Extension of isogeometric Kirchhoff-Love shell formulations towards brittle fracture, plasticity and ductile fracture problems

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ABSTRACT

This work deals with the extension of the isogeometric Kirchhoff-Love (KL) shell formulations developed by Kiendl et al. [1]-[2] towards brittle fracture, plasticity, and ductile fracture problems. Firstly, this rotation-free KL shell model is combined with phase-field brittle fracture description [3]. The kinematics and the phase-field are defined on the midsurface of the structure. It is shown that the variation of strains through the shell thickness has to be considered and the split into tensile and compressive elastic energy components, needed to prevent cracking in compression, has to be carried out at various points through the thickness, which prohibits the typical separation of the elastic energy into membrane and bending terms. Secondly, the KL shell formulation is applied to elasto-plastic models at infinitesimal and large deformations. For elasto-plastic analysis, the classical J_2 plasticity with isotropic hardening based on the additive decomposition of strain into elastic and plastic strain tensors is used, whereas under the finite strain setting a multiplicative decomposition of the deformation gradient in elastic and plastic parts is adopted. A general 3D elastoplastic constitutive model is used for the shell analysis and the necessary plane stress condition is enforced iteratively. Thirdly, this elasto-plastic KL shell formulation is coupled with phase-field ductile fracture model. To show the applicability of the proposed models, a careful investigation on various numerical and benchmark examples under different possible strain states and detailed comparisons with three dimensional solid simulations and with reference solutions from the literature are carried out.

REFERENCES

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