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A novel three-variable shear deformation plate formulation: Theory and Isogeometric implementation

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Abstract

This study brings to readers the generalized formulation of three-variable plate theory and an efficient computational approach for plates. The theory not only has three degree of freedoms (DOFs) per node complying with three dimensional space of full plate model as classical plate theory (CPT) but also accounts for the effect of shear deformation without any requirement of shear correction factors (SCF). A complete set of strong forms, weak form as well as classical and non-classical boundary conditions (BCs) for linear and geometrically nonlinear analysis are consistently derived in this paper through a variational approach. The strong forms are sixth order differential equations, resulting in the symmetrical fourth order differential weak form. It is known that Isogeometric Analysis (IGA) arguably outweigh classical finite element method in terms of high continuity and high order differentiability. Thanks to its advantage, an IGA framework for the generalized three-variable plate theory is formulated with completely locking-free and only three DOFs per node. The classical BCs are strongly enforced to system equations as usual whilst the non-classical BCs are weakly imposed by a penalty approach. The new plate theory with only three-variable is thereafter used for static linear and nonlinear analysis of isotropic and functionally graded material (FGM) plates to demonstrate its ability. The reliability and accuracy of the present approach are ascertained by comparing the obtained results with other existing ones. Based on a robust formulation devoted in the paper, the proposed approach can be further extended for numerous problems related to the shear deformable

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