CE 568: Dynamics of Soils and Foundations

Course Description:

Dynamic soil properties and their measurement. Foundation dynamics and soil-structure interaction. Sources and characteristics of dynamic loads. Vibration of single- and multi-degree-of-freedom systems. Vibration of continuous systems; 1D, 2D, and 3D analyses, wave propagation. Liquefaction concepts and analysis methods. Introduction to geotechnical earthquake engineering.

Course objectives (course designed to provide students with):

This course will explore the fundamentals of vibration theories and their application to problems in soil dynamics, foundation engineering and earthquake engineering.

Course Outcomes (students should be able to):

1. Demonstrate mastery of the theories of vibration for single and multiple degree of freedom discrete systems as well as continuous systems
2. Explain and interpret dynamic soil properties and their measurement by laboratory and in situ tests
3. Analyze the response of foundations and foundation-structure systems to dynamic and seismic loads
4. Determine the liquefaction susceptibility of a soil site

Course Topics

1. Introduction:
    - sources of dynamic loads and applications in geotechnical, structural, foundation and earthquake engineering
    - characteristics of different soil dynamics problems
2. Single degree of freedom (SDOF) systems:
    - free and forced vibration
    - energy balance
    - time domain analysis and numerical integration
    - frequency domain analysis and transfer functions
3. Dynamic soil properties and their measurement by laboratory and field tests:
    - basic characteristics
    - measurement by resonant column, geophysical, simple shear and triaxial tests
    - empirical relationships
    - nonlinear strain dependence of soil modulus and damping
4. Multi-degree of freedom (MDOF) systems:
    - natural frequencies and mode shapes
    - principal coordinates and modal analysis
    - forced vibrations
    - damped vibrations
    - application of response spectrum techniques in foundation and structural design
    - transfer functions for MDOF systems

5. Continuous systems:
    - 1-D site response analysis and wave propagation
    - 2D and 3D dynamic analyses
    - wave equations
    - reflection, refraction, mode conversions
    - Applications:
        - surface wave techniques (SASW, MASW, MSOR, ReMi)
        - wave equation analysis of pile driving (WEAP).
6. Foundation dynamics and applications:
    - vibration of foundations
    - soil-structure interaction
    - methods of analysis using simplified mechanical analogs and advanced compliance/impedance functions
7. Liquefaction:
    - underlying physical phenomena
    - methods of analysis and evaluation procedures
8. Introduction to earthquake engineering and code provisions for seismic design of foundations, retaining structures and earth dams (time permitting).