A modern approach to learning for structural analysis

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Basic principles

1 The modelling process

1.1 Introduction

Central to the arguments presented in this website is that the ability to use the modelling process effectively, is a main foundation for competence in structural analysis. This section provides a brief introduction to the process. For more detailed information see *Modern Structural Analysis*[1], Chapter3

Using the modelling process is basically about asking and responding to the right questions.

1.2 Modelling process activities

Define the requirements. The model is likely to be dependent on the accuracy required and the aspects of behaviour that need to be predicted

Validate the model i.e. answer the question 'Is the model capable of satisfying the requirements?' This question is of Class One importance in structural engineering. Using the wrong model can cause a disaster.

Verify the results i.e. answer the question: 'Has the model been correctly implemented?'

1. *Interpret the results for understanding* i.e. ask the question 'What can I learn from the results about the behaviour of the structure?'

Interpret the results of sensitivity analyses.

Challenge outcomes. For example, saying "I do not think that is right!" can have very useful consequences. If your are right you have found something important. If you are not right and identify the fault in your perception, you are likely to learn something about behaviour.

These activities are not independent. Results may inform validation. Interpretation is an important feature of verification.

1.3 What is gained from these activities?

1. *Reduced risk of structural failure.* Major structural failures have occurred due to lack of attention to the modelling process - particularly in relation to validation. Such failures could occur again. The prevention of failure is the most important issue in structural design. Therefore an engineer who is not properly

[1] MacLeod I A (2005), *Modern Structural Analysis Modelling Process and Guidance,* Thomas Telford Ltd, ISBN 978-0-7277-4192-8 (paperback edition 2010)

using the modelling process activities, is taking an unnecessary risk where the related consequences can be disastrous.

2. *Improved understanding of structural behaviour.* Understanding of structural behaviour is an essential ability for structural designers. The conventional wisdom in education is that one gets insight into behaviour by doing calculations. However the modelling process activities provide much richer in opportunities for identifying features of behaviour than by doing calculations. For example:

- Validation is about comparing the behaviour of the model against that of the real structural system. To do this one needs to understand the behaviour of both. The process of model validation therefore provides a strong stimulus to develop such understanding.
- Results of analysis models represent a main source of information about behaviour. Reflective interpretation of such results has significant potential to induce understanding.
- The purpose of sensitivity analysis is to provide information about behaviour.

1.4 How well is the modelling process used in practice?

While some engineers use the modelling process well - often tacitly, most engineers do not. Even some senior engineers in charge of complex innovative projects are not good at modelling. If you do not use the modelling process you cannot be good at modelling.
This problem relates to all types of predictive model.

1.5 How can this situation be changed?

- *Education* The learning objectives for structural analysis in degree courses needs to change - see Section 2.
- *Practice* Engineers in practice should study the modelling process and start to use it in a more formal way than is conventional. A source of encouragement towards this would be via the CPD requirement for chartered engineers.
- *The Institution of Structural Engineers* should require competence in the use of the modelling process in the assessment of applications for chartered membership.

2 Learning objectives for modern structural analysis

2.1 The objectives

Risk Faults in structural analysis have led to major failures. Three of these are described in Section 3.8 of *Modern Structural Analysis.* A major objective of learning in structural analysis should be do minimise the risk involved. This issue is not addressed in the conventional approach to teaching structural analysis

Understanding structural behaviour This is a main objective in the conventional approach but as noted in Section 2.2 it does not produce good results. There is a great deal to learn about structural behaviour. It is a lifetime activity for structural engineers and it may not be realistic to expect graduates to have more than a limited scope of such understanding. What one should expect is that new graduates would have ability to develop understanding of structural behaviour.

Structural mechanics Knowledge of structural mechanics is essential for competent use structural analysis.

The three fundamental objectives in teaching structural analysis should be to help students to:

(1) Learn how to minimise risk in the use of structural analysis

(2) Develop ability to understand structural behaviour

(3) Develop knowledge of structural mechanics

2.2 The role of the modelling process in achieving the learning objectives

(1) *Minimise risk*

A strategy for minimising risk is set out in Chapter 3 (Modelling Process) of *Modern Structural Analysis*. Since learning to minimise risk is a main requirement, use of this strategy must be intrinsic to the learning regime.

(2) Develop understanding of structural behaviour

A range of strategies for doing this are briefly discussed in Section 2.4 of *Modern Structural Analysis.* Note that the modelling process activities (Section 1.2) provide rich opportunities for developing understanding.

(3) Develop knowledge of structural mechanics

The need for learning about structural mechanics arises naturally from using the modelling process activities. This leads to a different emphasis as compared with the traditional approach. There may be less coverage of solution methods and the knowledge needed to assess the validity of assumptions made should be a prominent feature.

Since modelling process activities underpin all three fundamental learning objectives it is clear that they should be a central issue in learning.