Element Differential Method for Piezoelectric Problems

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Abstract

This work investigates electro–mechanical behaviors of piezoelectric materials with anisotropic parameters. A novel numerical method named element differential method (EDM) which is based on strong formulation is proposed for solving such problems. In this method isoparametric elements used in the standard finite element method (FEM) are utilized to discretize the piezoelectric semiconductors. Moreover, the spatial partial derivatives of the displacements and electric potentials are computed based on the isoparametric elements, where the first and second order partial derivatives of the shape functions are analytically derived with respect to global coordinates. Furthermore, a new collocation technique is introduced to construct the final system of equations. In this technique, the governing equations for piezoelectricity are collocated at nodes inside elements, while the traction equilibrium conditions as well as the boundary conditions are set to be satisfied at the other element boundary points. As a result, the proposed method can take the best from collocation methods and FEM, giving a highly accurate strong formulation-based technique with the adaptability of mesh generation for arbitrary configuration. The proposed method is implemented into computer codes, where several numerical examples with different types of piezoelectric material properties are performed. The accuracy and reliability of the proposed method are verified by comparing its numerical predictions with those of other available numerical approaches.

Keywords: Piezoelectric semiconductors, Element differential method, Strong formulation-based technique, Point collocation method