ICCES, 2023, vol.27, no.1
DOI: 10.32604/icces.2023.09510

PROCEEDINGS

Zonal Finite Line Method and Its Applications in Thermal-Mechanical Analysis of Composite Structures

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ABSTRACT

In this paper, a novel numerical method, Zonal Free Element Method (ZFLM), is proposed and used to solve thermal-mechanical problems composed of multiple and functionally graded materials. ZFLM is a collocation method, in which two or three lines in 2D or 3D problems, called as line-set, are used at each node to establish the solution scheme solving engineering problems governed by partial differential equations. In ZFLM, the Lagrange polynomial is adopted to approximate physical variables varying over each line of the line-set. The first-order partial derivative is derived by using a directional derivative technique along arclength of a line, and a recursive procedure is used to evaluate the second and higher order partial derivatives. The derived various order derivatives can be directly substituted into the governing equations and relevant boundary conditions to form the discretized system of equations. To solve the problem involving composite structures, a zonal technique is proposed, in which the computational domain is divided into several structured zones according to material types and geometric characteristics. For nodes shared by two or more zones, the traction/flux equilibrium equations are used to constrain their variation across the zonal interfaces. For irregular geometries and nodes with jumping loads, multiple line-sets are used at the same node to improve the accuracy and stability. The proposed method is used to solve some challenging thermal and mechanical problems of 2D and 3D composite structures to demonstrate the robustness of the proposed method.

KEYWORDS

Finite line method; zonal finite line method; collocation method; composite structure

Funding Statement: The author(s) received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.