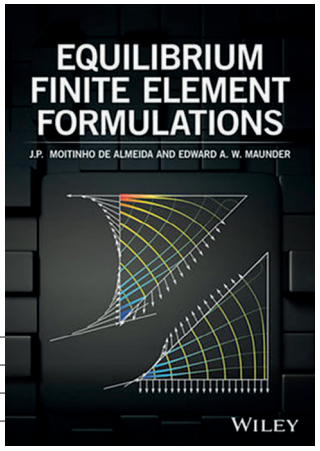
Review

Iain MacLeod is impressed by this book discussing the latest developments in equilibrium models, which will prove invaluable to postgraduate students, researchers and industrial practitioners alike.

Equilibrium Finite Element Formulations



Authors: J.P. Moitinho de Almeida and Edward A.W. Maunder
Publisher: Wiley
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The authors of this important book have addressed a very difficult and worthwhile issue in the development of the finite element method (FEM).

In January 1964, I attended a course on 'Stress Analysis' at Swansea University. The Professor of Civil Engineering at Swansea, Olek Zienkiewicz, had been inspired about the potential of the FEM during a visit to Berkeley University in California. The FEM had been in use for over 10 years in aeronautical engineering, both in Europe and the USA, and this course can be viewed as its introduction to civil/structural engineering in the UK.

One of the speakers at the course, B. Fraeijs de Veubeke, a Belgian Professor of Aeronautical Science, introduced the principle that if when deriving the properties of finite elements one assumed patterns of displacement that ensured compatibility at the boundaries of the elements, then the resulting predictions of displacement of the system would be smaller than from a correct solution. To be more precise, the value of an influence coefficient (i.e. the displacement under a unit load) from a fully compatible solution (what de Almeida and Maunder call 'strong compatibility') will be a lower bound to the correct value.

On the other hand, de Veubeke showed that assuming stresses over the area of an element that give equilibrium at the boundaries between elements (strong equilibrium) will result in an upper bound to an influence coefficient. Therefore, by producing a strong compatible solution and a strong equilibrium solution, one can bracket the error. Another advantage of equilibrium elements is that they provide better potential for accuracy of stress prediction. The authors of the book under review point out that the notorious Sleipner Platform collapse was due to uncritical use of stresses from an FE analysis.

Although having a dual approach to FE solutions is an attractive situation for assessment and refinement of FE models, use of such a strategy in practice has not been realised. The problem is that equilibrium solutions are much more difficult to formulate than compatible ones. De Almeida and Maunder's book brings us up to date with progress in the development of equilibrium models. In doing this, they demonstrate a very high level of technical expertise.

They give bracketed solutions, for both global and local outputs, for a bi-material plane stress example and for a simple Kirchhoff plate bending example and show how this information may be used to help to optimise the element mesh.

Some work needs to be done before this approach can be incorporated into software for use in practice. Such an outcome would be an important event in numerical modelling of structural systems.

It is stated on the back that 'the book is invaluable for those postgraduate students, researchers in software development or numerical analysis and industrial practitioners who need to keep up to date with progress in simulation tools'. I agree with that statement.

"THE AUTHORS OF THIS IMPORTANT BOOK HAVE ADDRESSED A VERY DIFFICULT AND WORTHWHILE ISSUE"

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Iain MacLeod is Emeritus Professor of Structural Engineering at the University of Strathclyde. His early research work was on the use of the finite element method for the analysis of tall buildings. Software techniques that he developed for this were used – in the 1970s – for the NAG/SERC Finite Element Library. His 2005 book *Modern Structural Analysis* focuses on modelling, rather than computational, issues.