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FINITE DISPLACEMENTS AND COROTATIONAL INTERFACES: CONSISTENT FORMULATION AND SIMMETRY OF THE STIFFNESS MATRIX

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Mechanical interfaces are theoretical and computational tools able to properly reproduce the progressive delamination of composite structures. Scientific literature is rich of interface models, mostly developed in small displacements, whereas a few of them assess the problem in a geometrically nonlinear setting.

In the present paper interface formulation is rigorously developed in a geometrically nonlinear setting, and the relevant interface constitutive relations are defined in the local reference with normal and tangential axes to the middle surface in the current configuration. The interface is defined as a zero thickness layer with tractions acting between the two connected surfaces. Membrane forces are assumed negligible and separation displacement is assumed to remain small, at least up to full debonding. Under this “constitutive” hypothesis rotational equilibrium, discussed in [1], is implicitly verified.

Geometric operators in the current configuration, such as the normal and tangential vectors to the middle surface and interface elongation, are defined as functions of nodal displacements. Corotational approach is also developed from the same formulation under the further hypothesis of small interface elongation.

The nodal force vector and consistent tangent stiffness matrix are computed for a two-dimensional interface element. At difference with the available formulations, the present approaches show that symmetry condition of the geometric stiffness matrix is achieved both for the finite displacement interface and for the corotational one. As pointed out in [2], symmetry of the tangent stiffness is in itself a relevant property and, moreover, it produces higher rate of convergence and reduced computational time by means of a symmetric solver.

The two proposed formulations have been implemented in an open source finite element code FEAP [3] coupled with the cohesive-frictional interface model proposed in [4] and some numerical simulations are presented. Correctness and effectiveness of the two formulations are shown and compared in terms of convergence rate.

References

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