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Three-dimensional hygrothermal vibration of multilayered cylindrical shells

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Abstract

The rise in moisture concentration and temperature reduces both strength and stiffness of composites. A thorough understanding of the effects of temperature and moisture concentration in composite structures is critical in ensuring safety design. There seems to be no such solutions available for multilayered composite cylindrical shells. This paper is therefore devoted to the three-dimensional hygrothermal vibration analysis of multilayered cylindrical shells under general boundary conditions for the first time. The formulation is based on the 3-D elasticity theory. The vibrational displacement field is numerically discretized by the sampling surface technique in the transfer domain and approximated by the spectral method in the remaining domains. The transverse deformations and interlaminar continuities are taken into account in combination with differential-quadrature concept. The governing equations are finally derived in a modified variational form for constrained system and the boundary conditions are taken into account in a unified form by utilizing penalty functions and Lagrange multipliers. The boundary conditions may be free, simply-supported, clamped or/and elastically restrained. The solutions match well with those reported in the literature in verification. The effects of hygrothermal environment, boundary conditions, shell geometry, lamination are brought out and discussed through parametric study.

Keywords: vibration; multilayered cylindrical shells; hygrothermal environment; spectral-sampling surface method; general boundary condition

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