Engineering Tripos Part IIA, 3D3: Structural Materials & Design, 2020-21

Module Leader

Dr R Foster [1]

Lecturers

Dr R Foster, Prof A Lawrence, Dr J Becque

Lab Leader

Dr R Foster [1]

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:

- choose structural forms appropriate to different materials
- identify factors (requirements, properties, behaviour) governing structural design in various materials
- make reasonable initial layout and sizing choices for simple structures in various materials
- carry out design calculations for basic structural elements in various materials
- determine what design approaches will be appropriate, and what calculations necessary, for more complex structures in various materials.
- consider the influence of risk, and variability of loading and material properties, in structural design and calculation
- consider the environmental impacts of structural material and design choices

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. Our basic aim is to establish means of making reasonable preliminary decisions about structural form, layout and initial sizing of structural members made from a range of common construction materials.

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

- materials of low tensile but high compressive strength, such as masonry and glass;
- composite materials of low tensile strength combined with a ductile tensile material, such as reinforced concrete;
- high-strength, ductile materials such as steel and aluminium alloys;
- moderate- to high-strength, anisotropic, brittle materials such as engineered timber.

The critical modes of failure of structures made from these materials tend to differ, as do other considerations such as environmental impacts, so design approaches will be correspondingly different.

Overview and principles (4 Lecture equivalent)

- Introduction to the course and overview of structural materials and implications of material properties for structural design
- Load paths and the application (and limitations) of the lowerbound theory in structural design
- Limit state design and consideration of material variability in achieving appropriate levels of reliability
- Resource efficiency and sustainability in structural design

Masonry (1 Lecture equivalent)

Concrete and reinforced concrete (2 Lecture equivalent)

Glass (2 Lecture equivalent)

Ductile Metals (3 Lecture equivalent)

Timber (3 Lecture equivalent)

Conclusions (1 Lecture equivalent)

Coursework

Concrete Lab

Learning objectives:

To be able to:
1. Describe the common ingredients of concrete and their properties;
2. Design a concrete mix to satisfy certain technical requirements and cast a trial cube;
3. Supervise the casting of reinforced concrete beams and various plain concrete specimens for subsequent testing;
4. Observe and record results of destructive testing and identify different failure modes in concrete;
5. Compare empirical results with theoretical predictions based on as built-data, and evaluate the effectiveness and limitations of the theory.

Practical information:

Details will be available on the course Moodle page early in the term.

Full Technical Report:

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

Please refer to the Booklist for Part IIA 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 [2].

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [3] 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 [4] which sets out the standard for degree accreditation.

The Output Standards Matrices [5] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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