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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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