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Thermo-Mechanical Analysis of Composite Structures Utilizing a Beam Finite Element Based on Global-Local Superposition

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Abstract : Accurate prediction of thermal stresses is particularly important for laminated composite structures, as large temperature changes may occur during fabrication and field application. The normal transverse deformation plays an important role in the prediction of such stresses, especially for problems involving thick laminated plates subjected to uniform temperature loads. Bearing this in mind, the present study aims to investigate the thermo-mechanical behavior of laminated composite structures using a new beam element based on global-local superposition, accounting for through-the-thickness effects. The element formulation is based on a global-local superposition in the thickness direction, utilizing a cubic global displacement field in combination with a linear layerwise local displacement distribution, which assures zig-zag behavior of the stresses and displacements. By enforcing interlaminar stress (normal and shear) and displacement continuity, as well as free conditions at the upper and lower surfaces, the number of degrees of freedom in the model is maintained independently of the number of layers. Moreover, the proposed formulation allows for the determination of transverse shear and normal stresses directly from the constitutive equations, without the need of post-processing. Numerical results obtained with the beam element were compared to analytical solutions, as well as results obtained with commercial finite elements, rendering satisfactory results for a range of length-to-thickness ratios. The results confirm the need for an element with through-the-thickness capabilities and indicate that the present formulation is a promising alternative to such analysis.

Keywords : composite beam element, global-local superposition, laminated composite structures, thermal stresses
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