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Micromechanics Modeling of 3D Network Smart Orthotropic Structures

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Abstract : Two micromechanical models for 3D smart composite with embedded periodic or nearly periodic network of generally orthotropic reinforcements and actuators are developed and applied to cubic structures with unidirectional orientation of constituents. Analytical formulas for the effective piezothermoelastic coefficients are derived using the Asymptotic Homogenization Method (AHM). Finite Element Analysis (FEA) is subsequently developed and used to examine the aforementioned periodic 3D network reinforced smart structures. The deformation responses from the FE simulations are used to extract effective coefficients. The results from both techniques are compared. This work considers piezoelectric materials that respond linearly to changes in electric field, electric displacement, mechanical stress and strain and thermal effects. This combination of electric fields and thermo-mechanical response in smart composite structures is characterized by piezoelectric and thermal expansion coefficients. The problem is represented by unit-cell and the models are developed using the AHM and the FEA to determine the effective piezoelectric and thermal expansion coefficients. Each unit cell contains a number of orthotropic inclusions in the form of structural reinforcements and actuators. Using matrix representation of the coupled response of the unit cell, the effective piezoelectric and thermal expansion coefficients are calculated and compared with results of the asymptotic homogenization method. A very good agreement is shown between these two approaches.

Keywords : asymptotic homogenization method, finite element analysis, effective piezothermoelastic coefficients, 3D smart network composite structures
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