# Structural Analysis IV

## *Course Introduction*

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# Contents

# 1. Introduction

## *1.1 Background*

Within 9 months of starting this course you will be qualified to practice as a structural engineer. Every single day of your career as a structural engineer, you will be responsible for the lives of every person that will ever use the structures you design. But more than that: at a minimum you will also be responsible for:

- The safety of the people who will build your structure;
- The quality of life of future generations – structural engineers are in a unique position to contribute to limiting the significant carbon emissions of the construction industry;
- The best economic use of your clients' money to best achieve their goals;
- The use of your time that best achieves your employer's goals.

Though mistakes that lead to collapse of a structure are rare, they do happen. Often it is through an unreasonable faith in a computer analysis that makes this so. With excellent structural intuition; an ability to properly model the structure with structural analysis software, and; an ability to check computer output with appropriate hand calculations, the risk of such collapses can be minimized.

This course builds on your ability to analyse statically indeterminate structures from the 3rd year course and introduces new ideas and areas of study. We do this so that you are best equipped to deal with the realities of structural analysis and design.

## *1.2 Course Aims*

Given the background just discussed, the general aims of this course are to provide students with:

- An improved understanding and intuition of structural behaviour;
- An ability to properly model structures and to check output by hand;
- Knowledge of different types of structures and their behaviour.

## *1.3 Programme*

### Teaching

This course is taught in Semester 1 only. It is taught as follows:

- 3 hours lectures per week;
- 2 hours of computer laboratory every two weeks.

### Assessment

We asses your performance on this course as follows:

- Submission of laboratory work - 20% of the marks;
- A 3-hour end-of-semester examination - 80% of the marks.

In the unlikely event of any changes to the above arrangements, the changes will be notified to you well in advance of their implementation by your lecturer.

## *1.4 Reading Material*

Reading about projects and new techniques will be a major part of your engineering career (CPD). You should read as many different versions or explanations of the same topic or material as you can. This way it is more likely that you will find a means of explanation that works best for you.

Some good sources for this course are:

**General Understanding of Structural Behaviour**

- Brohn, D., *Understanding Structural Analysis*, 4th Edn., New Paradigm Solutions, 2005.
- Heyman, J., *Basic Structural Theory*, Cambridge University Press, 2008.
- Jennings, A., *Structures: from theory to practice*, Spon Press, 2004.
- Ji, T., and Bell, A., *Seeing and Touching Structural Concepts*, Taylor & Francis, 2008.
- Williams, M.S., and Todd, J.D., *Structures: theory & Analysis*, Macmillan, 1999.

**General Structural Analysis**

- Coates, R.C., Coutie, M.G., and Kong, F.K., *Structural Analysis*, 3rd Edn., Chapman & Hall, 1987.
- Ghali, A., Neville, A., Brown, T.G., *Structural Analysis: A Unified Classical and Matrix Approach*, 5th Edn., Taylor & Francis, 2003.
- McKenzie, W.M.C., *Examples in Structural Analysis*, Taylor and Francis, Abington, 2006.

**Books for Specific Topics**


- Charlton, T.M., *Analysis of Statically Indeterminate Frameworks*, Longmans, 1961.
- Charlton, T.M., *Energy Principles in Theory of Structures*, Oxford University Press, 1973.
- Davies, G.A.O., *Virtual Work in Structural Analysis*, John Wiley & Sons, 1982.
- Dym, C.L., *Structural Modeling and Analysis*, Cambridge University Press, 2005.
- Guarracino, F. and Walker, A., *Energy Methods in Structural Mechanics*, Thomas Telford, 1999.
- Heyman, J., *Beams and Framed Structures*, 2nd Edn., Pergamon Press, 1974.
- Heyman, J., *Elements of the Theory of Structures*, Cambridge University Press, 1996.
- Hodge, P.G., *Plastic Analysis of Structures*, McGraw-Hill, New York, 1959.
- Kong, F.K., Prentis, J.M. and Charlton, T.M., 'Principle of virtual work for a general deformable body – a simple proof', *The Structural Engineer*, Vol. 61A, No. 6, 1983.
- Neal, B.G., *Structural Theorems and their Applications*, Pergamon Press, 1964.
- Rees, D.W.A., *Mechanics of Solids and Structures*, Imperial College Press, London, 2000.
- Thompson, F., and Haywood, G.G., *Structural Analysis Using Virtual Work*, Chapman and Hall, 1986.

**Structural Dynamics**


- Beards, C.F., *Structural Vibration Analysis: modelling, analysis and damping of vibrating structures*, Ellis Horwood, Chichester, England, 1983.
- Bhatt, P., *Structures*, Longman, Harlow, England, 1999.
- Case, J., Chilver, A.H. and Ross, C.T.F., *Strength of Materials and Structures*, 4th edn., Arnold, London, 1999.
- Clough, R.W. and Penzien, J., *Dynamics of Structures*, 2nd edn., McGraw-Hill, New York, 1993.
- Craig, R.R. and Kurdila, A.J., *Fundamentals of Structural Dynamics*, 2nd End., Wiley, New York, 2006.
- Irvine, M., *Structural Dynamics for the Practising Engineer*, Allen & Unwin, London, 1986.
- Kreyszig, E., *Advanced Engineering Mathematics*, 7th edn., Wiley, 1993.
- Smith, J.W., *Vibration of Structures – Applications in civil engineering design*, Chapman and Hall, London, 1988.

## *1.5 Website*

The course will be supported through the lecturer's website:

www.colincaprani.com – go to the *Structural Engineering* section of the site.

On the site there are two main resources:

- **Lecture notes**: most of the lecture notes will be available in PDF format for download from the website. Class handouts will still be the main source of material.
- **Discussion Forum**: to facilitate students studying on their own, or maybe when home for the weekend, there is a forum through which you can liaise with others. Feel free to ask questions and to answer them. Though the forum will be facilitated by your lecturer, there is no guarantee that a question will receive an answer from me. This is primarily a way to encourage student-to-student remote learning.

Some other resources that may prove useful will be links to sites with good material and the provision of some software (with absolutely no guarantees!).

The website support for the course is only meant to help, so please:

- Do not abuse either the facility or the facilitator!
- Try to use the site to best help you and your friends.
- Suggest ways to improve the usefulness of the website.
- Do not post inappropriate comment/content – your site access will be removed, with more serious consequences also possible.

You are required to register for the forum – **only registrations in your own name will be approved**. You can change your display name later on.

# 2. Syllabus

## *2.1 Semester 1 Only*

The topics to be covered in the lectures are as follows:

### Virtual Work (Compound Structures)

A Virtual Work analysis is used for structures whose members undergo a combination of stress resultants, most notably bending and axial force.

### Virtual Work (Arches)

Here we use Virtual Work to analyse moments/shears and axial forces in parabolic and semi-circular arches.

### Matrix Stiffness Method

This topic provides an introduction to the basis of modern structural analysis software. This is a particular case of finite element analysis.

### Influence Line Analysis

These are used to determine design loads for members in structures subjected to moving loads (e.g. bridges) or for repeated analysis of a structure under various loading scenarios.

### Structural Dynamics

This topic covers exact and approximate methods of determining the motion of structures under dynamic loading situations.

# 3. Assessment

## *3.1 Examination*

The examination will be held at the end of Semester 1. The format is:

### Layout

There will be 5 questions and you are to answer 4.

### Marking

Each question is worth 25%.

### Timing

The exam is 3 hours in duration.

### Format

The questions will examine a topic or topics from the lectures. Further information will be given.

### Exam Handout

A handout will be attached to the paper in each exam with relevant information and formulae. A copy of this will be given to you during Semester 1.

## *3.2 Continuous Assessment*

### General

For this year only, this course is being assisted by a DIT Teaching Fellowship. The means of teaching the conceptual understanding of structural behaviour is under study. In particular, the Matrix Stiffness Method will be examined. To measure the effectiveness of our interventions, we will be carrying out tests before and after the interventions to help us indentify best practice.

### Improvement Assessment

To assist the Teaching Fellowship, pre- and post-testing will be carried out before and after a specific intervention. This way, we will be able to assess the effectiveness of the intervention. For marking purposes only the post-tests will contribute to your Continuous Assessment marks. The exact amount will be conveyed to you.

### Laboratory Work

The laboratory work is being revised this year in line with the aims of the Teaching Fellowship. More information will be given in the laboratory handout. In summary, each student is make a number of submissions of work. These will be marked and returned to aid further study. Each submission counts towards the marks awarded for the laboratory component of the module.