

# Review

An ambitious book covering the basics of finite element methods through to advanced processes, the text can form the basis for discussion with engineering teams, writes **David Rafferty**.

## Finite element analysis for building assessment: advanced use and practical recommendations

**Authors:** Paulo B. Lourenço and Angelo Gaetani

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### THE ASSESSMENT OF EXISTING

structures is becoming increasingly sophisticated, with the availability of powerful non-linear analysis tools. This book takes on the technically challenging subject of non-linear finite element (FE) analysis of existing structures, in a publication aiming to be an aid to advanced structural analysts, professionals and students. The question is: do they succeed in providing a clear guidance text to a reasonably educated audience that would ultimately be of practical use? On the whole, yes – provided the reader has some prior

knowledge and experience in this somewhat narrow field.

Split into five chapters, the text begins with an attempt at providing a detailed description of the theory and implementation of the FE method for linear analysis. This is followed unsurprisingly by the second chapter that expands into the non-linear implementation of non-linear based methods of analysis, which are essential in representing the behaviour of existing structures. Most of which have been constructed from traditional materials and have been subjected to cycles of loading and alteration. Lourenço and Gaetani describe and evaluate both incremental and iterative strategies for creating suitably accurate models of existing structures. The early chapters try to explain the core aspects of what is a highly technical topic. The use of general, abstract, formulae and matrix assemblies is adopted and, to illustrate the complex modelling techniques further, some simplified specific examples are provided. Once these founding principles are established, chapter three covers the types of models typically developed as part of the assessment process, including their practical application and use in commercial software.

So far much of the content will be familiar to engineers who covered the basis of the FE method during their studies; it is when we get into the final chapters that things start to become quite complex, and somewhat impenetrable to those not fully familiar with the main topic of the text. For while Lourenço and Gaetani do put a lot of effort in informing the reader of core concepts of FE modelling of existing structures at the beginning of the book, they then expect too much of the non-specialist reader in these final two chapters. They delve into the modelling of historic structures in a way that requires detailed knowledge and understanding of the underlying methods described in the earlier chapters, as well as familiarity with software.

Chapter four focuses on the real non-linear behaviour of the materials most likely to be encountered in the assessment of existing buildings, particularly masonry. The processes for determining material properties are considered in detail, where they review methods and approaches from various international codes, particularly those used in Italy. A method for determining the material properties for masonry walls by a largely visual inspection will be of general interest to structural engineers engaged in the assessment of historic buildings.

The final chapter describes a general step-by-step process for the implementation of non-linear

FE analysis, taking the reader through pre-processing, verification, results validation, post processing and reporting. Some examples are given with a particular emphasis of how erroneous results can be obtained by using the wrong process. The importance of mesh size, element type and calibration are discussed in detail and potential methods of verifying the analysis model are described. The chapter concludes with some simple practical examples of the analysis process.

The authors have adopted an ambitious scope with this text, aiming to educate the reader on both the basics of the FE method as well as the advanced processes associated with non-linear analysis before covering the main subject of modelling existing structures. This makes the text necessarily academic in nature and it is not, therefore, an easy read. The basic understanding of the underlying principles is essential to the understanding and application of the later practical chapters.

Structural engineers already experienced with advanced non-linear analysis will find the later chapters useful in drawing out the decision-making process in assembling and using complex models in the analysis of historic structures. The final chapter's emphasis on planning, verification and clarity of reporting is particularly useful and can be applied to all analysis or modelling irrespective of the structure and method concerned.

This is not a book that will allow a practising structural engineer with little or no experience of the advanced analysis methods to pick up a new software tool and produce a comprehensive and accurate model of a historic structure, nor is it intended to be. The value of this book is how it explains the process and pitfalls associated with applying theoretical models to real existing structures. For a structural engineer managing the process of analysis, the book will form a sound basis for discussion with the engineering team and allow realistic expectations to be set for both the input information required and the communication and veracity of the results obtained.

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