

EFFECTIVE NUMERICAL TREATMENT OF BOUNDARY INTEGRAL EQUATIONS: A FORMULATION FOR THREE-DIMENSIONAL ELASTOSTATICS

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SUMMARY

The field equations of three-dimensional elastostatics are transformed to boundary integral equations. The elastic body is divided into subregions, and the surface and interfaces are represented by quadrilateral and triangular elements with quadratic variation of geometry and linear, quadratic or cubic variation of displacement and traction with respect to intrinsic co-ordinates. The integral equation is discretized for each subregion, and a system of banded form obtained. For the integration of kernel-shape function products, Gaussian quadrature formulae are chosen according to upper bounds for error in terms of derivatives of the integrands. Use of the integral formulation is illustrated by the analysis of a prestressed concrete nuclear reactor pressure vessel.

INTRODUCTION

The boundary integral equation method consists of the transformation of the partial differential equations describing the behaviour of the unknown inside and on the boundary of the domain to an integral equation over the boundary, and the numerical solution of this equation for functions on the boundary alone. If values at interior points are required, they are calculated afterwards from the surface data. The system of equations resulting from discretization of the boundary integral equation is smaller than that obtained by, for example, the finite element method, and the field equations are satisfied exactly everywhere inside the domain; but the matrix is non-symmetric and fully populated. A matrix of banded form can, however, be obtained by dividing the domain into subregions, for each of which the integral equation is written.

The integral equations considered here are those obtained directly from the divergence theorem and the elementary solution for the partial differential equation (e.g. the displacement of an infinite elastic space subjected to a concentrated force). The method is therefore applicable only where the elementary solution is known; this, however, is not a severe restriction because, for an elliptic operator with constant coefficients, the solution can be calculated by Hörmander's method.¹

Jawson and Ponter² and Symm³ solved in 1963 some simple boundary value problems for Laplace's equation in two dimensions, by the boundary integral equation method. The boundary is represented by straight segments, over each of which the unknown function is supposed to be constant, and the integral equation is written at the centre of each segment. The kernels of the integral equation are integrated by Simpson's Rule. The formulation for plane elastostatics by Rizzo⁴ is similar, except in that the integration is done analytically. A large number of boundary segments are still required for the solution of practical problems.

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Numerical Treatment Of Integral Equation

Michael Hoelscher



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