工程力学
ENGINEERING MECHANICS
ISSN 1000-4750
CN 11-2595/O3
CODEN GOLIEB
EI 收录期刊

工程力学 » 2012, Vol. 29 » Issue (6): 22-31 DOI: 10.6052/j.issn.1000-4750.2010.08.0594

线粘弹性断裂分析的增量加料有限元法

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THE INCREMENTAL ENRICHED FINITE ELEMENT METHOD FOR FRACTURE ANALYSIS IN A LINEAR VISCOELASTIC BODY

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全文: PDF (634 KB) HTML (1 KB) 输出: BibTeX | EndNote (RIS) 背景资料

摘要 提出了一种用于解决线粘弹性断裂问题的增量加料有限元法。为了反映裂纹尖端的应力奇异性,在裂尖附近的应力奇异区采用若干四边形加料单元和过渡单元,非奇异区采用常规四边形单元,三种单元分区混合使用形成求解域网格划分。加料单元通过引入裂尖渐近位移场,构造出可以较好反映裂尖奇异性的单元位移模式,过渡单元在加料单元基础上引入调整函数构造单元位移模式,用于连接加料单元和常规单元,以消除加料单元和常规单元间位移不协调。基于Boltzmann叠加原理,推导了粘弹性材料的增量型本构关系,进而获得了增量加料有限元列式,并基于节点位移外推法计算粘弹性介质中裂纹应变能释放率。数值算例验证了该文方法的正确性和有效性。

关键词: 线粘弹性体 断裂问题 加料单元 过渡单元 应变能释放率

Abstract: The incremental enriched finite element method (FEM) is developed for fracture problems in a linear viscoelastic body. To manifest the singularity at the crack tip, the quadrangular enriched elements and corresponding transition elements are employed, combined with ordinary elements used on the zone far away from the crack tip. The displacement mode of enriched elements is constructed by enriching the crack-tip asymptotic displacement fields, and that of transition elements is constructed by introducing a zeroing function based on the enriched elements. The role of the transition elements which are placed between the enriched elements and ordinary elements is to eliminate displacement field incompatibility. Based on the Boltzmann superposition principle, the incremental constitutive relation for viscoelastic materials is formulated. Further, the incremental formulations of the enriched FEM are derived. The strain energy release rate in a cracked viscoelastic body is obtained through the node displacement near the crack tip. The numerical results show that the present method is accurate and efficient.

Key words: linear viscoelasticity fracture problems enriched element transition element strain energy release rate

收稿日期: 2010-08-19;

PACS: O346.1

基金资助:教育部新世纪优秀人才支持计划项目(NCET-08-0148);高等学校博士学科点专项科研基金项目(20069998002)

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引用本文:

段静波,雷勇军,李道奎. 线粘弹性断裂分析的增量加料有限元法[J]. 工程力学, 2012, 29(6): 22-31.

DUAN Jing-bo,LEI Yong-jun,LI Dao-kui. THE INCREMENTAL ENRICHED FINITE ELEMENT METHOD FOR FRACTURE ANALYSIS IN A LINEAR VISCOELASTIC BODY[J]. Engineering Mechanics, 2012, 29(6): 22-31.

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