CE 325: Geotechnical Earthquake Engineering (3-0-0: 3)

Course objectives: This course aims to introduce the student to the fundamentals of soil dynamics giving emphasis on the behaviour of soils under seismic and dynamic loading and on the effect of superficial geology on strong-motion. The coursework of the module will enable the student to perform an equivalent-linear site response analysis.

Introduction

Scope and objective; Nature and types of earthquake loading; Importance of Geotechnical Earthquake Engineering.

Basics of Vibration theory

Concept of dynamic load, Earthquake load, Single degree of freedom system, Multiple degree of freedom system, Free and forced vibrations, Damped and undamped systems, Equation of Motion, Response spectra.

Engineering Seismology

Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Elastic rebound Theory, Faults, Plate tectonics, Seismograph and Seismogram, Prediction of Earthquakes, Protection against earthquake damage, Origin of Universe, Layers of Earth, Theory of Continental Drift, Hazards due to Earthquakes.

Strong Ground Motion

Size of Earthquake: Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude- Local (Richter) magnitude, surface wave magnitude, Moment magnitude, Seismic energy, Correlations. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency Content and duration, Spatial Variability of Ground Motion, Attenuation Relationships, Fourier Amplitude Spectra, Arias Intensity.

Wave Propagation

Elastic response of continua (one, two and three dimensional wave equations); Waves in unbound media; Waves in semi-infinite media; Waves in layered media, Mohorovicic Discontinuity and Gutenberg Discontinuity, Seismic Travel Time Curve, Three Circle Method for locating an Earthquake's Epicentre.

Dynamic Soil Properties

Stiffness, damping and plasticity parameters of soil and their determination (laboratory testing, intrusive and non intrusive in-situ testing); Correlations of different soil parameters; Liquefaction (basics, evaluation and effects), Liquefaction hazard map, Lateral Spreading.

Seismic Hazard Analysis

Magnitude Indicators, Segmentation, Deterministic Seismic Hazard Analysis (DSHA), Probabilistic Seismic Hazard Analysis (PSHA), Earthquake Source Characterization, Gutenberg-Richter recurrence law, Predictive relationships, temporal uncertainty, Probability computations, Seismic Hazard Curve, Logic tree methods.

Site Response Analysis

Ground Response Analysis, Transfer Function, Non-linear approach. Site Classification.

Seismic Analysis and Design of Various Geotechnical Structures

Pseudo-static method, Pseudo-dynamic method, other dynamic methods, Seismic analysis of retaining wall, Seismic slope stability analysis, Behaviour of reinforced soil under seismic conditions, Seismic design of retaining structures, Seismic analysis of Tailings Dam, Seismic displacement based analysis, seismic design of shallow foundations,

seismic design of pile foundations, seismic uplift capacity of ground anchors, seismic design of Municipal Solid Waste (MSW) landfills. Codal provisions/guidelines for seismic design of geotechnical structures.

Text Books:

1. *Prakash, S., "Soil Dynamics",* McGraw-Hill Book Company.
2. *Kramer, S. L., "Geotechnical Earthquake Engineering",* Prentice Hall Inc.

References:

1. *Day, R. W., "Geotechnical Earthquake Engineering Handbook",* McGraw Hill, New York.
2. *Ishihara K., "Soil Behaviour in Earthquake Geotechnics",* Oxford University Press, USA.
3. *Barkan, D.D., "Dynamics of Bases and Foundations",* McGraw-Hill Book Company.
4. *IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures.*

Expected outcome: The student will be able to: Develop basic competence in assessing seismic hazard and in characterising earthquake actions; Understand the fundamental principles of wave propagation and apply them in engineering examples; Understand basic facets of soil behaviour under dynamic loading; Understand the role of soil deposits in modifying the seismic ground motion; Perform a site response analysis using analytical and numerical approaches; Evaluate the liquefaction potential using a range of simplified methodologies and understand the principles of mitigation measures; Understand the behaviour of soil slopes under seismic loading and the sliding block methodologies.