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论文

几何非线性高性能复合材料筋混凝土梁Heterosis组合壳单元

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摘要：

对于高性能碳纤维增强聚合物复合材料(CFRP)筋混凝土梁，研究几何非线性组合壳单元模型，对预应力CFRP筋混凝土梁进行了全过程分析。引入Von Karman理论，推导了局部坐标系下Piola2Kirchhoff 应力矩阵和几何刚度矩阵；分别采用组合壳单元和分层壳单元模拟预应力CFRP 筋和玻璃纤维增强聚合物复合材料(GFRP)筋，并推导了CFRP筋对组合壳单元刚度矩阵的贡献，同时采用Heterosis选择积分技术以避免剪切锁定和零能量模式，研制了相应的非线性计算程序。计算结果与试验数据对比可知，挠度发展规律和预应力CFRP筋应变发展规律均吻合良好，说明了研究单元的有效性及研制程序的正确性；CFRP筋具有高强度性能，梁试件破坏时CFRP筋均未失效；利用预应力CFRP筋应变重分布系数研究了梁的刚度退化规律，表明采用GFRP筋代替普通钢筋在加载后期会使梁的刚度退化减小。

关键词： CFRP筋 几何非线性 组合壳单元 全过程 刚度退化

Geometrically nonlinear Heterosis combined shell element of concrete beam with high performance composite rebar

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Abstract:

In order to study the mechanical properties of concrete beam with high performance composite rebar (CFRP rebar) during the whole course, a geometrically nonlinear combined shell element analytical model of the beam with CFRP rebar was presented. The Von Karman theory was introduced and the Piola-Kirchhoff st ress matrix and geometrical stiffness matrix were deduced in the local coordinative system. The prest ressed CFRP rebar and the GFRP rebar were respectively modeled by the combined shell element and the layered shell element and then the cont ribution stiffness matrix of the prest ressed CFRP element to the combined shell element was completed.Based on Heterosis selecting integral technology, the shearing lock and the zero energy pattern were both avoided. The nonlinear analytical procedure was compiled, with which the computational results were obtained. The calculations including displacement variation regularity and strain variation regularity of CFRP rebar are in good agreement with those in the experiment results, which show the efficiency of the studied nonlinear element and the correctness of the finished nonlinear procedure. CFRP rebars are still in elastic status when the beam reaches the ultimate loads because of high strength property. The stiffness degraded regularity of the beam was studied by using the strain redistribution coefficient of CFRP rebar , and the result showes that in the final stage of adding loads, the stiffness degradation is decreased when the GFRP rebar substitutes the common steel.

Keywords: CFRP rebar geometrically nonlinear combined shell element whole course stiffness degradation

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