Course Title: Earthquake Engineering – Seismic-Resistant Structural Design

Course Code: 4028-CIV
Duration: 8 Weeks
Total Hours: 48 Training Hours (6 hours/week)
Format: Lectures – Software Workshops – Case Studies – Capstone Project
Delivery Mode: In-Person / Online Live / Hybrid

Introduction

This course introduces the principles and practices of Earthquake Engineering, focusing on how structures respond during seismic events and how to design buildings that can resist those forces. Participants will explore seismic design codes, dynamic structural analysis, and software-based modeling for real-world earthquake-resistant projects.

Description

In this advanced civil engineering course, students will:

- Learn the science behind earthquakes and their effects on different structural systems.

- Perform dynamic analyses such as time-history and response spectrum methods.
- Design earthquake-resistant structures in compliance with international seismic codes (e.g., ASCE 7, Eurocode 8, IBC).
- Use structural analysis tools like ETABS and SAP2000 to model, analyze, and simulate real earthquake scenarios.
- Evaluate case studies of seismic failures and redesign solutions.

Course Modules and Detailed Outline

Module 1: Introduction to Earthquake Engineering (Week 1)

- Fundamentals of Seismology:
  - Causes of earthquakes (tectonic plates, seismic activity).
  - Types of seismic waves and their effects on structures.
  - Earthquake measurement (Richter scale, ground acceleration).
- Historical evolution of earthquake engineering.
- Introduction to seismic design concepts.
- Review of major global seismic disasters (e.g., Turkey, Japan, Nepal).

Module 2: Seismic Loads and Structural Response (Week 2)

- Calculation of seismic loads:
  - Peak ground acceleration (PGA).
  - Natural period of vibration.
- Base shear and its significance.
- Dynamic vs static loading behavior.
- Structural configuration and its effect on seismic performance.

Module 3: Dynamic Analysis of Structures (Week 3)

- Single-Degree-of-Freedom Systems (SDOF):
  - Equation of motion and solution methods.
  - Response curves and interpretation.
- Response Spectrum Analysis (RSA).
- Time History Analysis for real ground motion data.
- Linear vs Nonlinear Dynamic Analysis.

Module 4: Seismic Design of Structural Components (Week 4)

- Seismic design principles:
  - Ductility and avoiding brittle failure.
  - Seismic detailing of beams and columns.
- Shear Walls: Function, behavior, and design.
- Detailing for seismic resistance:

- Reinforcement confinement at critical regions.
- Seismic joints and beam-column connections.

Module 5: Seismic Isolation and Energy Dissipation (Week 5)

- Seismic isolation systems:
  - Base isolation theory and mechanisms.
  - Practical applications in real structures.
- Energy dissipation devices:
  - Viscous dampers.
  - Tuned mass dampers (TMDs).
- Designing buildings using seismic control systems.

Module 6: Seismic Design Codes and Standards (Week 6)

- Overview of seismic codes:
  - ASCE 7-16 (USA).
  - Eurocode 8 (Europe).
  - Egyptian Seismic Code.
- Key differences in code requirements:
  - Load combinations.
  - Seismic zone classifications.
  - Safety factors and design criteria.
- Workshop: Seismic load calculation based on a selected code.

Module 7: Software-Based Seismic Modeling & Analysis (Week 7)

- Overview of earthquake engineering software:
  - **SAP2000**: Model creation, load definition, RSA.
  - **ETABS**: High-rise building modeling, base shear interpretation.
- Hands-on modeling:
  - Defining material and section properties.
  - Input of seismic data and load cases.
- Validation and interpretation of results.

Module 8: Case Studies & Final Project (Week 8)

- Real-world earthquake failures:
  - Causes of collapse in buildings and bridges.
  - Lessons learned from post-disaster assessments.
- Capstone Group Project:
  - Design of a multi-story building with seismic resistance.
  - Structural modeling in ETABS/SAP2000.
  - Generation of structural drawings and reports.

- Project presentation and defense.
- Final Review and Key Takeaways.

🎓 Learning Outcomes

By the end of the course, participants will be able to:

- Understand the impact of earthquakes on various structural systems.
- Perform seismic design following international standards.
- Conduct dynamic analysis using professional tools like SAP2000 and ETABS.
- Apply proper seismic detailing in design and documentation.
- Deliver a complete seismic-resistant building project from modeling to analysis.

🛠️ Included Tools & Software

- ETABS
- SAP2000
- Seismic Design Codes (ASCE 7, Eurocode 8, Egyptian Code)

📌 Expected Outcomes

- Design earthquake-resistant structures based on modern standards.
- Conduct dynamic analysis using professional tools.
- Interpret and apply seismic codes effectively.
- Present and defend a full structural seismic design project.