Foundations of Engineering Mechanics

Shorr

Springer

Berlin
Heidelberg
New York
Hong Kong
London
Milan
Paris
Tokyo

B. F. Shorr

The Wave Finite Element Method

With 164 Figures

Springer

Series Editors:
V. I. Babitsky
Department of Mechanical Engineering
Loughborough University
Loughborough LE11 3TU, Leicestershire
United Kingdom

J. Wittenburg
Institut für Technische Mechanik
Universität Karlsruhe (TH)
Kaiserstraße 12
76128 Karlsruhe
Germany

Author:
B. F. Shorr
Central Institute of Aviation
Motors (CIAM)
Aviamornaya str. 2, 111250
Moscow
Russian Federation

ISBN 978-3-642-53605-2 ISBN 978-3-540-44579-1 (eBook)
DOI 10.1007/978-3-540-44579-1

Cataloging-in-Publication Data applied for
Bibliographic information published by Die Deutsche Bibliothek.
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data is available in the Internet at <http://dnb.ddb.de>.

Springer-Verlag is a part of Springer Science+Business Media

springeronline.com

Softcover reprint of the hardcover 1st edition 2004

Typesetting: Camera-ready copy by translator
Cover-design: de'blik, Berlin
Printed on acid-free paper 62 / 3020 hu - 5 4 3 2 1 0

Preface

Computational mechanics, as a science employed for the numerical modeling of processes in nature and engineering, has over the last few decades developed two strands. The first concerns the putting of more and more powerful software packages into computational practice, using increasingly high-performance computers with increasingly large memory. The traditional finite element and finite difference approaches are still prevalent.

Over the years however, researchers have met with new problems; their solutions on the basis of traditional methods are at best difficult and at worst impossible to obtain. Such problems provided a powerful impetus in the development of the second strand, resulting in the development of essentially new approaches for numerical modeling, for example meshless methods, "molecular" dynamics, neuron networks. The current state of the art formed the basis of many papers presented at the Fifth World Congress on Computational Mechanics, Vienna 2002.

It is within the framework of the second strand that this book has been written.

The book concerns the problem of numerical finite element analysis of non-stationary dynamic processes in solids, using a novel 'wave' approach. The method is able to take into account strong discontinuities of stress, deformation, and velocity wave fronts, as well as finite wave propagation speeds. Such phenomena are particularly important within problems for which the time-scale is the same order as that of the time taken for a wave to propagate over the system; for instance, within explosions, shocks, seismic waves and structures with rapidly varying mass or stiffness.

The investigations were begun by the author in the mid 1970's at the Central Institute of Aviation Engines (Moscow). The first results relating to 1-D problems were presented in a number of reports and journal papers. The methodology was applied to analysis of numerous engineering problems and generalized in a monograph by Shorr B.F and Mel'nikova G.V. "Calculation of Mechanical Systems Using the Method of Direct Mathematical Modelling", 1988. However, all these publication, and other up until 1995, were in Russian and remain little known to western professionals.

In the last few years the 'wave' approach has been refined and extended to multi-dimensional processes, allowing a number of new solutions for unsteady problems in solids to be found. In this book the wave finite element method (WFEM) is systematically presented for the first time.

The book is designated for researchers, lecturers, post-graduates, and final year under-graduate students interested in problems of numerical modeling of non-stationary dynamic processes in deformable bodies and continua, as well as general problems of computational mechanics. Engineers and researchers, engaged in the design and analysis of machines and structures in which shock, vibro-impact and other unsteady dynamic processes play an important role may well find the book beneficial to their own research. The author believes that acquaintance with the method can be also of utility to specialists in design of electrical circuits and liquid currents in pipelines.

The author expresses deep gratitude to Prof. V.Babitsky, under which initiative the English edition of the book was carried out and which valuable councils the author repeatedly used, Prof. G.Rogerson, whose aid in 'polishing' the English of the book was very appreciated, and Dr. D.Merkle and the staff of Springer-Verlag for assistance in preparation and publication of the book. The author is also grateful to Prof. Ju.Kaplunov for useful discussion of a number of aspects of this work and to colleagues who have rendered help in realization of some numerical computations.

And finally, I am externally grateful to my wife and colleague Dr. G.Mel'nikova, without whose daily help and support this book would never have been ready for publication.

Boris Shorr, Moscow

Contents