Large time steps in the explicit formulation of transient heat transfer problems

*Eric Li¹, ZC He²

¹State Key Laboratory of Mechanical System and Vibration, Shanghai Jiaotong University, Shanghai, 200240 PR China ²State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, 410082 PR China

*Presenting and corresponding author: ericsg2012@gmail.com

Abstract

It is well known that the explicit time integration of heat transfer problem is conditionally stable. The very small time step leads to increase of computational time dramatically. In this work, the location of integration points in the mass matrix [1-5] using quadrilateral elements is discussed in detail in the simulation of transient heat transfer problems. From both theoretical and numerical perspectives, the stability of dynamic heat transfer model is improved significantly with adjustment of integration points in the mass matrix. The quantitative study has indicted that the numerical stability of discretised model is proportional to r value controlling the location of integration points in the mass matrix as r > 0 in the 2D problems. Numerical experiments including heat conduction, convection and radiation with regular and irregular mesh have demonstrated the superior performance of the proposed integration points in terms of accuracy as well as stability. The successful development of robust, efficient and accurate explicit algorithms has opened a new window in the simulation of general transient heat transfer problems.

Keywords: Integration point; Explicit method; Heat Transfer; Stability; Mass Matrix

References

- [1] Eric Li, ZC He, Yong Jiang, Bing Li. 3D mass-redistributed finite element method in structuralacoustic interaction problems. Acta Mechanica 227 (2016) 857-879.
- [2] ZC He, GY Li, GR Liu, AG Cheng, Eric Li. Numerical investigation of ES-FEM with various Mass redistribution for acoustic problems. Applied Acoustics 89 (2015) 222–233
- [3] ZC He, GY Li, GY Zhang, GR Liu, YT Gu, Eric Li. Acoustic analysis using a mass-redistributed smoothed finite element method with quadrilateral mesh. Engineering Computations. 32(5) (2015) 1251-1274.
- [4] Eric Li, ZC He, Xu Xu, GY Zhang, Yong Jiang. A faster and accurate explicit algorithm in the dynamic quasi-harmonic problems. International Journal of numerical methods in Engineering 2016 10.1002/nme.5233.
- [5] Eric Li, ZC He, ZP Zhang, Xu Xu, GR Liu, Q Li. Stability analysis of generalized mass formulation in dynamic heat transfer. Numerical Heat Transfer, Part B: Fundamentals. 2015 DOI: 10.1080/10407790.2015.1104215.