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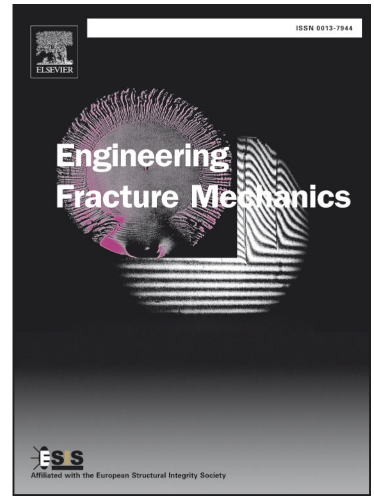

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Chen Xing, Chuwei Zhou

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Finite element modeling of crack growth in thin-wall structures by method of combining sub-partition and substructure

Chen Xing [a], Chuwei Zhou [b]
State Key Laboratory of Mechanics and Control of Mechanical Structures, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu 210016, China
[a] xingchen@nuaa.edu.cn
[b] Corresponding author: zcw@nuaa.edu.cn

Abstract: A combination of sub-partition and substructure methods in finite element is developed to simulate the crack propagation in plate and shell structures. This method allows modeling arbitrary shape crack independent of element mesh and only the elements overlapping crack need to be operated. An element cut apart by a crack is sub-partitioned into ordinary sub-elements while an element enveloping crack tip is sub-partitioned into several singular sub-elements. The whole sub-elements constitute a substructure and the additional nodal freedom degrees introduced by element sub-partition are condensed to nodes of original mesh. In this way global re-meshing is avoided when the crack grows or new crack nucleates. Good accuracy of the crack tip fields prediction and good adaptability of moving crack simulation by the proposed method are proven through designed examples.
Keywords: crack propagation; finite element method; sub-partition; substructure; interaction integral

1. Introduction

Thin-wall structures are extensively used in aero and space vehicles, industrial facilities and large-span buildings. Some of them, e.g. aircraft fuselage, pressure pipe and vessel, have high safety requirements. Since the micro defects such as micro cracks inevitably exist in structures, the subsequent development of cracks during serve life or repair period must be assessed to guarantee the structure have enough residual strength and prevent catastrophic accident. Thus, estimation of crack propagation in plate or shell structure is concerned in mechanical research and engineering design.

The Reissner plate theory is widely used in fracture analysis of thin-wall structures, as it allows for transverse strain through the plate thickness and obtains an angular distribution of stress around the crack tip which consistent with three-dimensional elasticity theory. In practical, numerical methods, especially finite element method (FEM) is useful in fracture analysis of thin-wall structures for their adaptations for problems with complicated configuration, boundary condition and loading.

3D degenerated shell element [1] is flexible for the implementation of shell theory, since its formulation actually agrees with Reissner theory and can be approximated by C^0 interpolation. The early shell elements often suffer from the shear locking phenomenon [2] and various methods have been suggested to overcome this drawback. An attractive one among them is MITC method [3,4] proposed by Bathe’s group in which the assumed natural strain (ANS) technique is employed