A 3D finite element model for layer-wise analysis of multilayered plates via the exponential matrix method

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ABSTRACT

GENERAL SIGNIFICANCE

The study of behaviour of plates under different physical load conditions is one of the most studied and challenging problem in the structural analysis field. The use of numerical methodologies, such as the Finite Element Method (FEM), permits obtaining a wide range of results for different cases without any limitations in terms of geometries, constraint conditions and load boundary conditions. This powerful feature allows to simulate the behaviour of structures for practical applications in each engineering field (biomedical, civil, naval and aerospace ones).

MAIN FEATURES

A novel 3D layer-wise numerical mathematical formulation for plates is proposed. The three second-order differential equilibrium equations for plates are written in weak form and then solved considering two different techniques: a FEM resolution in the in-plane directions and the exponential matrix method in the thickness direction. The use of the latter resolution method permits obtaining correct results in the post-processing for the transverse normal/shear stresses for each analysis. In the present 3D numerical model, the layer-wise approach is implemented considering the continuity of displacements and transverse shear/normal stresses in weak form. Load boundary conditions at the outer surfaces are also imposed considering the same weak form method.

RESULTS

Results for static analysis of single-layered/multilayered plates are given in both graphical and tabular form in terms of displacements, stresses and strains; these results are compared with other 3D analytical/numerical reference solutions. New benchmarks are proposed for different material configurations, geometries, thickness ratios and mechanical loads.

CONCLUSION

Thanks to the present 3D numerical formulation, complicated behaviour of single-layered/multilayered plates are evaluated with a simple and low computational cost layer-wise FE formulation. This model has all the main features to be successfully extended to coupled multifield applications.