Analysis of large deformation problems using a stable node-based smoothed finite element method

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Abstract

A stable node-based smoothed finite element method (SNS-FEM) without introducing of any uncertain parameter is proposed to cure the temporal instability of the node-based smoothed finite element method (NS-FEM) in large deformation problems. In present method, the analysis domain is firstly discretized into a set of linear triangular or tetrahedral elements, which further forms the so-called node-based smoothing domains based on the weakened-weak forms. Then, the integration domains of SNS-FEM can be recognized as equivalent circular or spherical regions. Subsequently, four or six virtual integration points symmetrically lie at the crossover points of an equivalent region and the local coordinate axis. Through this operation, a stabilization item associated with the variance of the corresponding field variable gradient is constructed, and then can be used to better capture the nonlinear change of stress distribution. On this basis, SNS-FEM not only can keep the advantages of NS-FEM: high convergence and resistance to mesh distortion, but also performs better in effectiveness and efficiency than the finite element method (FEM). In complicated time-dependent situations, the super stability of SNS-FEM can significantly reduce the NS-FEM's error in the analysis, which illustrates the feasibility and great potential of SNS-FEM in practical engineering.

Keywords: Node-based smoothed finite element method (NS-FEM); Temporal stability; Large deformation problems; The stable node-based smoothed finite element method (SNS-FEM)