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:

- Provide a general understanding of the relationship between the properties of common structural materials, and the principles and approaches underpinning their use in structural design
- Provide a bridge between the fundamental general engineering understanding of structures and materials developed in Part I and the applied specialist modules of Part II
- Provide knowledge and knowhow enabling structural designers to improve our use of energy and material in the design of the built environment while providing safe, useful structures for people to use

Objectives

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

- [1] Use the lower-bound theory of plasticity to perform load-path design of structural arrangements and to appreciate the benefits and limitations of the approach
- [2] Consider the influence of risk, and variability of loading and material properties, in structural design and calculation
- [3] Explain the environmental impacts of structural material and design choices
- [4] Understand and carry out early-stage structural design with various structural materials
- [4.1] Identify the theoretical and practical considerations governing structural design in various materials and explain how these may be accommodated in design
- [4.2] Make reasonable conceptual design decisions regarding appropriate structural form, initial layout and initial member sizing for simple structures in various materials;
- [4.3] Perform preliminary technical design calculations for simple structures in various materials
- [4.4] Determine what design approaches may be appropriate, and what calculations necessary, for more complex structures in various materials

Content

The course this year will be 'blended', meaning that a mix of in-person, online live (Teams) and online recorded
(Moodle) components will be used. We plan to deliver some of our lectures in-person in the department (although these will also be recorded and subsequently uploaded to Moodle). We plan to deliver others remotely through a combination of recorded lectures and ‘live’ Q&As. Recorded lectures have been updated for this year and benefit from the many lessons we learned during 2020. Full details are available on the course Moodle page.

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.

**Lecture timetable**

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture</th>
<th>Date</th>
<th>Timeslot</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1. Introduction and overview</td>
<td>Thu 7th Oct</td>
<td>1100-1200</td>
<td>Dr Foster</td>
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<tr>
<td></td>
<td>2. Load paths and lower bounds</td>
<td>Mon 11th Oct</td>
<td>0900-1000</td>
<td>Dr Foster</td>
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<td>2</td>
<td>3. Limit states and variability</td>
<td>Thu 14th Oct</td>
<td>1100-1200</td>
<td>Dr Foster</td>
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<td>4. Resource efficiency</td>
<td>sustainability</td>
<td>Mon 18th Oct</td>
<td>0900-1000</td>
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<td>3</td>
<td>5. Timber design 1</td>
<td>Thu 21st Oct</td>
<td>1100-1200</td>
<td>Prof Lawrence</td>
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<td>6. Timber design 2</td>
<td>Mon 25th Oct</td>
<td>0900-1000</td>
<td>Prof Lawrence</td>
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<tr>
<td>4</td>
<td>7. Timber design 3</td>
<td>Thu 28th Oct</td>
<td>1100-1200</td>
<td>Prof Lawrence</td>
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<td></td>
<td>8. Masonry design</td>
<td>Mon 1st Nov</td>
<td>0900-1000</td>
<td>Dr Foster</td>
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<td>5</td>
<td>9. Glass design 1</td>
<td>Thu 4th Nov</td>
<td>1100-1200</td>
<td>Dr Foster</td>
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<td>10. Glass design 2</td>
<td>Mon 8th Nov</td>
<td>0900-1000</td>
<td>Dr Foster</td>
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<td>6</td>
<td>11. Concrete design 1</td>
<td>Thu 11th Nov</td>
<td>1100-1200</td>
<td>Dr Foster</td>
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<td></td>
<td>12. Concrete design 2</td>
<td>Mon 15th Nov</td>
<td>0900-1000</td>
<td>Dr Foster</td>
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<td>7</td>
<td>13. Steel design 1</td>
<td>Thu 18th Nov</td>
<td>1100-1200</td>
<td>Dr Becque</td>
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</tbody>
</table>
Lecture
14. Steel design 2
Date
Mon 22nd Nov
Timeslot
0900-1000
Lecturer
Dr Becque

Week 8
15. Steel design 3
Date
Thu 25th Nov
Timeslot
1100-1200
Lecturer
Dr Becque

16. Conclusions
Date
Mon 29th Nov
Timeslot
0900-1000
Lecturer
Dr Foster

Coursework
Concrete Lab
This lab will run in 'blended' form for 2021, with the morning session remote and the afternoon session in-person.
Feedback from our first experience of running the lab in this way in 2020 was overwhelmingly positive, so we have changed very little this year. We retain the capability to run the afternoon session fully remotely, but we are hopeful that this will not be needed this year.

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.

Last modified: 01/10/2021 03:45

Source URL (modified on 01-10-21): http://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iiia-3d3-structural-materials-design-2021-22

Links
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