Engineering Tripos Part IIA, 3D3: Structural Materials & Design, 2018-19

Module Leader

Dr M Overend [1]

Lecturers

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Lab Leader

Dr C Morley

Timing and Structure

Michaelmas Term. 16 Lectures.

Aims

The aims of the course are to:

- cover the basic principles of practical design of typical engineering structures, with applications across a range of commonly-used structural materials.
- establish links between the theory of structures, taught in the Part I courses IA Structural Mechanics and IB Structures, and the properties of materials as covered in courses on Materials and Engineering Applications.
- study what differing approaches to design are appropriate for structures in different materials.
- develop a design methodology that provides a firm basis for the structures courses taught in Part IIA and for the more advanced courses in the fourth year.

Objectives

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

- have developed a good understanding of the structural forms appropriate in the various materials.
- be aware of the likely critical factors (requirements, properties, behaviour) for design in the different materials.
- be able to make sensible initial layout and sizing choices for simple structures in the various materials.
- be able to carry out design calculations for basic structural elements in the various materials.
- be aware of what design approaches will be appropriate, and what calculations necessary, for more complex structures in the various materials.
- appreciate the influence of risk, and variability of loading and material properties, on structural design and calculations.

Content

The implications of the general principles of structural mechanics – equilibrium, compatibility, constitutive laws, and stability – are investigated for different materials. This leads to discussion of typical structural forms in the various materials, the reasons for adopting them, and appropriate methods of construction. The significant types of structural behaviour, and therefore the most useful methods of analysis and calculation, are investigated for the different material types. A basic aim is to establish means of making reasonable preliminary decisions about structural form and layout, and initial sizing of members, before detailed calculation need begin.

Design methodologies will be developed, and design of typical elements will be discussed, for the following materials:

- high-strength, ductile materials such as steel and aluminium alloys
- moderately-high-strength, anisotropic, brittle materials such as advanced composites and timber
- materials of low tensile but high compressive strength, such as concrete and masonry
- reinforced concrete where concrete is combined with a ductile tensile material
- brittle materials, such as glass

The critical modes of failure of structures made from these materials tend to differ – for example, global and local instability play a very significant role in thin-walled structures of high-strength materials, while shear-induced delamination is a major concern only in wood and composites. So design approaches will be correspondingly different.

Overview and General Principles (5L)

- evolution of structural form, with case studies. Influence of available construction techniques. Bridge forms and materials economic in certain span ranges.
- requirements of a successful structure (considering collapse, buckling, deflection, cracking, imposed deformation, fatigue, fire, accident, corrosion etc, as well as construction method, cost and sustainability)
- relevant material properties (modulus, anisotropy, strength, toughness, cost, fabrication possibilities, energy content)
- risk, variability, and limit state design (brief introduction)
- Span-to-depth ratio and design.
- ‘load path’ approaches to simplified design, and the ‘lower bound’ theorem as a design tool, with limitations.

Design approaches for different materials

(in most cases, highlighting the important aspects of behaviour, covering the initial design of typical elements such as beams, columns and joints, and studying forms for complete structures).

Ductile Metals (primarily steel) (3L)

Masonry (mention) and Reinforced Concrete (3L)

Timber and Advanced Composites (3L)

Glass (2L)

Coursework

[Coursework Title]

Learning objectives:

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Practical information:

- Sessions will take place in [Location], during week(s) [xxx].
- This activity [involves/doesn't involve] preliminary work ([estimated duration]).
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Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the **Booklist for Part IIA 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.

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.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

S4

Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.

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.

P1

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

P4

Understanding use of technical literature and other information sources.

P6

Understanding of appropriate codes of practice and industry standards.

P7

Awareness of quality issues.

US1

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

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

US3

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

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:mo318@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46551
[3] https://teaching24-25.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching24-25.eng.cam.ac.uk/content/uk-spec