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abst. 2554
Virtual Room
Tuesday
September 1
14h15

A 3D SHELL MODEL FOR THE THERMAL AND HYGROSCOPIC STRESS ANALYSIS OF COMPOSITE AND SANDWICH STRUCTURES

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A general 3D exact shell solution for the thermo-hygro-elastic analysis of a heterogeneous group of multi-layered composite and sandwich structures is proposed. The 3D equilibrium equations are written in orthogonal mixed curvilinear coordinates, they are valid for spherical shells and they automatically degenerate in those for simpler geometries. The elastic part of the proposed model is based on a layer-wise exact solution where the exponential matrix method allows to solve the differential equations through the thickness direction. Simply-supported boundary conditions and harmonic forms for each variable are employed. The temperature and moisture content amplitudes are imposed at the external surfaces in steady-state conditions. Therefore, the related profiles can be evaluated through the thickness direction in three different ways: - calculation of temperature and moisture content profiles using 3D Fourier heat conduction and 3D Fick diffusion equations, respectively; - evaluation of temperature and moisture content profiles using 1D version of Fourier heat conduction and Fick diffusion equations, respectively; - a priori assumed linear temperature and moisture content profiles through the thickness direction. After the definition of the temperature and moisture content profiles, they can be considered as known terms in the 3D differential equilibrium equations. A set of non-homogeneous second order differential equilibrium equations are obtained. After a reduction to a first order differential equation system, the exponential matrix method is used for both the general and the particular solutions. The effects of the temperature and moisture content fields on the static response of plates and shells are investigated for different thickness ratios, geometries, lamination schemes, materials and temperature/moisture content values. Results will demonstrate the importance in the 3D shell model of both the correct definition of the elastic part and the appropriate evaluation of the temperature and moisture content profiles through the thickness of the structures.

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