



Engineers in need of an improved conceptual design toolbox

Martin Fröderberg

Structural Engineer, MSc
Tyréns/ Lund University
Lund, Sweden
martin.froderberg@kstr.lth.se

Martin Fröderberg, born 1976, received his civil engineering degree from Lund University 2000. He is a Structural engineer at Tyréns and PhD-student at the div. of Structural Engineering, Lund University.



Roberto Crocetti

Professor
Limträteknik/ Lund Univ.
Lund, Sweden
roberto.crocetti@kstr.lth.se

Roberto Crocetti, born 1968, received his civil engineering degree from Bologna University 1995 and PhD in Steel and Timber Structures from Chalmers University of Technology, 2001. He is a Professor of Structural Engineering at Lund University.



Summary

This paper presents the results of an investigation conducted on a number of practicing structural engineers. The investigation was designed as a round-robin investigation where 16 engineers performed two early stage structural engineering tasks; the first a load take-down calculation for a five-storey concrete building, and the second the conceptual design of a 68 m span steel roof truss. The results revealed a large variability both in load effect calculation for the first task, and in truss steel weight for the second task. Moreover, the investigation as a whole indicated that both the development of conceptual understanding and the quality of conceptual design are negatively affected by the premature use of advanced analysis tools. It is proposed that more education resources, both in academia and in practice, should be invested in the development of conceptual design skills and basic principles of engineering.

Keywords: Conceptual Design; Structural Design; Round-robin; Uncertainty; Human Error

1. Background

The early design phase of a building project and the search for efficient conceptual structural systems is synonymous with quick decisions and abrupt shifts. This is the essence of the design procedure of this stage – the structural engineer thinks and rethinks over and over again, in order to incorporate the structural needs with both architectural and other technical requirements. The structural engineer has an important role in this “conceiving” part of the process, as wise decisions will ensure fewer difficulties later in the process [1].

The trend, at least in Sweden, is that this part of the process seldom takes place. Instead, the engineer often gets involved late in the process and he/she is put in front of an almost completed building design. Then he/she is asked to “make the building stand up”. The active act is transformed into a passive reaction, leaving nothing but the possibilities to sub-optimize the structure at hand. This is common for small to medium sized projects with tight time schedule where, for some reason, the architect or client chooses not to involve the structural engineer until later in the process.

One major reason for this probably lays within the craft itself and how the engineers are trained into it [1]. Unlike how for instance an architect is trained, the engineer, during his or her education, spends most of the time searching for the correct solutions to very well defined problems. This is difficult to replace in a time of continuous extension of building codes, due to new scientific findings, but it means that little time is left for the development of conceptual design skills. Society expects the engineer to be able to perform accurate and safe calculations for various structures and building materials. But, by doing so, the tendency is that the basic knowledge – vital to conceptual design and understanding – is paid less and less attention. This in turn may be explained by the fact that the education often is led by the same specialists who pushes the research front forward and at times also the evolution of the design codes. Inherently, this means a risk that engineers will be provided very deep but scattered knowledge.

Already in 1967 this “dilemma of engineering education” was mentioned by Harvey Brooks from Harvard University [2]. He described it as, “the professional school instruction constantly faces the threat of becoming like a group of blind men describing an elephant”. If this problem persists, it is