

论文

混杂CFRP/GFRP筋HPC梁的非线性梁壳组合单元研究

(1. 南京航空航天大学航空宇航学院, 南京 210016|2. 东南大学交通学院, 南京 210096| 3. 河海大学工程力学研究所, 南京 210098)

摘要:

对于混杂CFRP/GFRP筋高性能混凝土(HPC)梁, 研究一种新的三维非线性梁壳组合单元, 对HPC梁进行了全过程分析. 引入实体退化壳单元理论, 利用空间梁单元模拟预应力CFRP筋, 并根据CFRP筋单元节点线位移和转角位移的协调性, 推导CFRP筋单元对梁壳组合单元刚度矩阵的贡献, 同时对GFRP筋和HPC梁采用分层壳单元模拟. 并运用Jiang屈服准则、Madrid强化准则等描述混凝土的材料非线性, 提出一种新的非线性梁壳组合单元, 研制相应的三维非线性计算程序. 计算结果与试验数据吻合良好, 说明本文构造的非线性梁壳组合单元的正确性和研制程序的可靠性, 以及混凝土材料非线性描述的合理性; 采用组合单元能准确模拟CFRP筋的几何构形, 能综合考虑其拉压弯剪性能, 利于全面地反映配筋对结构的增强作用.

关键词: CFRP筋 GFRP筋 梁壳组合单元 HPC梁 材料非线性

Nonlinear beam-shell composite element of HPC beam mixed with CFRP/GFRP rebars

(1. College of Aerospace, Nanjing University of Aeronautics & Astronautics, Nanjing 210016, China| 2. College of Transportation, Southeast University, Nanjing 210096, China| 3. Institute of Engineering Mechanics, Hohai University, Nanjing 210098, China)

Abstract:

To study the mechanical performances of HPC beam mixed with CFRP/GFRP rebars during the whole course, a new three-dimensional nonlinear beam-shell composite element was derived. After the degraded shell element theory was introduced, the prestressed CFRP rebar was modeled by a spatial beam element and then based on the compatibility of displacements and rotations of the nodes of CFRP rebar element, the contribution in the stiffness matrix by the prestressed CFRP element to the beam-shell composite element was completed. The GFRP rebar and HPC beam were both modeled by the layered shell element. Combined with Jiang-yielding and Madrid-hardening criteria which were used to depict the material nonlinearity of concrete, a new nonlinear beam-shell composite element was put forward. The nonlinear analytical procedure was compiled. The calculations are in good agreements with experiment results, which shows the efficiency of the studied nonlinear beam-shell composite element and the reliability of the gained nonlinear procedure and the correctness of the adopted criteria of material nonlinearity of concrete. By the composite element, the configuration of CFRP rebar is precisely expressed and the performances such as tension, suppression, torsion and bending are comprehensively considered, which helps to synthetically embody the reinforcement of assembled rebars to the structure.

Keywords: CFRP rebar GFRP rebar beam-shell composite element HPC beam material nonlinearity

收稿日期 2009-09-15 修回日期 2009-12-15 网络版发布日期

DOI:

基金项目:

国家自然科学基金(10472045, 10772078); 南京航空航天大学引进人才科研基金(S0851013)

通讯作者: 张剑, 博士, 讲师, 研究方向: 新型复合材料、结构优化设计

作者简介:

作者Email: jianzhang78@126.com

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