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MESHLESS ANALYSIS OF SHEAR DEFORMABLE SHELLS: KINKS AND MULTI-REGION PROBLEMS

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Meshless approximations provide a great resource in the analysis of structures as the desired continuity in the approximated fields can be achieved. This feature is well suited for thin structures like shells, as stresses can be obtained as smoothly as desired. The present work aims at developing the study of the Element-Free Galerkin Method (EFG) for the geometrically exact analysis of shells. It started with the derivation of a geometrically linear model [1] and now focus on the imposition of boundary displacements and interface continuity in multi-region problems.

A common approach in shell analysis, especially in a meshless framework, is to map the initial geometry from a reference plane configuration, in a stress-free transformation. A problem arise when the initial configuration presents kinks, e.g., the domain must be described by multiple regions and joined together. Similar problem arise when different regions must be refined independently, or different structural theories are to be used in different regions.

This problem resembles that of non-conforming Finite Element meshes or blending FE and meshless approximations [2] or even of imposing essential boundary conditions on EFG [3]. This work compares three approaches based on modifications in the weak form: to use Lagrange Multipliers, the traditional Penalty Method and the Interior Penalty Method [4].

Lagrange Multipliers are the traditional solution for imposing EBCs in the EFG and are suitable for bonding multiple regions. Nevertheless, the interface boundary must be discretized along with the essential boundary. New unknowns are introduced in the problem and the choice of a discretization space is subtle, as one must obey an inf-sup condition.

The Interior Penalty Method uses the original approximation field (displacements and rotations in this case) to express the stresses normal to the Dirichlet and interface boundaries, therefore avoiding the introduction of new unknowns. The new terms introduced in the weak form maintains the original differential expressions even when a traditional penalty term is added to retain optimal convergence rates.

Results shows that the Interior Penalty Method is suitable for the linear analysis of shells, as it showed to be in plane elasticity. A more complex formulation is required, but the use of Moving Least Squares approximation, continuous for any desired degree, made easy to express stresses from generalized displacements.

There is, however, a small loss in accuracy, easily compensated by the reduced size of the linear system of equations. The works also proposes its continuity towards the geometrically exact shell theory.

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