

I-O-3.1

DEVELOPMENT OF SMOOTHED FINITE ELEMENT METHODS (S-FEM)

Nguyen Thoi Trung

Faculty of Mathematics and Computer Science, University of Science – VNU HCMC

Abstract

This paper presents the development of smoothed finite element methods (S-FEM) including cell-based smoothed FEM (CS-FEM), node-based smoothed FEM (NS-FEM), edge-based smoothed FEM (ES-FEM), face-based smoothed FEM (FS-FEM) and alpha-FEM (α FEM) by combining the existing standard FEM and the strain smoothing technique. In the S-FEM models, the strain smoothing domains and the integration of the weak form are performed over the smoothing domains associated with elements, nodes, edges or faces, respectively. The results of the research showed four crucial contributions: 1) S-FEM models are promising to provide more feasible options for computational mechanics, especially for methods using triangular and tetrahedral elements; 2) S-FEM models give more the freedom and convenience in constructing shape functions, and also in using distorted elements and n-sided polygonal elements; 3) NS-FEM which possesses interesting properties of an equilibrium FEM model is promising to provide a much simpler tool to estimate the quality of the solution (global error, bounds of solutions) by combining itself with FEM; 4) α FEM has a very meaningful contribution in providing more the reference benchmark solutions with high accuracy.

Key words: numerical methods, meshfree methods, smoothed finite element method (S-FEM), cell-based smoothed finite element method (CS-FEM), node-based smoothed finite element method (NS-FEM), edge-based smoothed finite element method (ES-FEM), face-based smoothed finite element method (FS-FEM), alpha finite element method (α FEM).

References

- [1] Liu GR, Dai KY, Nguyen-Thoi T. A smoothed finite element method for mechanics problems. *Computational Mechanics* 2007; 39: 859–877.
- [2] Liu GR, Nguyen-Thoi T, Dai KY, Lam KY. Theoretical aspects of the smoothed finite element method (SFEM), *International Journal for Numerical Methods in Engineering* 2007; 71: 902–930.
- [3] Liu GR, Nguyen-Thoi T, Lam KY. A novel Alpha Finite Element Method (α FEM) for exact solution to mechanics problems using triangular and tetrahedral elements. *Computer Methods in Applied Mechanics and Engineering* 2008; 197: 3883-3897.
- [4] Liu GR, Nguyen-Thoi T, Nguyen-Xuan H, Lam KY. A node-based smoothed finite element method (NS-FEM) for upper bound solution to solid mechanics problems. *Computers and Structures* 2009; 87: 14-26.
- [5] Liu GR, Nguyen-Thoi T, Lam KY. An edge-based smoothed finite element method (ES-FEM) for static, free and forced vibration analyses in solids. *Journal of Sound and Vibration* 2009; 320: 1100-1130.
- [6] Nguyen-Thoi T, Liu GR, Lam KY, Zhang GY. A Face-based Smoothed Finite Element Method (FS-FEM) for 3D linear and nonlinear solid mechanics problems using 4-node tetrahedral elements. *International Journal for Numerical Methods in Engineering* 2009; 78: 324-353.
- [7] Liu GR, Nguyen Thoi Trung. *Smoothed Finite Element Methods*. CRC Press, Taylor and Francis Group, NewYork, 2010.