**FACULTY OF ENGINEERING, SCIENCE AND THE BUILT ENVIRONMENT**

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| Unit title: | Advanced Structural Analysis | |
| Unit number: | BCE/M/414 | |
| Unit level: | M | |
| Unit value: | 1.0 | |
| Unit co-ordinator: | M H Datoo | |
| Contact time: | Lectures | 30 hours |
| | Tutorials/Laboratory | 30 hours |
| Private study time: | 90 hours | |
| Unit pre-requisites: | BCE/3/129 or equivalent | |

**SHORT DESCRIPTION**

This unit is offered as a core on the Structural Design pathway of the Civil Engineering programme. The unit covers three main areas of study: structural and stress analyses of thin walled beams subjected to a combination of load systems, finite element modelling of thin walled structures using shell elements, and advanced structural/stress analysis. A hand-on approach is sued for the finite element modelling exercises.

**AIMS**

To acquaint the student with linear elastic analysis of thin-walled section beams. Practical introduction to finite element modelling techniques will be performed. Also, it is aimed to introduce the student to elastic plate theory and three-dimensional stress analysis.

**LEARNING OUTCOMES**

The student should be able to:

- distinguish between thin walled and thick-walled sections
- calculate section properties of thin walled sections
- understand the principles behind the stress calculations for thin walled beams
- calculate the bending stress on thin walled symmetric and unsymmetric section
- appreciate the significance of the section shear centre
- determine shear stresses due to vertical and horizontal shear forces on thin walled sections
- distinguish between free torsion, restrained torsion and torsion-bending loading cases
- calculate the warping, shear and direct stresses associated with torsion problems
- understand and apply the principles of multi-cell section problems
- understand and apply the theory elastic plates for the determination of moments and stresses in rectangular plates with various support conditions
- model a beam of thin walled sections subjected to a loading, using the finite element technique, and interpret the displacements, forces and stresses output

**TEACHING AND LEARNING PATTERN**

Lectures and tutorials supplemented by printed handouts, worked solutions to tutorials and past examination questions. The lectures are complemented by supervised computing sessions.

**INDICATIVE CONTENT**

Section properties
Idealisation and calculation of section properties of thin-walled sections.

Bending theory
Symmetric and unsymmetric bending of thin-walled open and closed section beams.

Shear loads
Shear flow distribution in thin-walled open and single-cell closed section beams subjected to shear loads. Shear centre of open sections.

Torsion
The St Tenant torsion theory for thin-walled open sections, and Bredt-Batho torsion theory for single-cell closed sections. Torsional stiffness and warping of open and single-cell closed sections.

Torsion of multi-cell beams
Shear flows and torsional stiffness of thin-walled multi-cell closed sections subjected to torsion.

Torsion-bending of open sections
Torsion-bending behaviour of thin-walled open section beams due to a warping restraint. Torsion-bending constant and axial constraint direct stress.

Bending of thin rectangular plates
The governing differential equation of a thin rectangular plate. Boundary conditions. Navier's and Levy's method of analyses.

Three-dimensional stresses and strains
Three-dimensional stress and strain transformations. Direction cosines. Principal stresses and strains. Maximum shear stress.

Finite element modelling
Hands-on case studies to illustrate following features: Choice of elements, input data preparation, axes system, load application, boundary restraints, mesh density, convergence tests, element topology, aspect ratios, equilibrium checks, results interpretation and verification.

**ASSESSMENT METHOD**

The unit is assessed by a combination of examination and coursework.

70% 3 hour end of unit written examination. Four out of six questions to be attempted.

30% Coursework based on a finite element modelling exercise and a series of open book in-class tests.

**INDICATIVE SOURCES**

Background Reading

Ugural A C; Stresses in Plates and Shells; 2nd ed, McGraw Hill, 1999.

Megson, T.H.G.; Aircraft Structures for Engineering Students; 2nd ed, Edward Arnold; 1990.

Megson, T.H.G.; Linear Analysis of Thin-walled Elastic Structures; Surrey University Press; 1974.

Murray, N.W.; Introduction to the Theory of Thin Walled Structures; 2nd ed, Clarendon Press; 1986.

Jaeger, L.G.; Elementary Theory of Elastic Plates; Pergamon Press; 1964.

Lowe, P.G.; Basic Principles of Plate Theory; Surrey University Press; 1982.

Rees, D.W.A.; Mechanics of Solids and Structures; McGraw Hill; 1990.

Heyman, J.; Elements of Stress Analysis; Cambridge University Press; 1982.

Rockey, K.C. et.al.; The Finite Element Method; Granada; 1983.

Fagan, M.J.; Finite Element Analysis : Theory and Practice; Longman Scientific and Technical; 1992.

MacLeoad, I.A.; Analytical Modelling of Structural Elements; Ellis Horwood; 1990.

Clough, R.W. et. al.; Dynamics of Structures; McGraw Hill; 1975.

Woodford, C H et al.; Engineering Analysis Using PAFEC; Blackie; 1992.

Cook, R.D; Finite Element Modelling for Stress Analysis; Wiley; 1995.

Mottram, J.T. et al; Using Finite Elements in Mechanical Design; McGraw Hill; 1996.

Marshall & Nelson, Structures, Longman, 3rd Ed, 1990

Megson, T H G, Structural and Stress Analysis, Arnold, 1996

Bhatt, P, Structures, Longman, 1999