

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Finite Element Method

L-T-P: 3-0-2

Credits: 04

Subject Area: PCC

Course Outlines:

Method of weighted residuals; Variational principles and approximate solutions; Convergence of approximate solutions; Rules of domain discretization; discretization errors. Continuity requirement; Truss/rod/shaft, beam bending; Modeling of framed structures; Skewed boundary conditions; plane stress, plane strain and axi-symmetric idealizations; Triangular and rectangular elements; Interpolation functions; Evaluation of domain and surface integrals; Tetrahedral and brick elements; Numerical integration; Full reduced and selective integration; Finite elements for plates and shells; Semi-analytical procedure for axi-symmetric shells. Consistent mass matrix; lumping procedures.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Structural Dynamics

L-T-P: 3-0-2

Credits: 04

Subject Area: PCC

Course Outlines:

Dynamic equilibrium and mathematical models; dissipation mechanisms; Undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response; Harmonic response and applications to vibration isolation; Seismometers, accelerometers; Convolution integral; Numerical methods for time marching; response/shock spectra; Fourier transforms and frequency domain; Lagrange's equations; MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Mode superposition method; Mode-truncation and correction for the missing mass; Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Vibrations of elastic half-space.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Earthquake Resistant Design of Structures

L-T-P: 3-0-2

Credits: 04

Subject Area: PCC

Course Outlines:

Seismic performance of structures during earthquakes; ground motion parameters; response spectrum, design spectrum. Concept of strength, overstrength and ductility, Concept of equal displacement and equal energy principles, Capacity Design; buildings with irregularities. Equivalent static analysis, response spectrum analysis, Time history analysis; Modelling concept of building. Seismic resistant properties of reinforced concrete; Seismic Behaviour and design of linear reinforced concrete elements; design of water storage tanks, codal provisions.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Continuum Mechanics of Solids

L-T-P: 2-1-0

Credits: 03

Subject Area: PCC

Course Outlines:

Tensor calculus, eigenvalues and eigenvectors, integral theorems; kinematics of deformation Lagrangian and Eulerian description, material derivative, strains, polar decomposition; stress and equilibrium, conservation laws, closure conditions and constitutive laws; linear elastic constitutive law, Lamé's parameters; stress and strain transformation, stress invariants, principal stresses; isotropy, anisotropy and elastic symmetry; Airy's stress functions, elastic limits, Mohr-Coulomb, Tresca and von-Mises criteria, and Drucker-Prager models, flow rules, post-yield behaviour, isotropic and kinematic hardening, plastic stress-strain equations, plastic potential theory

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Numerical Methods for Dynamic Systems

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Elementary concepts of vector spaces, subspaces; Column and row space of a matrix; orthogonal bases, vector and matrix norms, errors in floating point arithmetic. Formulation of stiffness matrix for prismatic, non-prismatic frame elements, global stiffness matrix, response analysis of frame structure using stiffness method. solution of large system of equations for dynamic problems, Implementation details for band and/or skyline solvers, vector processing and parallel processing. techniques in the eigen solution of large problems. Interpolation and extrapolation, numerical differentiation and quadrature methods. Response by the Integration of ODEs with emphasis on accuracy and stability, integration of stiff ODE, concepts of A-stability and stiff-stability.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Advanced Earthquake Resistant Design of Structures

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Force-based vs. displacement-based design, Seismic hazard – hazard levels, uniform hazard spectrum vs. conditional mean spectrum. Post-yield behaviour of materials, sections and members under reversed cyclic loading - hysteresis and back-bone curve. Lumped and distributed plasticity models of RC, steel and masonry components. Nonlinear static and dynamic analyses, selection and scaling of ground motions. Performance-based design - performance levels and performance objectives, performance evaluation of structures, services and equipment. Direct displacement based design; Risk targeted design.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Earthquake Resistant Design of Masonry Structures

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Behaviour of masonry structures, modes of failure, effect of unit shapes and mortar type, grout and reinforcement; Masonry under compression; slenderness effect of openings; Masonry under lateral loads, In-plane and out-of-plane loads; arching action; combined axial and bending actions; Earthquake resistant measures, concept and design of bands, bandages, splints and ties; vertical reinforcement at corners and jambs; measures in random-rubble masonry, confined masonry; code provisions. Study the effect of masonry infills on the seismic behavior of framed buildings; failure modes; simulation of infills – FEM and equivalent strut; safety of infills in in-plane action. Retrofitting of masonry building: Techniques of repair and retrofitting of masonry buildings

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Seismic evaluation and retrofitting of structures

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Basic terminology; basic principles of seismic evaluation and retrofit. Qualitative methods of seismic evaluation, Quantitative methods of seismic evaluation, performance-based methods, nonlinear static push-over analysis, non-linear dynamic method of analysis; estimation of strength and ductility. Local and global Methods of seismic retrofitting of RC Buildings: strengthening of existing components; RC, Steel and FRP Jacketing; addition of new components – frames, shear walls and braced frames; introduction to supplemental energy dissipation and base isolation, re-evaluation of buildings with retrofitting elements; Seismic evaluation and retrofitting of RC bridges:

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Earthquake Resistant Design of Bridges

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Performance of RC bridges in past earthquakes; General concept and seismic design principles: earthquake loading and analysis; Conceptual design of bridges: constraints, bent configuration; superstructure pier connection, superstructure-abutment connection; foundation systems. mathematical modelling of RC bridges: modelling of super structure, substructure and bearings; modelling of foundations; Seismic analysis of RC bridges, seismic design provision based on Indian codes (IRC-6, IS 1893); major international codes (ASTHO, CALTRANS, EURO, NZ and JSCE), capacity design of piers, ductile detailing of piers; joints, footings and pile caps; movement design, unseating prevention systems, bearing, design using isolation and energy dissipation devices.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Earthquake Resistant Design of Steel Structures

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Description of steel structures and their performance during previous earthquakes. Material level understanding: stress-strain curve, effect of temperature, strain-rate, plasticity and hysteresis, low-cycle and high-cycle fatigue, buckling, material models; Plastic analysis at sectional level under pure flexural yielding, combined flexural-axial, flexural-shear, flexural-axial-shear, pure torsion, combined flexure-torsion loadings, moment redistribution methods, Building design philosophy, capacity design framework, performance based seismic design framework, discussion on international code guidelines. concentrically braced frames, eccentrically braced frames, buckling restrained frames, steel plate shear walls, steel truss moment frames, light gauge steel systems and other energy dissipating systems. Consideration of panel zones, specific connection details, welded and bolted connections, pre-qualifying connection details

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Structural Response Control for Seismic Protection

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Principle of base isolation; linear and nonlinear procedures of isolation design, Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; modelling of isolation bearings; design process for multi-layered elastomeric bearings and buckling behaviour of elastomeric bearings; isolation system testing, implementation of energy dissipation devices; metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; shape memory alloy dampers; modelling, linear and nonlinear procedures; detailed system requirements; application to multistorey buildings; testing of energy dissipation devices.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Random Vibration

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables. Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem. Single degree and multi-degree of freedom systems; Continuous system and non-linear system- equivalent linearisation and Gaussian closure technique.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Reliability-Based Design

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Evolution of design codes; Hazards, risks and economy of structural design. Probability theory, random variables, probability distributions, moments, extreme value statistics, utility and descriptive statistics; Fuzzy set theory. A priori and posteriori probability; Bayes strategy and computation. Model estimation, hypothesis testing, confidence intervals and significance testing. Classic strength models - ideal brittle material, ideal plastic material, fibre bundle; Fatigue - damage accumulation laws, cycle counting, damage statistics; Bogdanoff's cumulative damage model. Gust wind loads, wave loads, earthquake loads, traffic load and live load modeling; Stochastic theory of load combinations. Multiple safety factor formats; Characteristic values; Reliability index and system reliability; Code calibrations.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Earthquake Resistant Design of Special Structures

L-T-P: 3-1-0

Credits: 04

Subject Area: PEC

Course Outlines:

Earthquake resistant design of industrial structures - Categories and loads on industrial structures; Methods of analysis; Chimneys and stacks, silos, TV towers; Interaction between primary and secondary systems. Earthquake resistant design of gravity dams – earthquake actions on gravity dams, loads and load combinations; Behavior of dams during past earthquakes; Modelling and analysis; Foundation-dam-reservoir interaction; Stability and stresses in dams; Acceptance criteria; design of overflow, non-overflow and RC components of dams; Codes and guidelines. Earthquake resistant design of nuclear power stations – different components of a nuclear power station; Modelling of structural and non-structural components; Piping and equipment; performance criteria; In-structure demand for secondary systems; seismic instrumentation.

Indian Institute of Technology Roorkee
Department of Earthquake Engineering

Subject Code: EQX-XXX

Course Title: Experimental Techniques in Earthquake Engineering

L-T-P: 3-0-2

Credits: 04

Subject Area: PEC

Course Outlines:

Measurement of vibrations and ground motion – seismographs and accelerometers; instrument records and corrections; representation of results. Measurement of displacement and strain – types of sensors, LVDTs; electric, vibrating wire and optical fibre grating strain gauges; Digital image correlation. Small scale testing – principles of scaling and similitude; Full/large scale structural testing – force and displacement control; quasi-static and pseudo-dynamic testing; loading protocols and interpretation of results; Hybrid and distributed testing. Shake-table testing. Testing of masonry walls - application of air-bags and water-bags in reversed cyclic loading. Testing for fatigue capacity.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Earthquake Engineering

Subject Code: EQN- **Course Title:** High Performance Scientific Computing

L-T-P: 3-0-0

Credits: 3

Subject Area: STAR

Course Outline:

Overview of scientific computing and its importance, Challenges in high-performance computing, Shared memory vs. distributed memory architectures, OpenMP for shared-memory parallelism, Parallel matrix operations, Compiler optimization, Loop optimization, Parallel matrix operations (equation solvers, eigenvalue decomposition, fast fourier transforms).