CORE
CONCEPT

Earthquake Engineering: Structural Dynamics, Seismic Analysis and Ductile Design

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Introduction:

Earthquake engineering decides whether a building rides out ground shaking with repairable damage or collapses, yet many design offices still treat seismic loads as one more static load case and leave ductility, irregularity and detailing checks to chance. This Core Concept course takes structural engineers from seismic hazard and structural dynamics through response spectrum and modal analysis, capacity design and ductile detailing of frames and walls, to isolation, assessment and retrofit of existing buildings. Participants produce a Seismic Design Basis and Lateral System Verification Report for one building.

Course Objectives:

- Define the site seismic hazard, ground type and design response spectrum for a building from hazard maps and soil data
- Model single and multi degree of freedom systems and calculate natural periods, mode shapes, damping and modal participation
- Derive design base shear and storey forces with the equivalent lateral force and modal response spectrum methods and check drift limits
- Apply capacity design, behaviour or response modification factors and irregularity rules to select and proportion a lateral force resisting system
- Specify ductile detailing for reinforced concrete moment frames, structural walls, steel braced and moment frames, diaphragms and collectors
- Evaluate existing buildings and non-structural components for seismic deficiencies and choose strengthening, isolation or damping options

Target Audience:

- Structural engineers who design lateral force resisting systems for buildings in seismic regions
- Checking engineers who review seismic calculations, analysis models and drift results before approval
- Assessment engineers who evaluate the seismic capacity of existing buildings and propose strengthening
- Engineering leads who set the seismic design basis for multi-storey, industrial and public building projects
- Specialists who coordinate the seismic bracing and anchorage of architectural, mechanical and electrical components

Course Outline:

Day 1: Seismology, Seismic Hazard and Ground Motion for Design

- Plate Tectonics, Fault Rupture Mechanisms and Seismic Wave Types
- Magnitude, Intensity Scales and Peak Ground Acceleration Records
- Probabilistic Seismic Hazard Analysis and Return Period Selection
- Site Classification, Soil Amplification and Liquefaction Screening
- Lessons from Past Earthquakes: Soft Storey, Short Column and Pounding Failures

Day 2: Structural Dynamics: SDOF and MDOF Response

- Single Degree of Freedom Equation of Motion, Natural Period and Viscous Damping
- Duhamel Integral and Newmark Time-Stepping for Ground Acceleration Input
- Elastic and Inelastic Response Spectra and Idealised Design Spectrum Shapes
- Multi Degree of Freedom Mass and Stiffness Matrices and Eigenvalue Mode Shapes
- Modal Participation Factors, Effective Modal Mass and SRSS and CQC Combination

Day 3: Seismic Analysis Procedures and Design Principles

- Equivalent Lateral Force Procedure: Base Shear, Period Formulae and Storey Force Distribution
- Modal Response Spectrum Analysis Set-Up and Base Shear Scaling Checks
- Behaviour Factor, Response Modification Coefficient and Ductility Class Selection in ASCE 7 and EN 1998-1
- Plan and Vertical Irregularity Checks, Accidental Torsion and Redundancy
- Storey Drift Limits, P-Delta Stability Coefficient and Seismic Joint Width

Day 4: Ductile Detailing, Walls, Diaphragms, Isolation and Existing Buildings

- Capacity Design Hierarchy: Strong Column Weak Beam and Plastic Hinge Confinement Detailing
- Special Structural Walls: Boundary Elements, Coupling Beams and Shear Demand Amplification
- Steel Concentrically Braced, Eccentrically Braced and Moment Frame Seismic Connection Rules
- Diaphragm Force Transfer, Chords, Collectors and Drag Strut Design
- Base Isolation Bearings, Viscous and Friction Dampers and EN 1998-3 Assessment and Retrofit Strategies

Day 5: Seismic Design Case Work and Verification Report

- Mid-Rise Reinforced Concrete Frame-Wall Building Case: Hazard, Spectrum and Modal Model Build
- Base Shear, Drift and Irregularity Verification Worksheet for the Case Building
- Non-Structural Component Anchorage Force Calculation for Equipment, Ceilings and Piping
- Existing Hospital or School Building Deficiency Screening and Retrofit Option Matrix
- Seismic Design Basis and Lateral System Verification Report Presentation and Peer Check

Skills You Will Gain:

- Seismic Hazard Characterisation
- Structural Dynamic Modelling
- Response Spectrum Analysis
- Lateral System Selection
- Capacity Design Detailing
- Diaphragm Load Path Design
- Seismic Deficiency Assessment
- Non-Structural Anchorage Design

Why Attend This Course:

- Return with a Seismic Design Basis and Lateral System Verification Report covering hazard, spectrum, modal results, drift and detailing for one building
- Challenge analysis software output by checking periods, modal mass and scaled base shear against hand calculations
- Spot irregularities, weak storeys and missing collectors early, before they force redesign late in a project
- Compare seismic design and retrofit practice with engineers from commercial, industrial, healthcare and infrastructure projects

Conclusion:

Buildings survive strong ground shaking when hazard, dynamics, ductility and load path are designed as one system. The five days move from seismology and site hazard through structural dynamics and response spectra, to the equivalent lateral force and modal methods, irregularity and drift checks, capacity design and ductile detailing of frames, walls and diaphragms. They close with isolation, damping, assessment of existing buildings, non-structural anchorage and case work that produces a Seismic Design Basis and Lateral System Verification Report.