4A62 – Advanced Design of Structures (Structures 2) [5 credits]

Lecturer(s):  Asst. Prof. Maria Nogal [nogalm@tcd.ie]

Module organisation
This module held in the second semester (9 weeks) of the academic year and comprises three lectures per week for the entire period. In addition there is tutorial every week for the module.

<table>
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<tr>
<th>Semester</th>
<th>Start Week</th>
<th>End Week</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Practicals</th>
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<td>Per Week</td>
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<tr>
<td>2</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>27</td>
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<td>Per Week</td>
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Total Contact Hours: 36

Module description, aims and contribution to programme
This module aims to build on design principles presented in the first semester SS module (4A61) so as to:

- Provide students with the ability to design prestressed concrete structures
- Develop an understanding for plastic ULS analysis of concrete structures, the basic principles of which may equally be applied for any material
- Enable students to design composite steel-concrete structures building on the steel design principles covered in previous JS and SS modules.

This module builds on work established in previous years of the undergraduate curriculum and, is relevant to all civil and structural engineers as the principles taught are important for anyone working in the design or construction of structures.

Learning outcomes
On successful completion of the module, students will:

Have knowledge to:
1. Recognize the principle of permissible stresses (SLS & ULS) and their significance
2. Discuss concepts of flexural strength of concrete and fully and partially pre-stressed structures
3. Assess the losses that occur in pre-stress force at transfer and during the service life of the member
4. Distinguish between Elastic analysis, elasto-plastic analysis and plastic analysis
5. Explain, locate and calculate levels of plastic moment re-distribution at the ULS
6. Recognise the differences between Reinforced Concrete and Pre-stressed concrete, and, to choose which one is appropriate in any given circumstance
7. Describe the components of steel-concrete composite beams and their modes of failure
8. Distinguish between the different behaviour of full and partial shear connections in composite beams

Have gained practical skills to:
1. Perform ULS analysis of pre-stressed concrete members from 1st principles
2. Estimate suitable cross-sections, identify the minimum pre-stress force required and determine suitable eccentricities of the tendons
3. Derive Magnel equations from 1st Principles and hence, sketch and use efficiently Magnel Diagrams to determine optimal combinations of pre-stressing force and eccentricity.
4. Calculate pre and post-transfer losses
5. Evaluate the parasitic effects in indeterminate structures
6. Apply elasto-plastic analysis to evaluate the ULS capacity of reinforced concrete beams
7. Use yield-line analysis to determine the ultimate capacity of reinforced concrete slabs
8. Calculate the bending moment and shear force capacities of composite beams
9. Choose an appropriate grade and number of shear connectors in the design of composite beams

Have gained intellectual skills to:
1. Estimate and visualize the structural behaviour of beams and slabs
2. Develop expressions for capacity using their knowledge of 1st principles

Module content
1. The principle of permissible stresses
2. Minimum section moduli
3. Pre-stressing force and eccentricity (Magnel Diagram)
4. Tendon profile (Post-tensioned) and de-bonding (pre-tensioned)
5. PSC losses
6. Secondary effects of pre-stress
7. Ultimate moment capacity of PSC
8. Partially pre-stressed members
9. Plastic moment redistribution
10. Yield line analysis of slabs
11. Hillerbourg strip analysis of slabs
12. Bending moment and shear force capacities of composite beams
13. Partial shear connections in composite beams

Teaching strategies
This module is taught by a combination of lectures and tutorial sessions. The tutorial sessions are overseen by a Teaching assistant as well as the lecturer. During these
sessions students are encouraged to work in groups to develop their communication and teamwork skills. The teaching approach in the lectures combines theory with as many practical examples as possible.

**Assessment**
Assessment is performed by examination and performance in this count for 85% of the final mark together with a further 15% contribution from the tutorials. The examination is two hours long and students are expected to answer three questions. Exam questions are designed to test the students understanding as well as their design abilities.

For those students who require a re-assessment, the same examination format will be used.

**Required textbook**
- *Reinforced and pre-stressed Concrete Design: The complete process* – O’Brien and Dixon (Longman)
- *Reinforced and Pre-stressed Concrete* – Kong and Evans (Nelson)
- *Structural Steel Design* – Owens and Knowles. (Butterworths)

**Further information**
School of Engineering weblink.