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Book review
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Structural Optimization

William R. Spillers and Keith M. MacBain. Springer Science + Business Media LLC, 2009, ISBN: 978 0387 95864 4, £117, 320 pp, with CD-ROM.

Every civil engineering structural design includes a piece called computer aided design. This largely involves finite-element programs which accomplish the required structural analysis. A usual process calls for the analysis of the proposed design and then the adjustment of the structural elements to account for shortcomings with respect to safety and operation. Further re-analysis and re-adjustment follow until a satisfactory structure results. A true completion would lead to a procedure that results in the best structure. This is the topic of *Structural optimization* by Spillers and MacBain.

The attainment of minimum weight is usually defined as the best structure. This reflects the dominance of the aeronautical industry on the optimisation problem. In an aircraft Newton's law, $F = ma$, applies. Here a contains the performance specification and F the power requirements to attain the performance. The minimisation of weight is then an obvious objective function. In civil engineering structures the equation is usually homogeneous and there is no guarantee that minimum weight leads to minimum cost. Even though most of the discussion in the book concerns minimum weight attainment, all of the procedures are applicable to a restatement of the objective function to cost or any other desired measure. Indeed the practical matters of fabrication and other costs are dealt with by the authors. The optimality criteria method, in which the iterative design approach is carried through to an optimum as opposed to a satisfactory conclusion, is developed and contrasted with the sequential programming of incremental linear equations. In the first approach the practical vision of each step is evident, in the second the use of the readily available linear programming methods is efficient but the practical vision may be elusive. There is no doubt of the authors' preference for the second approach and the advantages that can be gained by their development of the incremental equations of structures.

The range of topics covered should please practising engineers. Included are: beams, plates, frames and trusses; multiple loading and multi-criteria optimisation; transient and steady-state dynamic problems and the special case of tuned mass dampers. An insight into on-going work considers wind loads on high buildings and a short discussion of design theory is given. Accompanying the book is a CD containing 34 programs. Most of these are in Fortran but Excel and Matlab are represented. All are integrally related to the text and the result is a holistically satisfactory composition. The authors represent both research and the professional application of optimisation in structural engineering. The book is a continuation of their joint research and professional efforts. From the view of the reader there can be confidence in the professional applicability of the procedures.

A sense of fairness pervades the book. The originators of various topics are named, and often the actual methodology of the original work is included. This presents an historical picture which is augmented by the inclusion of three seminal papers. The earliest by the Australian A. G. M. Michell dates from 1904 and establishes not only member sizes but shapes for optimality. The 1960 paper by Keller was at the time when there was only a hint of computer aided design in the air. The problem was the determination of the optimum shape of a column. This shape is recovered by contemporary methods in the text. The start of the full use of computer structural optimisation in the aeronautical industry is recorded in the comprehensive 1973 paper from the Wright-Patterson Air Force base by Venkayya, Khot and Berke. This line of history is largely confined to work undertaken in the USA. Certainly this is not all encompassing and thus there is an invitation for another contribution which may complete the picture.

The book contains a prediction that the methodologies of structural analysis and structural optimisation will be rolled into one and the process will become computer structural design. Certainly the analysis and the optimisation can be cast in the sequential linear analysis format and the structural designer may be in a position of getting the process going and waiting for the completed design. The responsibility on the designer is now onerous and the deep professional questions of understanding and authorisation will be dominant.

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