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## A deformation mechanism based material model for topology optimization of laminated composite plates and shells

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### Abstract

This paper presents a novel deformation mechanism based material model for topology optimization of laminated plates and shells considering large displacements. Discussed firstly are the one-node hinges in optimum designs of plate and shell structures and the numerical issues caused by void elements in geometrical nonlinear analysis. To circumvent these two problems, we propose a new material model in which different penalties are applied to different strain energy terms related to extensional, shear, bending and extensional-bending coupling deformation mechanisms and void elements are removed in nonlinear finite element analysis. An efficient algorithm is developed by using the present material model and the moving iso-surface threshold method. Numerical results are presented for isotropic and composite plates and shells and compared with those available in the literature to validate the present material model.

**Keywords:** material model, plate and shell, large deflection, optimization

### Nomenclature

$[_0^t \mathbf{B}_L]$  Linear strain-displacement transformation matrix

$[_0^t \mathbf{B}_{NL}]$  Nonlinear strain-displacement transformation matrix

$[_0^t \mathbf{K}_L]$  Global linear strain incremental stiffness matrix

$[_0^t \mathbf{k}_L]$  Element linear strain incremental stiffness matrices

$[_0^t \mathbf{K}_{NL}]$  Global nonlinear strain incremental stiffness matrix

$[_0^t \mathbf{k}_{NL}]$  Element nonlinear strain incremental stiffness matrix

**N** Extension force

**M** Bending moment

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