# Preface

In 1909, Ritz proposed a method for the approximate solution of differential equations. The proposition was that a set of arbitrary functions which only satisfy boundary conditions could be used to approximate the exact solution. This paper subsequently provided the basis for the well known finite element method (FEM).

In 1926, Trefftz published a paper entitled *Ein Gegenstück zum Ritzschen Verfahren* (An alternative to the Ritz method) where he suggested that, instead of functions which satisfy boundary conditions, those satisfying only the governing differential equations could be used. This paper then supplied the basic idea for the lesser known boundary element method (BEM).

The development of both methods, which started almost simultaneously when digital computers became available, has been quite different. Whereas the FEM is very well known and widely used, the BEM has become a sort of 'Cinderella' of numerical methods, that is, one the beauty of which is being kept hidden away and not fully appreciated.

At the very early stage in the development of the FEM, the first edition of the book *The Finite Element Method in Engineering Science*, by O. C. Zienkiewicz, was published. This was a book that engineers could understand and, more importantly, one which showed how the method could be implemented and used. Furthermore, the undying enthusiasm and drive of Oleg Zeinkiewicz convinced a myriad of people, including myself, to work with the FEM.

In contrast, early texts on the BEM concentrated on the mathematics of the method and in most cases ignored the original contribution of Trefftz. Nearly all earlier texts used tensor notation. Engineers at that time were not used to this notation and this would have prevented many from working in this field or using the method. All this gave the impression that the method was difficult to understand and to program, an opinion which, unfortunately, seems to be still very much prevalent today.

The motivation for writing this book was to show that the numerical implementation of the BEM is not significantly more difficult than that of the FEM, and that, if the theory is presented in engineering terms, not more difficult to understand. With this book I hope to make more engineers aware that for certain applications the method can not only mean a substantial saving in effort but also result in greater accuracy. In contrast to other books on the BEM my aim was to present the topic in a very practical way and this is demonstrated by devoting a whole chapter on industrial applications.

I make no secret of the fact that this book was inspired by the very successful text by Smith and Griffiths *Programming the Finite Element Method,* published by Wiley, now in its third edition. Indeed, on the cover of both books there is an example of a numerical simulation of the rock caverns, that house the scientific equipment of the CERN particle accelerator. By comparing both pictures the subtle differences between the FEM and BEM may be clearly seen.

In a sense, the present book is a companion to my earlier one, co-authored by J. Watson, *Introduction to Finite and Boundary Element Methods for Engineers,* published by Wiley in 1992, which goes into much greater detail with respect to the mathematical treatment of the BEM and concentrates on the coupling with the FEM.

There is considerably less mathematical rigour in the present book as compared with others, and I have often explained some of the more difficult aspects of the method in engineering terms. No apologies are made for this, since one of the main aims of this book is to increase the use and popularity of the BEM in the engineering community. Excellent books dealing with the mathematical treatment of the method are readily available and may be consulted.

However, this book is not just about learning how to program the BEM, but about understanding the method, not through complicated mathematical derivations but through numerical experiments. Throughout the book the reader will be able to try and test the method on small examples by using a series of programs, and will thus be able to learn intuitively by experience.

It is hoped this book will help to bring the numerical Cinderella out into the open, so that her beauty can be seen and appreciated by more engineers.

## COMPUTER PROGRAMS

All software (libraries and programs) can be downloaded free of charge from the website http://www.ifb.tu-graz.ac.at/publications

**G. Beer**
Graz, Austria, January 2001