The scaled boundary finite element method

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Abstract

In the finite element method, a problem domain is divided into elements of simple geometries. The shapes of the finite elements are typically limited to triangles and quadrilaterals in 2D and tetrahedrons, wedges and hexahedrons in 3D. On these elements, polynomial interpolations can be easily performed. The simplicity and versatility of the element formulations contribute to the great success of the finite element method. On the other hand, the associated task of mesh generation is often not trivial, especially for moving boundary problems. When the field variables, such as the singular stresses around a crack tip, do not resemble polynomials, the accuracy of the finite element method deteriorates. Various techniques have been developed to reduce the burden on mesh generation and to enrich the basis functions.

In the scaled boundary finite element method, the problem domain can be divided into subdomains of more complex geometries as long as a scaling centre from which the whole boundary is visible can be selected. Interpolation is performed on the boundary only, which offers great flexibility and simplicity in mesh generation. High-order and NURBS basis functions can be applied directly and mixed with each other. The solution in the domain is obtained analytically, which permits accurate and efficient modelling of stresses singularities without the use of asymptotic enrichments. Only standard Gauss integration on the boundary is required. The salient features of this method are illustrated by numerical examples involving stationary cracks, crack propagation, fully automatic analysis of CAD models and images, moving boundaries and adaptive analysis.

Keywords: Scaled boundary finite element method, Polytope elements, Crack propagation, Image-based analysis, Adaptive analysis.