A node-based smoothed finite element method (NS-FEM) for free and forced vibration analysis of three-dimensional (3D) structures

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Abstract

The smoothed finite element method (S-FEM) has been found to be an effective solution method for solid mechanics problems. This paper represents an effective approach to compute the lower bounds of free vibration and the upper bounds of the forced vibration of solid structures, by making use of the important softening effects of node-based smoothed finite element method (NS-FEM). This paper explores, for the first time, this unique feature of NS-FEM to develop a complete formulism and procedure to study free vibration and forced vibration of solid structures, via 1) solving eigenvalue problems that produces vibration modes of a given structure; 2) using model superimposition techniques and the Lanczos algorithm to obtain transient dynamic solution for structures subjected to arbitrary dynamics forces. For easy automation in creating 3D solids, we use only the automatically generatable tetrahedral mesh, while to ensure excellent stress solution using the NS-FEM models. The results are compared with those from the commercial finite element analysis software ABAQUS in terms of accuracy and convergence.

Keywords: Node-based smoothed finite element method; Free vibration; Forced vibration; Lanczos algorithm; Mode superposition method