

TIME INTEGRATION ALGORITHMS FOR STRUCTURAL OPTIMIZATION

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Abstract

We minimize failure criteria with respect to element-wise fiber orientation in laminae (and laminates) undergoing finite strains. A fully mechanical optimization approach is adopted: the analysis is encapsulated in a Newmark time integration equivalent to Nesterov's first-order minimization algorithm, with Newton iteration followed by the solution of an adjoint system to obtain analytical sensitivities. This is implemented in our in-house software, Simplas. We consider transversely isotropic elasticity; and hyperelasticity, via the homogenized model of an incompressible Neo-Hookean material filled with cylindrical (fiber-like) pores. Two stress-based criteria are adopted: Tsai–Wu and modified Tsai–Hill. A finite strain solid-shell element, known to be locking-free, is used and here extended to perform the sensitivity operations. Three examples of optimized transversely isotropic elastic composites are shown, exhibiting remarkable advantages when compared with traditional optimization algorithms. One example is dedicated to finding optimal cylindrical void orientation in a hyperelasticity framework. The algorithm works for very high values of deformation. During stress minimization, stiffness can either decrease or increase, and this was observed in the numerical experiments.

A open source package GPL v.3 containing source code will be presented with the algorithm and application.