Global element collocation method

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Abstract

In this paper, a family of global elements are constructed based on corresponding complete basis functions formulated in terms of the global coordinates. The nodes of these elements can be distributed and numbered in an arbitrary manner and therefore can be used to simulate complex geometries. Since the shape functions of these elements are explicitly expressed in terms of the global coordinates, the first and high order partial derivatives of them with respect to global coordinates, which usually appear in the partial differential equations PDFs (or called the governing equations) of the problem, can be directly derived, without need of introducing the local parameters (or called intrinsic coordinates) as done in FEM [1] and in FECM [2] to express the elemental shape functions which have the difficulty to use non-uniformly distributed nodes over an isoparametric element.

Based on the constructed global elements and their spatial derivatives, a simple and robust new numerical method, called as the Global Element Collocation Method (GECM), is proposed for solving general 2D and 3D boundary value problems of PDFs. GECM is a strong-form global element method, combining the advantages of the FEM [1] and mesh free method (MFM) [3] in the aspects of using elements to express coordinates and physical variables, and generating computational meshes and setting up system of equations through the process of node by node. The distinct features of the proposed GECM are as follows: (1) the derived shape functions and their spatial derivatives can be directly substituted into the PDFs of the problem for internal points and the Neumann boundary conditions for boundary points to set up the system of equations, without need of any functional principles or an energy principle to set up the solution scheme; and (2) only one individual element is needed for each collocation point, which make the bandwidth of the final system of equations extremely narrow and without need to consider the continuity of physical variables on the interfaces of elements.

The detailed description of GECM to solve linear, non-linear thermal and mechanical problems will be presented in the paper, and a number of 2D and 3D examples will be given to demonstrate the potential of the proposed method.

Keywords: Global element; global element method; global element collocation method; strong-form global element method; finite element method; mesh free method.

References

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