Numerical evaluation of singular integrals using the tetrahedron polar co-ordinates

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Abstract

Tetrahedron polar co-ordinates for analysis of Boundary Integral Equation Method (BIEM) developed by Li et al. (Int. J. Numer. Meth. Eng. 21 (1985) 2071-2098) has been applied to investigate three-dimensional elastostatic problems in an unbounded isotropic matrix containing multiple anisotropic inclusions using the Volume Integral Equation Method (VIEM). The tetrahedron polar co-ordinates are used to reduce the order of singularity of the singular elements by one degree and to carry out the cubature of singular volume integrals over three-dimensional isoparametric quadratic, tetrahedral or hexahedral, internal cells as occur in applications of the VIEM to multiple arbitrarily shaped three-dimensional inclusion problems. In this paper, 56 different tetrahedral elements are used for facilitating numerical evaluation of singular integrals over quadratic hexahedral elements with a singular point while 156 different tetrahedral elements are used for quadratic tetrahedral elements with a singular point. This strategy results in good numerical approximations of singular volume integrals and converts weakly singular integrals into integrals over smooth functions. A Fortran code is implemented for the tetrahedron polar co-ordinates technique. Numerical examples for 3D problems demonstrate the accuracy of the proposed technique. Furthermore, the VIEM is shown to be very accurate and efficient for solving general three-dimensional elastostatic and elastodynamic problems involving multiple anisotropic inclusions whose shape and number are arbitrary.

Keywords: Three-dimensional singular integrals, Tetrahedron polar co-ordinates, Gaussian quadrature, Fortran code, Volume integral equation method, Boundary integral equation method

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