



D. J. EWINS

**MODAL
TESTING**

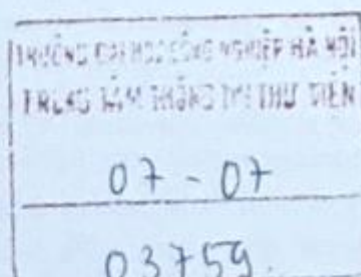
theory, practice
and application

SECOND EDITION



Modal Testing: Theory, Practice and Application

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Preface

Some 15 years and more have passed since the foreword to the first edition of *Modal Testing: Theory and Practice* was written. In some ways, little has changed since then concerning the origins of the subject, and as a result, much of the original book has survived the intervening years almost intact. At the same time, there have been great developments in the subject, with the result that some of today's technology would be largely unrecognisable to the practitioner of the early 1980s. It is to embrace these developments that the present book has been written, and it is because of the tremendous growth in the subject – not only in the relevant theory, but also in the practice of the subject and in the ever-widening range of applications – that this second edition is much longer than its predecessor.

It has to be admitted that the subject has become so large that one cannot hope to cover everything in a single book. For example, the topic of model updating – effectively introduced as part of the subject to the community in the first edition – has been the subject of perhaps 500-800 published papers in the past 15 years and a book in the last 5 years. Modal analysis methods have become a very advanced topic with sophisticated numerical analysis procedures which are beyond the scope of most modal testing practitioners. A huge number of papers have been published since the first edition of *Modal Testing*: there have been 15 IMACs (with about 400 papers in each), plus 10 ISMAs (with perhaps 200-250 papers presented at each) plus other more specialised conferences so that there must be well over 10000 papers published on modal testing and analysis since the first edition of this book appeared. It would be foolish to pretend that this new edition can have absorbed any more than a fraction of this volume of literature but, nevertheless, it does seek to bring the work somewhat more up to date. This book is still aimed at the serious practitioner, as well as the student to some of the "new" structural dynamics analysis methods. It may also still serve

as a useful basis to the researcher in one or other of the various disciplines, of which the modal analysis and the model updating areas are two good examples where for each topic a whole new subject has grown out of part of the main one. For those seeking such advanced expositions, other texts now take on the story in greater detail.

In talking of references, and noting the vast number of relevant papers that have appeared in recent years, it should also be noted that in this text we have sought to provide the reader with a judicious selection of reference material which is not overwhelming by its very quantity. It is accepted that such a selection process is relatively subjective but the concerned reader can find literature reviews in many of the different areas covered by this book in some of the references that are cited here.

The refinements and additions to the text which result in the present edition have grown out of 15 years of using the text as the basis of a series of over 100 short courses, typically of between 20 and 40 hours concentrated instruction, that have been presented by the author in many countries around the world. In the time between these two editions of *Modal Testing*, the modal analysis community has grown to use the singular value decomposition as a routine tool, to use MIMO testing techniques on a standard basis, to expect much more quantitative performance from the applications of the results of its modal tests, and to be more ambitious in these applications it seeks to address. Reliability and speed of testing methods is demanded by industrial and commercial pressures which lead us towards greater use of simulation, test planning and 'virtual testing' in order that the tests we do conduct provide the quality and selection of data that are required to solve the problems being tackled.

However, behind all this progress and evolution is a re-assertion of the need for testing in structural dynamics in general and for modal testing in particular. One might have thought, 15 years ago, that by the end of the century the tremendous growth in computing technology would have rendered experimental testing more or less obsolete. However, even though our projections in 1984 of what would be possible by 2000 have almost certainly proved to be conservative, the need for testing is as deep rooted as ever. There are probably two main reasons for this - and it may be appropriate to bear these in mind throughout any testing exercise that one is involved in - and these are (1) that there are some parameters, quantities or effects that are effectively unpredictable, and likely to remain so for the foreseeable future, such as damping, friction and fatigue properties, as well as excitation forces

— and (2) no matter how much we improve our structural dynamic modelling and prediction capabilities (which is certainly a direct consequence of the dramatic advances in our computing technologies), we are always driven to seek better results. When we succeed in predicting a structure's natural frequencies to within 5%, or a response level to within 50%, then those targets will move to ones demanding an accuracy of 1%, or 10% in response, and so it will continue, and the only reference against which these predictions can be assessed is one that comes from experimental observation of what really happens in practice. And lest we imagine that we are 'close' to meeting the expectations of our designers in our ability to predict the dynamic behaviour of 'real' structures with sufficient reliability to permit paper designs which are "right first time", we have only to recall the current situation regarding the performance of our analysis tools at predicting the vibration response of a typical engineering structure which is composed of an assembly of separate components and subjected to various excitation forces generated by or in the operating environment for that structure to realise that we are still far from attaining the aspirations of our subject.

Hence, it is believed that the experimental branches of structural dynamics should be seen to have a very secure and long-term future, clearly justifying the investments that have been made in certain areas, and especially the one treated here of modal testing.

Acknowledgements

Although this book appears as the work of but one author, in fact it contains the contributions of a great many colleagues and fellow travellers who have accompanied that author along various parts of the road that its contents describe.

The book first appeared in the early 1980s as the result of a set of lecture notes prepared for some early short courses in modal testing. Over the ensuing 15 years, that course was developed and refined and presented by the author over 100 times in more than 20 countries around the world. The present second edition of the book is, to a large extent, the result of that development of teaching the subject, together with the parallel activity of researching, developing and practicing the technology which it describes. As a result, there are two groups of people who have contributed to this new edition. The first group comprises those who have worked with me in the development of the subject – mostly, research students and research assistants whose collected theses are listed in the bibliography section of the book. Clearly, their contributions are very significant for they constitute most of the currently-used techniques. The second group include all the colleagues who have participated in various ways in the courses which have played such an important role in the developments of the subject as well as its practice in a wide range of industries.

This important group of contributors includes, first and foremost, my colleagues at Imperial College – Peter Grootenhuis, David Robb and Mehmet Imregun – the first of whom encouraged me to undertake the voyage that 30 years of research in the field has become, while the others have played a major role in the running of the courses themselves and in the development of the MODENT software whose algorithms are a direct result of the same research. Their contributions to this book are to be found everywhere. There are also a band of colleagues who have promoted and facilitated the actual courses

themselves, and significant amongst these have been: Ron Eshelman, Dominique Bonnecase, Ole Doessing, Harry Zaveri, Menad Sidamed, Dominique Carreau as well as Dick DeMichele, the initiator of the Modal Analysis courses run at IMAC every year for the past 15 years.

I must record my thanks for the support, encouragement and incredible patience of those who have helped to realise this publication. First amongst these is Veronica Wallace who, in her role as publisher of my first book, encouraged and indulged me to the point where this second edition has actually been completed. Not – I have to admit – before she retired from RSP, as I had promised, but completed nevertheless. And that completion is due in some not inconsiderable measure to the persistence of her successor, Guy Robinson. I hope that they will find that their patience will be rewarded by the result. The actual mechanics of the production has also been made manageable for me by the constant help of my secretary, Liz Savage, and in the latter stages by Liz Hall and several of my current students, not forgetting the major editorial review carried out by my daughter, Caroline, at the critical time when the last phase had to be kick started back into action.

There are in addition to these named helpers a small number of other people whose support in all manner of ways has been the deciding factor in the long-running debate as to whether or not a second edition would ever appear: I know that they know who they are, and I acknowledge the support of each of them individually although they will remain properly anonymous to the book's readers. They have each played a critical role in providing me with the space and the support I needed to get to this point.

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