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Finite Element Analysis of Piezolaminated Structures with Both Geometric and Electroelastic Material Nonlinearities

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Abstract : Piezoelectric laminated smart structures can be subjected to the strong driving electric field, which may result in large displacements and rotations. In one hand, piezoelectric materials usually behave very significant material nonlinear effects under strong electric fields. On the other hand, thin-walled structures undergoing large displacements and rotations exist nonnegligible geometric nonlinearity. In order to give a precise prediction of piezo laminated smart structures under the large electric field, this paper develops a finite element (FE) model accounting for material nonlinearity (piezoelectric part) and geometric nonlinearity based on the first order shear deformation (FSOD) hypothesis. The proposed FE model is first validated by both experimental and numerical examples from the literature. Afterwards, it is applied to simulate for plate and shell structures with multiple piezoelectric patches under the strong applied electric field. From the simulation results, it shows that large discrepancies occur between linear and nonlinear predictions for piezoelectric laminated structures driving at the strong electric field. Therefore, both material and geometric nonlinearities should be taken into account for piezoelectric structures under strong electric.

Keywords : piezoelectric smart structures, finite element analysis, geometric nonlinearity, electroelastic material nonlinearities
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