Engineering Tripos Part IIB, 4D6: Dynamics in Civil Engineering, 2020-21

Module Leader

Prof FA McRobie [1]

Lecturers

Prof FA McRobie, Dr JP Talbot, Prof G Madabhushi [2]

Lab Leader

Prof FA McRobie [1]

Timing and Structure

Lent term. 12 lectures + coursework. Assessment: 75% exam/25% coursework

Prerequisites

3D7, 3D2 and 3D4 useful

Aims

The aims of the course are to:

- introduce the behaviour and design of civil engineering structures subjected to time-varying loads.
- introduce earthquake-resistant design, dynamic soil-structure interaction, machine foundation design, blast effects on structures and the fundamentals of wind engineering.

Objectives

As specific objectives, by the end of the course students should be able to:

- identify cases where a static model of a structure is inadequate, and a dynamic model should be used
- produce a simple estimate of the natural frequency and fundamental natural mode of any linear-elastic structure.
- estimate linear-elastic spring parameters for a given foundation.
- compute the natural frequencies and natural modes of structures using the ABAQUS package and include simple soil models to account for soil-structure interaction.
- estimate the response of complex linear-elastic structures to earthquakes using modal superposition and the response spectrum.
- use elastic and inelastic design spectra, and to understand their form.
- perform simple designs for vibration isolation.
- perform simplified soil stiffness calculations accounting for partial liquefaction, and to use this approach in simple liquefaction resistant designs.
- describe some standard methods of seismic-resistant structural design.
- describe blast processes and their effects on structures.
- appreciate the factors involved in the estimation of wind climates and of structural response to wind.

- understand the various measures that characterise atmospheric turbulence.
- anticipate the circumstances under which aeroelastic phenomena may be problematic.
- estimate the dynamic response of a tall structure in a given wind environment

Content

LECTURE SYLLABUS

Structural dynamics (3L, Dr James Talbot)

Linear Elastic dynamics

á Introduction to dynamic loads in Civil Engineering; dynamic amplification factors.

á Approximate single-degree-of-freedom analysis of complex structures; sway frames; structures with distributed mass.

á Rayleigh's principle; natural frequency of simple systems using energy methods.

á Linear models to represent structures and their relevance; analysis in frequency domain; mode superposition method.

á Modal analysis of vibration; use of finite element packages.

Application of dynamics in Civil Engineering Structures :

Soil-Structure Interaction (3L,Prof G Madabhushi)

Non-linear Systems

á Sources of nonlinearity in structures and foundations

Soils during earthquakes

á Earthquake loading on structures; response and design spectra;

á Structures subject to ground motion; deformations due to lateral accelerations; Newmark's sliding block analysis; concept of threshold acceleration

á Foundations effects; stiffness of soil foundation and soil-structure interaction;

á Pore pressure build-up during earthquakes; partial liquefaction; degradation in soil stiffness; non-linear soil models.

á Liquefaction resistant design, simple examples.

Earthquakes Effects on Structures and Seismic resistant design *(3L,* Prof F.A. McRobie)

Response Spectrum Analysis for Earthquakes

á Introduction to Response Spectrum Analysis

á Earthquake Spectra and Design Spectra, Design of linear systems á Non-linear Response Spectrum Analysis, Ductility in Structures

Seismic Resistant Design

á Structural design and detailing considerations.

Wind Engineering and Blast Resistant Design *(3L,* Prof F.A. McRobie)

Wind loading

á Nature of wind;

á Wind forces on structures.

á Response of structures to buffetting.

á Aeroelasticity. Fluid-structure interaction (vortex-shedding, galloping and flutter). Long-span bridge case study.

Blast Loading

á Physics of blasts; blast effects on structures; blast-resistant design.

Coursework

Seismic analysis of an existing tall building using the ABAQUS finite element package and a study of the effect of foundation softening on the overall structural response. Total time 8 hours.

Coursework	Format	Due date & marks
Coursework Activity 1 <u>Learning objective:</u> • Simplified Analysis of a multi-storied building in Mexico City • Use of ABAQUS to carry out dynamic analysis and determine mode shapes and frequencies • Simple estimates of the response to the earthquake	Individual Report anonymously marked	4.00pm, 19 F Moodle 10 out of 25 r
Coursework Activity 2 <u>Learning objective:</u> • Time Domain Analysis of the multi-storied building in Mexico City • Determination of time histories in response to an input earthquake (Mexico earthquake of 1983)	Individual Report anonymously marked	4.00pm, 16 M Moodle 15 out of 25 r

Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

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