# Analysis of time-dependent problems using a stable node-based smoothed finite element method

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## Abstract

It is well-known that the classical "overly-soft" node-based smoothed finite element method (NS-FEM) fails to provide reliable results to time-dependent problems due to the "temporal instability". In order to cure this fatal drawback, a stable node-based smoothed finite element method (SNS-FEM) by considering the strain gradient is presented in this work. Three-node triangular (for 2D space) and four-node tetrahedral (for 3D space) elements that can be generated automatically for any complicated geometries are first adopted to discretize the problem domain. Based on the node of the element, the smoothed gradient fields together with the gradient variance items are then formed, which will be further used to construct the discretized system equations through the generalized Galerkin weakform. As the addition of the stabilization term can provides the SNS-FEM model a "close-to-exact" stiffness, thus successfully cures the temporal instability of NS-FEM. Numerical examples, including both mechanics, thermotics, acoustics and electromagnetics cases, demonstrate that the SNS-FEM possesses the following interesting properties: (1) temporal stability; (2) super-accuracy and super-convergency; (3) higher computational efficiency; (4) insensitive to mesh distortion.

**Keywords:** Numerical methods, Node-based smoothed finite element method, Time-dependent problems, Temporal stability.