Engineering Tripos Part IIB, 4D6: Dynamics in Civil Engineering, 2017-18

Module Leader

Prof G Madabhushi [1]

Lecturers

Prof G Madabhushi, Dr J Talbot, Mr F A McRobie and Dr M DeJong

Lab Leader

Dr M DeJong

Timing and Structure

Lent term. 14 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 (4L, 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.

Spectral Analysis & Earthquake Spectra (2L, Dr Matt DeJong)

á Introduction to spectral analysis

á Earthquake Spectra and Design Spectra, Design of linear systems

á Non-linear Spectral Analysis, Ductility in Structures

Application of dynamics in Civil Engineering Structures :

Part A: Soil-Structure Interaction (5L, Dr S.P.G.Madabhushi)

Non-linear Systems

á Sources of nonlinearity in structures and foundations.

á Analysis in time domain; numerical integration of equations of motion.

Seismic design

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.

á

Part B : Seismic resistant design, blast effects and wind engineering *(3L, Mr F.A.* McRobie)

Seismic Resistant Design

á Structural design and detailing considerations.

Blast Loading

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

Wind loading

á Nature of wind;

á Wind forces on structures.

á Response of structures to buffetting. Fluid-structure interaction (vortex-shedding, galloping and flutter). Long-span bridge case study.

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 title / Interim] Coursework 1 brief description Learning objective: • Simplified Analysis of a multi-storied building in Mexico City • Use of ABAQUS to carry out dynamic analysis and determine Eigen Values and Eigen Modees	Individual/group Report / Presentation [non] anonymously marked	day during te Thu week 3 [6/15]
[Coursework activity #2 title / Final] Coursework 2 brief description Learning objective: • 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	Wed week 9 [9/15]

Booklists

Please see the Booklist for Group D Courses [2] for references for this module.

Examination Guidelines

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

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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