Jin, Z. R.; **Zhang, D. M.**; **Wang, Y. H.**; **Li, Z. L.**

Dynamic element discretization method for solving 2D traction boundary integral equations.

(English) Zbl 1259.74050
Eng. Anal. Bound. Elem. 35, No. 11, 1204-1213 (2011).

Summary: A sufficient condition for the existence of element singular integral of the traction boundary integral equation for elastic problems requires that the tangential derivatives of the boundary displacements are Hölder continuous at collocation points. This condition is violated if a collocation point is at the junction between two standard conforming boundary elements even if the field variables themselves are Hölder continuous there. Various methods are proposed to overcome this difficulty. Some of them are rather complicated and others are too different from the conventional boundary element method. A dynamic element discretization method to overcome this difficulty is proposed in this work. This method is novel and very simple: the form of the standard traction boundary integral equation remains the same; the standard conforming isoparametric elements are still used and all collocation points are located in the interior of elements where the continuity requirements are satisfied. For boundary elements with boundary points where the field variables themselves are singular, such as crack tips, corners and other boundary points where the stress tensors are not unique, a general procedure to construct special elements has been developed in this paper. Highly accurate numerical results for various typical examples have been obtained.

MSC:

74S15 Boundary element methods applied to problems in solid mechanics
74B05 Classical linear elasticity

Keywords:

traction boundary integral equation; boundary element method; isoparametric elements; dynamic element discretization method

Full Text: DOI

References:

[1] Krishnasamy, G.; Rizzo, F.J.; Rudolphi, T.J., Continuity requirements for density functions in the boundary integral equation method, Computational mechanics, 9, 267-284, (1992) · Zbl 0755.65108

[2] Martin, P.A.; Rizzo, F.J., Hypersingular integrals: how smooth must the density be, International journal for numerical methods in engineering, 39, 687-704, (1996) · Zbl 0846.65070

[3] Krishnasamy, G.; Schmerr, L.W.; Rudolphi, T.J.; Rizzo, F.J., Hypersingular boundary integral equations: some applications in acoustic and elastic wave scattering, Journal of applied mechanics ASME, 57, 404-414, (1990) · Zbl 0729.73251

[4] Rudolphi, T.J., The use of simple solutions in the regularization of hypersingular boundary integral equations, Mathematical and computer modelling, 15, 269-278, (1991) · Zbl 0728.73081

[5] Portela, A.; Aliabadi, M.H.; Rook, D.P., The dual boundary element method: effective implementations using the boundary element method, International journal for numerical methods in engineering, 33, 1269-1287, (1991) · Zbl 0825.73908

[6] Guiggiani, M.; Krishnasamy, G.; Rudolphi, T.J.; Rizzo, F.J., A general algorithm for the numerical solution of hypersingular boundary integral equations, Journal of applied mechanics ASME, 59, 604-614, (1992) · Zbl 0765.73072

[7] Guiggiani, M.; Gigante, A., A general algorithm for multidimensional Cauchy principal value integrals in the boundary element method, Journal of applied mechanics ASME, 57, 906-915, (1990) · Zbl 0735.73084

[8] Gallego, R.; Dominguez, J., Hypersingular B.E.M. for transient elastodynamics, International journal for numerical methods in engineering, 39, 1681-1705, (1996) · Zbl 0881.73131

[9] Dominguez, J.; Ariza, M.P.; Gallego, R., Flux and traction boundary elements without hypersingular or strongly singular integrals, International journal for numerical methods in engineering, 48, 111-135, (2000) · Zbl 0987.74074

[10] Polch, E.Z.; Cruse, T.A.; Huang, C.J.; Traction, B.I.E., Solutions for flat cracks, Computational mechanics, 2, 253-267, (1987) · Zbl 0616.73093

[11] Young, A., A single-domain boundary element method for 3-D elastostatic crack analysis using continuous elements, International journal for numerical methods in engineering, 39, 1265-1293, (1996) · Zbl 0894.73207

[12] Ligget, J.A.; Salmon, J.R., Cubic spline boundary elements, International journal for numerical methods in engineering, 17, 453-556, (1981)

[13] Walters, H.G.; Oritiz, J.C.; Gipson, G.S.; Brewer, J.A., Overhauser boundary elements in potential theory and linear elastostatics, (), 459-464

[14] Camp, C.V.; Gibson, G.S., Overhauser elements in boundary element analysis, Mathematical and computer modelling, 15, 59-69, (1991) · Zbl 0726.65129

[15] Watson, J.O., Hermitian cubic boundary elements for the analysis of cracks of arbitrary geometry, (), 465-474

[16] Li, Z.L.; Zhan, F.L.; Du, S.H., A highly accurate BEM in fracture mechanics, Key engineering materials, 183-187, 91-96, (2000)

[17] Ke, L.; Ch, Wang; Zhan, F.L., BEM with single-node quadratic element in crack analysis, Acta mecanica solida sinica, 54-64, (2002), [in Chinese]

[18] Huang, Q.P.; Cruse, T.A., On the nonsingular traction-BIE in elasticity, International journal for numerical methods in engineering, 37, 2041-2072, (1994) · Zbl 0832.73076

[19] Cruse, T.A.; Richardson, J.D., Non-singular somigliana stress identities in elasticity, International journal for numerical methods in engineering, 39, 3273-3304, (1996) · Zbl 0886.73005

[20] Richardson, J.D.; Cruse, T.A.; Huang, Q., On the validity of conforming BEM algorithms for hypersingular boundary integral equations, Computational mechanics, 20, 213-220, (1997) · Zbl 0902.73079

[21] Richardson, J.D.; Cruse, T.A., Weakly singular stress-BEM for 2D elastostatics, International journal for numerical methods in engineering, 45, 13-35, (1999) · Zbl 0960.74073

[22] Jorge, A.B.; Cruse, T.A.; Fisher, T.S.; Ribeiro, G.O., A new variational self-regular traction-BEM formulation for inter-element continuity of displacement derivatives, Computational mechanics, 32, 401-414, (2003) · Zbl 1038.74665

[23] Wang, Ch; Li, ZL, Application of relations of singularity intensities of tangent derivatives of boundary displacements and tractions to BEM, Engineering analysis with boundary elements, 33, 618-626, (2009) · Zbl 1244.74197

[24] Li, Z.L.; Wang, Ch, Particular solutions of a two-dimensional infinite wedge for various boundary conditions with weak singularity, Journal of applied mechanics ASME, 76, 1-13, (2009)

[25] Portela, A.; Aliabadi, M.H.; Rooke, D.P., Efficient boundary element analysis of sharp notched plates, International journal for numerical methods in engineering, 32, 445-470, (1991) · Zbl 0758.73061

[26] Youn, S.; Rudolphi, T.J., On dual boundary integral equations for crack problems, Journal of Korean society of precision engineering, 12, 10, 89-101, (1995)

[27] Muci-Küchler, K.H.; Rudolphi, T.J., Application of tangent derivative boundary integral equations to the formulation of higher order boundary elements, International journal of solids and structures, 11, 1565-1584, (1994) · Zbl 0946.74581

[28] Muci-Küchler, K.H.; Rudolphi, T.J., A weakly singular formulation of traction and tangent derivative boundary integral equations in three dimensional elasticity, Engineering analysis with boundary elements, 11, 195-201, (1993) · Zbl 0780.73094

[29] Muci-Küchler, K.H.; Rudolphi, T.J., Coincident collocation of displacement and tangent derivative boundary integral equations in elasticity, International journal for numerical methods in engineering, 36, 2837-2849, (1993) · Zbl 0780.73094

[30] Brebbia, C.A.; Telles, J.C.F.; Wrobel, L.C., Boundary element techniques, (1984), Spring-Verlag New York · Zbl 0556.73086

[31] Cruse, T.A., Boundary element analysis in computational fracture mechanics, (1988), Kluwer Academic Publishers Dordrecht, Boston · Zbl 0648.73039