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A SHELL MODEL FOR LAYERED STRUCTURES WITH VARIATIONALLY EMBEDDED INTERLAMINAR STRESSES

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The goal of the paper is to present a 2D shell formulation which is capable to describe the complicated 3D stress state in layered composite shells. Especially the interlaminar stresses as driving forces for initiation and growth of delamination have to be evaluated sufficiently accurate. The theory is based on Reissner–Mindlin kinematic assumptions along with an inextensible director field. This leads in a basic version to averaged transverse shear strains and vanishing transverse normal strains when exploiting the Green–Lagrangian strain tensor. Subsequently the displacement field is enriched by an additional part using layerwise cubic interpolation functions. The weak form of the boundary value problem is derived with the equilibrium equations for the stress resultants and stress couple resultants, the local equilibrium equations in terms of stresses, the geometric field equations, the constitutive equations and a constraint which enforces the correct shape of the displacement fluctuations through the thickness. Thereby an interface to three–dimensional material laws is created. The independent mechanical fields are approximated introducing appropriate interpolation functions. Static condensation is applied to eliminate a set of parameters on element level. The resulting quadrilateral finite shell element possesses the usual 5 or 6 nodal degrees of freedom. This is an essential feature since standard geometrical boundary conditions can be applied and the element is applicable also to shell intersection problems. For linear elasticity the computed transverse shear stresses are automatically continuous at layer boundaries and zero at the outer surfaces. In comparison to fully 3D computations present formulation needs only a fractional amount of computing time. Several linear and nonlinear test examples are investigated. Amongst others stability problems, eigenfrequencies and load deflection behaviour of layered structures considering inelasticity are computed.

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