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Isotropic-BEM coupled with a local point interpolation method for the solution of 3D-anisotropic elasticity problems

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ABSTRACT

This paper presents a solution procedure for the three-dimensional linear elastic problem with anisotropic properties. The approach uses the partition of the displacement field into complementary and particular parts. The former is the solution of a differential equation similar to that of an isotropic elastostatic and is obtained by the isotropic boundary element method. The particular integral is obtained by solving the corresponding strong form differential equations, using the local radial point interpolation method. This promising approach is simple to implement and leads to highly accurate solutions in some simple tested situations.

1. Introduction

Due to its characteristics of reducing the dimension of the problem by one, the boundary element method has become a popular tool for solving many problems in engineering, particularly when the governing partial differential equation is linear. This is the case with isotropic elasticity problems for which a well known analytical fundamental solution exists. For elastic problems without body forces, the implementation of the method is straightforward and has reached a mature level, such that a very accurate numerical solution is always obtained. In the presence of body forces, the integral formulation involves a volume integral. The easiest way to treat it is to use volume cells, which to a certain extent eliminates the advantage of the boundary element method. To solve the problem of volume integrals, a number of strategies have been proposed to convert them into surface integrals such as the dual reciprocity method (Nardini and Brebbia [1]), the radial integration method (Gao [2]).

The 3D-anisotropic elasto-static problems can also be solved by the boundary element method (e.g. [3–11]). However in this case, the implementation of the method involves tedious calculations of the derivatives of the displacement Green's functions. In another approach, the formulation uses Kelvin's fundamental solution. The resulting relation contains a domain integral, which is converted into surface integral by the dual reciprocity method (Schlar and Partridge [12]). A method similar to the dual reciprocity method is that of particular integrals, which has well-established mathematical roots and has been successfully applied in various fields, including 2D-anisotropy (Deb and Banerjee [13]).

Within the framework of domain reduction numerical methods, meshless methods also known as meshfree methods have attracted much attention for the solution of various types of solid mechanic problems in recent years (e.g. [14–17]). Amongst these methods, the strong form meshfree collocation method is very attractive and has been successfully applied for the solution of some problems, including mixture problems [18]. In the presence of Neumann type boundary conditions which deteriorate the solution accuracy when radial basis function is employed, another approach which combines the advantages of the strong form collocation and the weak form formulation is known as the meshfree weak–strong form and has been proposed by Liu and Gu [19]. For a solid mechanics problem, the latter approach seems inevitable due to the existence of natural boundary conditions in most real problems. It is difficult to perform an accurate numerical integration over the background cells.

In this work, a simple solution procedure of 3D-anisotropic elastic problem is proposed. The philosophy of particular integrals is adopted. The complementary function is obtained by using the isotropic-BEM and the particular integral by using the strong form local radial point interpolation. Regarding the implementation, only a reasonable modification of an existing isotropic elasto-static boundary element code is required.

The proposed solution procedure is outlined in Section 2 below, where the meshfree approach is more detailed. In Section 3, the validity of the approach is demonstrated using some simple examples of uniform loading of a cubic specimen, tension and torsion of a cylindrical specimen of circular cross section.

2. Solution method

Consider a homogeneous anisotropic elastic material occupying the domain Ω. When volume forces are neglected, the equilibrium

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