A new meshfree method: free element collocation method (FECM)

†Xiao-Wei Gao[1]*

[1]Dalian University of Technology, State Key Laboratory of Structural Analysis for Industrial Equipment, School of Aeronautics and Astronautics, Dalian 116024, China.

*Presenting author: xwgao@dlut.edu.cn
†Corresponding author: xwgao@dlut.edu.cn

Abstract

In this paper, a new type of isoparametric elements, called as Cross-Line Elements (CLEs), are constructed, which have very few nodes to simulate geometries and interpolate physical variables in both two-dimensional (2D) and three-dimensional (3D) problems. Based on these CLEs, a completely new numerical method, called as Free Element Collocation Method (FECM), is proposed based on the element differential formulations [1, 2] for solving general 2D and 3D boundary value problems of partial differential equations. FECM is a strong-form collocation method, combining the advantages of the finite element method [3] and meshfree method [4] in the aspects of setting up shape functions and generating computational meshes through node by node. The distinct feature of FECM is that only one element is needed for each node and the collocation element can be freely formed by the nodes surrounding the collocation node, which make the bandwidth of the final system of equations extremely narrow.

When solving a specific problem using FECM, only the governing differential equations and boundary conditions are needed, no additional mathematical or mechanical principles being required and no any integrations needing to be evaluated. In addition, since the free elements used in FECM can be easily formed by arbitrarily selecting local nodes surrounding the collocation node, distorted elements can be easily avoided and the stable and accurate results can be achieved. A number of 2D and 3D numerical examples for thermal and mechanical problems are given to show the correctness and efficiency of the newly constructed elements and the proposed numerical method.

Keywords: **Cross-line element; free element collocation method; element differential method; finite element method; mesh free method; thermal-mechanical problem.**

References

[1] Gao, X. W., Huang, S. Z., Cui, M., Ruan, B., Zhu, Q.H., Yang, K., Lv, J. and Peng, H.F. (2017) Element differential method for solving general heat conduction problems, *International Journal of Heat & Mass Transfer* **115**, 882–894.

[2] Gao, X. W., Li, Z. Y., Yang, K., Lv, J., Peng, H. F., Cui, M., Ruan, B. and Zhu, Q. H. (2018) Element differential method and its application in thermal-mechanical problems, *Int J Numer Methods Eng.* **113**, 82–108.

[3] Zienkiewicz, O. C. and Taylor, R.L., *The Finite Element Method*. McGraw-Hill: London, UK, 1989.

[4] Liu, G. R. (2016) An overview on meshfree methods: for computational solid mechanics. *International Journal of Computational Methods* **13** (5), 1630001.