Electro-magneto-elastic coupling in 3D static and free vibration analysis of multilayered plates

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ABSTRACT

GENERAL SIGNIFICANCE

A challenging aspect in designing new aerospace structures is the capability to withstand loads from different physical fields acting during operative flight conditions. In this sense, piezoelectric/piezomagnetic smart materials are interesting as they naturally couple electric/magnetic fields with the elastic one. Some multilayered smart structures embedding both piezoelectric and piezomagnetic laminae include the electro-magneto-elastic behaviour: the action of an external mechanical load generates an output in terms of both magnetic and electric fields (sensor configuration) and the simultaneous action of magnetic and electric potentials generates a global deformation (actuator configuration)[1].

MAIN FEATURES

To understand the behaviour of these smart structures, a 3D full coupled electro-magneto-elastic formulation is developed. A set of five second-order differential equations for plates involving the three equilibrium equations for motion, the divergence equation for electric displacement and the divergence equation for magnetic induction is proposed. This set of equations is solved in a closed-form solution considering harmonic forms in the in-plane direction; the exponential matrix method is employed in the thickness direction. The complicated trends along the thickness direction of magnetic and electric variables must be evaluated considering a layer-wise formulation.

RESULTS

In the present work, static and free vibration results for multilayered plates embedding piezoelectric and piezomagnetic laminae are given in graphical and tabular form in terms of displacements, stresses, magnetic/electric potential, electric displacement, magnetic induction, frequency values and vibration modes. Results are proposed for different configurations, geometries, thickness ratios and load boundary conditions.

CONCLUSION

The present mathematical formulation allows the evaluation of complicated behaviours along the thickness direction in terms of electric, magnetic and elastic variables for different multilayered structures embedding piezoelectric and piezomagnetic laminae. As a 3D formulation is presented, results can be used as a reference for those scientists interested in the development of 2D/3D analytical or numerical models involving the electro-magnetic-elastic coupling.

REFERENCES

[1] E. Pan and P.R. Heyliger, *Exact solutions for magneto-electro-elastic laminates in cylindrical bending*, International Journal of Solids and Structures, **40**, 6859–6876, (2003).