

Course syllabus

Department of Civil Engineering, Indian Institute of Technology Madras

CE7018 - GIAN 151003: Advances in Seismic Hazard Analysis and Soil-Structure Interaction

Credit Distribution: C:6 L:2 T:1 P:0 E:0 O:3 TH:0

Course Type: Theory

Description: To identify recent advances in the engineering seismology and seismic hazard analysis; To address seismic geotechnical risk, particularly surface fault rupture and seismic instability of natural slopes; and To address the theoretical framework of soil-structure interaction under earthquake loading and advances in the numerical modelling of SSI problems.

Course Content: Module 1: Review of geotechnical earthquake engineering concepts Fundamentals of (a) engineering seismology, (b) propagation of seismic waves and (c) ground response analysis: 1D linear, linear-equivalent and non-linear analysis, (d) geotechnical modelling and site characterization: geophysical and laboratory tests. Module 2: Seismic Hazard Assessment Identification of seismic sources, active faults, historical and instrumental seismicity. Earthquake catalogues, process of occurrence of seismic events, Poissonian and non-Poissonian models. Completeness analyses. Representation of regional seismicity, Gutenberg Richter frequency magnitude relationship. Attenuation models and ground motion prediction equations, seismogenic zoning and seismotectonic model. Probabilistic method to predict seismic hazard at the local and regional scale. Design earthquakes and scenario earthquakes. Epistemic and aleatory uncertainty. The logic tree approach. Disaggregation of the seismic hazard. Selection of seismo- and spectrum-compatible records. Generation of synthetic seismograms through kinematic modelling of the seismic source. Module 3: Phenomena of Seismic Geotechnical Risk Overview on induced seismic geotechnical effects, surface fault ruptures and ground settlements. Dynamic behaviour of soils, threshold cyclic shear strains, dilatancy, critical state theory. Cyclic degradation of stiffness and strength, energy dissipation, undrained response of coarse-grained soils. Linear and volumetric threshold cyclic shear strains. Simplified constitutive modeling of dynamic behaviour of soils, cyclic models, skeleton curves, Masing criterion. Geotechnical characterization of soil deposits for seismic purposes. Liquefaction and cyclic mobility, simplified methods for the assessment of liquefaction susceptibility. Co-seismic and post-seismic instability of natural slopes, pseudo-static analyses and Newmark simplified dynamical method. Module 4: Soil-Structure Interaction Historical perspective on SSI, kinematic and inertial interaction; Analysis approaches: Direct approach; Sub-structure approach; Macro-elements; Dynamic impedance functions (DIF): Construction of DIF for shallow foundations; Construction of DIF for pile foundations; Construction of DIF using the cone model; Applications using the substructure approach; Kinematic interaction effects of large-diameter shafts foundations.

Text Books: NIL

Reference Books

- Bolt, B. A. (2005). Earthquakes: 2006
- Centennial Update, W. H. Freeman, New York. Stein, S. and Wyssession, M. (2003).

- An Introduction to Seismology, Earthquakes, and Earth Structure, Blackwell Publishing, Oxford. Kramer, S. L. (1996).
- Geotechnical Earthquake Engineering, Prentice Hall, New Jersey. Mc Guire, R. K. (2004).
- Seismic Hazard and Risk Analysis, MNO-10, EERI, Oakland, CA. Day, D. (2012).
- Geotechnical Earthquake Engineering Handbook, McGraw-Hill, New York. Bozorgnia, Y. and Bertero, V. V. (Eds.) (2004).
- Earthquake Engineering From Engineering Seismology to Performance- Based Engineering, CRC Press, Boca Raton. Nakai, T. (2013).
- Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton. Potts, D. M. and Zdravkovic, L. (2001).
- Finite Element Analysis in Geotechnical Engineering: Application, Thomas Telford, London. Clough, R. W. and Penzien, J. (1993, 2003).
- Dynamics of Structures, McGraw Hill, Singapore and Computers and Structures, Inc., Berkeley. Chopra, A. K. (2012).
- Dynamics of Structures Theory and Applications to Earthquake Engineering, Pearson Education Inc., New Jersey. Wolf, J. P. and Deeks, A. J. (2004).
- Foundation Vibration Analysis: A Strength-of-Materials Approach, Elsevier, Amsterdam. Wolf, J. P. (1988).
- Soil-Structure-Interaction Analysis in Time Domain, Prentice-Hall, New Jersey. Zaman, M., Gioda, G. and Booker, J. (2001).
- Modelling in Geomechanics, John Wiley and Sons, New York. Zienkiewicz, O. C., Taylor, R. L. and Fox, D. D. (2014).
- The Finite Element Method for Solid and Structural Mechanics, Elsevier, Amsterdam. de Borst, R., Crisfield, M. A., Remmers, J. J. C. and Verhoosel, C. V. (2012).
- Nonlinear Finite Element Analysis of Solids and Structures, John Wiley and Sons, New York. Belytschko, T., Liu, W. K., Moran, B. and Elkhodary, K. (2014).
- Nonlinear Finite Elements for Continua and Structures, John Wiley and Sons, New York. Ng, C. W. W., Simons, N. and Menzies, B. (2004).
- A Short Course in Soil-Structure Engineering of Deep Foundations, Excavations and Tunnels, Thomas Telford, London. Orense, R. P., Chouw, N. and Pender, M. J. (2010 (Eds.). .
- Soil-Foundation-Structure Interaction, CRC Press, Boca Raton. Desai, C. S. and Zaman, M. (2014).
- Advanced Geotechnical Engineering: Soil Structure Interaction Using Computer and Material Models, CRC Press, Boca Raton. Wolf, J. P. and Song, C. (1996).
- Finite Element Modelling of Unbounded Media, John Wiley and Sons, New York. Maekawa, K., Pimanmas, A. and Okamura, H. (2003).
- Nonlinear Mechanics of Reinforced Concrete, Spon Press, London.

Prerequisite: NIL