

Engineering Tripos Part IIB, 4D6: Dynamics in Civil Engineering, 2021-22

Module Leader

[Prof FA McRobie](#) [1]

Lecturers

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

Lab Leader

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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 buffeting.

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> <ul style="list-style-type: none">• 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 m
Coursework Activity 2 <u>Learning objective:</u> <ul style="list-style-type: none">• 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 m

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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