped mass and flexible models, sources of excitation: track inequality, wind and earthquake, Dynamic equations for bridge vehicle couple system. Solution techniques: time domain and frequency domain method. Effect of vehicle speed, nonstationarity for variable vehicle speed, horizontal longitudinal and transverse effects. Aeroelastic phenomena: Divergence and flatter of bridges, Fatigue assessment of Bridges.

Texts/References

1. L. Fryba, Vibration of Solids and Structures Under Moving Loads, Academia, Prague, Noordhoff International Publishing, Groningen, 1972.
2. L. Fryba, Dynamics of Railway Bridges, Thomas Telford, 1996.
3. L. Meirovitch, Principles and Techniques of Vibration, Prentice Hall 1997.
4. N.C. Nigam, Introduction to Random Vibration, MIT Press, 1983.
5. D.E. Tonias, Bridge Engineering, McGraw Hill, 1995.

CE 612 Advanced Concrete Technology (3-0-0-6)

Pre-requisite: Nil

Concrete as a composite material; Rheological properties of concrete; Microstructure studies in concrete, techniques for measurement of porosity; Reinforcement corrosion: an electrochemical process, techniques for corrosion monitoring, corrosion protection measures, application of coatings on rebar, corrosion inhibitors in concrete; Use of industrial waste and their influence on physical, mechanical and durability properties of concrete; Fiber reinforced concrete: mechanism of fiber reinforcement, types of fibers, properties of fiber reinforced concrete; High strength concrete: constituents, mix proportioning, properties at fresh and hardened state; Reactive powder concrete; Macro Defect Free (MDF) cement; Self compacting concrete; Roller compacted concrete; Ferrocement composites; Polymers in construction, polymer concrete composites; Chemical testing of concrete; Non-destructive evaluation of reinforced concrete by surface hardness techniques, wave propagation techniques, penetration resistance techniques, electrochemical and electromagnetic techniques.

Texts

1. P. K. Mehta and P. J. M. Monteiro, Concrete: Microstructure, Properties and Materials, McGraw-Hill, 3rd Ed., 2006.
2. J. Newman and B. S. Choo, Advanced Concrete Technology: Processes, Elsevier, Butterworth-Heinemann, 2003.

References

1. A. M., Neville and J. J. Brooks, Concrete Technology, Pearson Education, 4th Indian reprint, 2004.
2. M. S. Mamlouk and J. P. Zaniewski, Materials for Civil and Construction Engineers, Pearson, Prentice Hall, 2nd Ed., 2006.
3. P. C. Aitcin, High Performance Concrete, E & Fn Spon, 1998.
4. J. Newman and B. S. Choo, Advanced Concrete Technology: Concrete properties, Elsevier, Butterworth-Heinemann, 2003.
5. E. G. Nawy, Fundamentals of High-Performance Concrete, John Wiley & Sons Inc., 2nd Ed., 2001.

CE 613 Engineering Fracture and Fatigue Mechanics (3-0-0-6)

Pre-requisite: Nil

Historical perspective; linear elastic fracture mechanics; elastic-plastic fracture mechanics; interface fracture mechanics; metal fracture mechanics; non-metal fracture mechanics; fracture testing of metals and non-metals; fracture of structures; computational fracture mechanics; and fatigue crack propagation; crack closure; variable amplitude fatigue loading.

Texts

1. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, 1999.
2. T.L. Anderson, Fracture Mechanics – Fundamentals and Applications, CRC press, 1995.

References

1. M.F. Kanninen and C.H. Popelar, Advanced Fracture Mechanics, Oxford Engineering Science Series, 1985.
2. S.P. Shah, S.E. Swartz, Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi-Brittle Materials, John Wiley and Sons Inc., 1995.
3. S. Suresh, Fatigue of Materials, Cambridge University Press, 1998.
4. D.R.J. Owen, and A.J. Fawkes, Engineering Fracture Mechanics: Numerical Methods and Applications, Pineridge Press Ltd., 1983.

CE 614 Financing Infrastructure Projects (3-0-0-6)

Pre-requisite: Nil

Introduction to infrastructure financing; Role of governments in financing infrastructure projects; Economic multiplier effects of infrastructure; Means of financing – public finance and private finance; Procurement of infrastructure projects through Public Private Partnership route – Types of PPP models, Contractual structure of PPP projects, Value for money evaluation, Lifecycle of PPP projects, PPP procurement process; Concessions for infrastructure – Design and award, Allocation of responsibilities, Price setting, Penalties and bonuses, Dispute resolution; Financing infrastructure projects with private capital - Introduction to project finance concept, Analyzing project viability, Designing security arrangements, Structuring the project, Preparing project financing plan; Risk management of infrastructure projects – Risk associated with various infrastructure projects, Risk identification techniques, Risk allocation frameworks, Risk mitigation strategies; Ratings of infrastructure projects – Role of credit ratings in financial infrastructure projects, Rating frameworks used by national and international credit agencies; Case studies.

Texts/References

1. A. Akintoye, M. Beck and C. Hardcastle, Public-Private Partnerships - Managing risks and opportunities, Oxford: Blackwell Science Limited, 2003.
2. J. D. Finnerty, Project Financing - Asset-Based Financial Engineering. New York: John Wiley & Sons, Inc, 1996.
3. T. Merna and C. Njiru, Financing Infrastructure Projects, Thomas Telford, 2002.
4. P. K. Nevitt, and F. J. Fabozzi, Project Financing, Euromoney Books, 7th Ed., 2000.
5. G. Raghuram, R. Jain, S. Sinha, P. Pangotra, and S. Morris, Infrastructure Development and Financing: Towards a Public-Private Partnership, MacMillan, 2000.
6. R. Tinsley, Project Finance in Asia Pacific: Practical Case Studies, Euromoney Books, 2002.
7. UNIDO, Guidelines for Infrastructure Development through Build-Operate-Transfer (BOT) Projects, UNIDO, Vienna, 1996.
8. C. Walker, and A.J. Smith, Privatized Infrastructure: the Build Operate Transfer Approach, Thomas Telford, 1995.
9. E.R. Yescombe, Principles of Project Finance, Academic Press, 2002.

CE 669 Advanced Mathematics for Engineers (3-0-0-6)

Course Content

Real Analysis: Sets and functions, The real line, Sequences and Series, Continuous functions, Inverse functions, Differentiation, Riemann integral, Generalized functions, Sequence of functions, Special functions, Infinite series, Series of functions, Metric space, Function space and L2, Ordinary and Partial differential equations; Areas of application.

Vector and Tensor Analysis: Definitions, Products of vectors, Differentiation and Integration of vectors, Vector concepts associated with partial differentiation, Transformations and tensors, Curvature tensor; Areas of application.

Complex Analysis: The complex plane, Functions of complex variables, Cauchy-Riemann equations, Analytic functions, Line and Contour integrals, Conformal mapping, Harmonic functions, Laplace and Fourier transforms; Areas of application.

Texts/References

1. Tsuneyoshi Nakayama and Hiroyuki Shima. Higher Mathematics for Physics and Engineering, Springer; 2010.
2. Erwin Kreyszig. Advanced Engineering Mathematics, Wiley; 10th Ed, ISV, 2015.
3. Robert G. Bartle and Donald R. Sherbert. Introduction to Real Analysis, Wiley India; 4th Ed, 2016.
4. Joseph Bak and Donald J. Newman. Complex Analysis, Springer; 2nd Ed, 1996.
5. Robert C. Wrede. Introduction to Vector and Tensor Analysis, Dover Publications, New York; 1972.
6. Howard J. Wilcox and David L. Myers. An Introduction to Lebesgue Integration and Fourier Series, Dover Publications, New York; 1994.

7. Steven G Krantz. A Handbook of Real Variables: With Applications to Differential Equations and Fourier Analysis, Birkhäuser; 2004.
8. Howard B. Wilson, Louis H. Turcotte and David Halpern. Advanced Mathematics and MechanicsApplications Using MATLAB, Chapman & Hall/CRC; 3rd Ed, 2003.
9. B. S. Grewal. Higher Engineering Mathematics, Khanna Publishers; 43rd Ed, 2014.