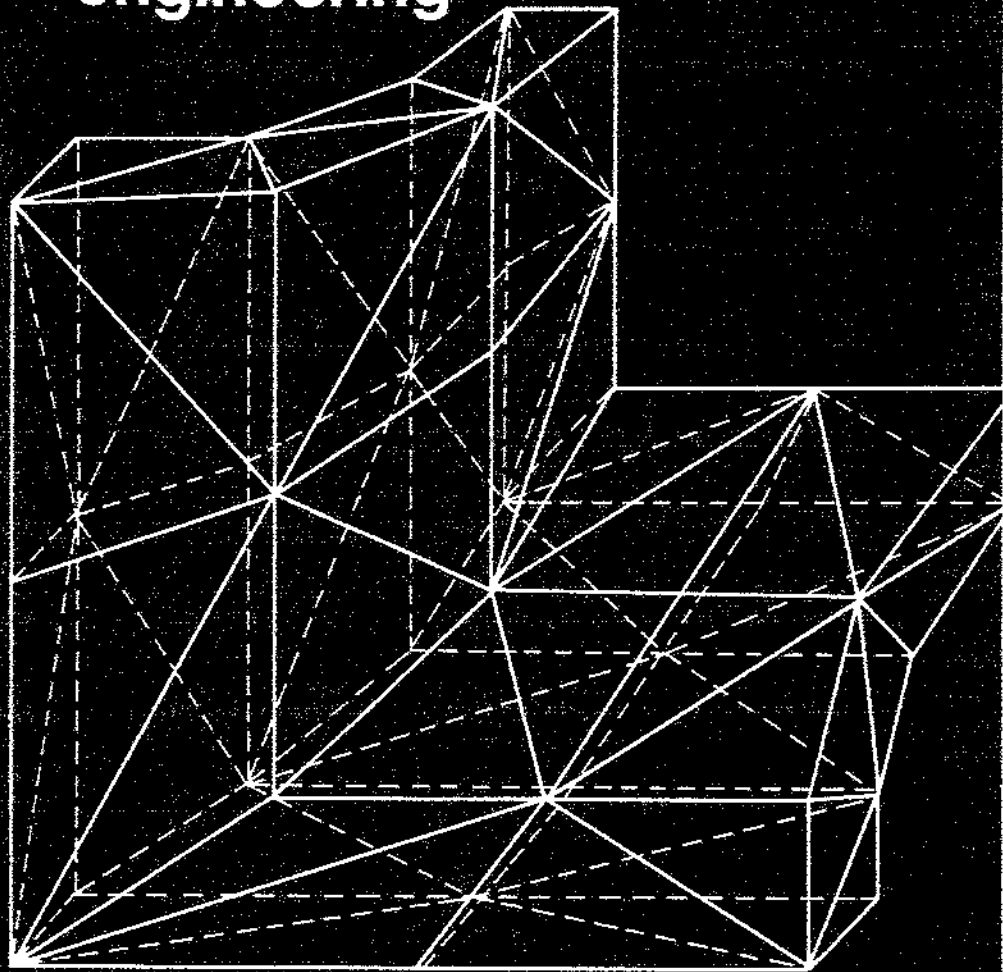


**C.A. Brebbia
S. Walker**

**Boundary element
techniques in
engineering**



Newnes-Butterworths

Preface

The boundary element method originated at Southampton University from previous work on classical integral equations and finite elements. The new method has the advantages of both techniques, that is, it reduces the dimensions of the problem by one as boundary integral equations and it allows for complex surface elements to define the external surface of the domain. It represents an advance over classical finite elements and overcomes many of the main disadvantages such as the difficulty of defining with accuracy domains extending to infinity, having to solve large systems of equations and the need to define complicated data structure.

The method is ideally suited to the solution of many two- and three-dimensional problems in elasticity and potential theory for which finite elements, although popular, are inefficient. In the authors' opinion, finite elements are appropriate for problems such as shells, highly anisotropic media, some non-linear and convective problems but their applicability to a wide range of problems has been overstated. This is doubtless due to the energy of finite element researchers as well as to the coincidental appearance of the method with the development of the first generation of powerful computers. The authors are also aware that the boundary element may not appeal to present-day finite element-oriented engineers and consequently dedicate this book to the coming generation with the warning that they should never take any written work as definitive. Therefore we not only expect but clearly hope that this book will be superseded in due course and that, when this happens, we shall be able to bow gracefully rather than enter into fruitless argument.

It is suggested that readers who wish to have an introduction to boundary elements and a basic knowledge of how boundary element programs are developed should refer to the main author's earlier book, *The Boundary Element Method for Engineers* (Pentech Press, London, 1978).

The Butterworth Group

United Kingdom Butterworth & Co. (Publishers) Ltd
London: 88 Kingsway, WC2B 6AB

Australia Butterworths Pty Ltd
Sydney: 586 Pacific Highway, Chatswood, NSW 2067
Also at Melbourne, Brisbane, Adelaide and Perth

Canada Butterworth & Co. (Canada) Ltd
Toronto: 2265 Midland Avenue, Scarborough, Ontario M1P 4S1

New Zealand Butterworths of New Zealand Ltd
Wellington: T & W Young Building, 77-85 Customhouse Quay, 1,
CPO Box 472

South Africa Butterworth & Co. (South Africa) (Pty) Ltd
Durban: 152-154 Gale Street

USA Butterworth (Publishers) Inc.
Boston: 10 Tower Office Park, Woburn, Mass. 01801

First published 1980

© Butterworth & Co. (Publishers) Ltd., 1980

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, including photocopying and recording, without the written permission of the copyright holder, application for which should be addressed to the Publishers. Such written permission must also be obtained before any part of this publication is stored in a retrieval system of any nature.

This book is sold subject to the Standard Conditions of Sale of Net Books and may not be re-sold in the UK below the net price given by the Publishers in their current price list.

British Library Cataloguing in Publication Data

Brebbia, Carlos Alberto

Boundary element techniques in engineering.

1. Engineering mathematics

2. Boundary value problems

I. Title II. Walker, Stephen, b. 1949

620'.001:515353 TA347.B/ 79-4272

ISBN 0-408-00340-5

Typeset by The Macmillan Co. of India Ltd., Bangalore
Printed in England by The Camelot Press Ltd., Southampton

Contents

1 Approximate Methods 1

- 1.1 Introduction
- 1.2 Weighted Residual Techniques
- 1.3 Weak Formulations
- 1.4 The Inverse Problem
- 1.5 Boundary Methods

2 Potential Problems 25

- 2.1 Introduction
- 2.2 The Fundamental Solution and Direct Formulation
- 2.3 The Indirect Formulation
- 2.4 Matrix Formulation
- 2.5 Poisson's Equation
- 2.6 The Orthotropic Case
- 2.7 The Helmholtz Equation

3 Higher-Order Elements 54

- 3.1 Introduction
- 3.2 Linear Elements for Two-Dimensional Problems
- 3.3 Quadratic and Higher-Order Elements
- 3.4 Elements for three-Dimensional Problems
- 3.5 Three-dimensional Elements
- 3.6 Order of Interpolation Functions

4 Fundamental Solutions**80**

- 4.1 Introduction
- 4.2 Eigenfunctions and the Dirac Delta Function
- 4.3 Fundamental Solutions on a finite Region
- 4.4 Infinite Domains
- 4.5 The Fundamental Solution in Infinite Space
- 4.6 Numerical Solutions (Anisotropic Bodies)
- 4.7 The Method of Images
- 4.8 The Fundamental Solution and Boundary Elements
- 4.9 Explicit Forms for the Fundamental Solution

5 Elastostatics**120**

- 5.1 Introduction
- 5.2 Weighted Residual Statements
- 5.3 Fundamental Solution
- 5.4 Source Approach
- 5.5 Matrix Formulation
- 5.6 Two-Dimensional Elasticity

6 Time-Dependent and Non-Linear Problems**151**

- 6.1 Introduction
- 6.2 Transform Methods
- 6.3 Fourier Transforms
- 6.4 Laplace Transforms
- 6.5 Transient Elastodynamics
- 6.6 Steady State Elastodynamics
- 6.7 Viscoelastic Problems
- 6.8 Time Integration Using Time Stepping
- 6.9 Time-Dependent Fundamental Solution
- 6.10 Non-Linear Problems
- 6.11 Plasticity and Soil Mechanics Problems

7 Combination of Regions**180**

- 7.1 Introduction
- 7.2 Division into Regions
- 7.3 Approximate boundary Solutions
- 7.4 Infinite Elements
- 7.5 Combination of Finite and Boundary Elements

Index**209**