

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

Module Leader

[Dr M Overend](#) [1]

Lecturers

Dr M Overend and Prof F A McRobie

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

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the '[Accreditation of Higher Education Programmes](#)' ([AHEP](#)) document [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

Last modified: 13/09/2018 14:40

Source URL (modified on 13-09-18): <http://teaching.eng.cam.ac.uk/content/engineering-tripos-part-ii-a-3d3-structural-materials-design-2018-19>

Links

[1] <mailto:mo318@cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46551>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>