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高速铁路双块式无砟轨道计算模型约束方程的建立

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摘 要：为合理处理高速铁路双块式无砟轨道结构动力学分析中梁-板与弹簧、梁-杆与板壳、板壳与实体等连接问题，基于Timoshenko板壳理论和直接法建立多点约束方程，构造双块式无砟轨道组合结构计算模型，将组合结构中相关节点的位移通过偏心关系与板壳理论的直线假设建立的多点约束方程引入Galerkin法的弱积分形式中，解决各种不同类型单元因自由度不同和偏移连接而对组合结构总体刚度矩阵的贡献不同等问题。从理论上分析各种不同类型单元相结合的多点约束方程构建问题，并在此基础上，建立高速铁路双块式无砟轨道结构动力学有限元模型。结果表明：基于Timoshenko板壳理论和直接法所建立的有限元模型是合理的，双块式无砟轨道不同结构层连接良好，能消除常规方法产生的不合理附加应力。

关键字：双块式无砟轨道；有限元；约束方程；直接引入法

Constraints equations establishment for calculation model of double-block ballastless track in high speed railway

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Abstract: In order to appropriately deal with connection problems in kinetics analysis such as shell-beam-bar, superposition plates, beam axis-spring, shell-spring, shell-solid connections in high speed railway's slab track, Timoshenko-type shell theory and direct introduction method were based for establishing multi-point constraint equations and calculation model of the composite slab track. In the composite structure, to counteract different type elements' attribution to the composite structure's total rigid matrix caused by the elements' offset connections, the multi-point constraint equations on the basis of both the linear hypothesis in shell theory and eccentricity relations among relative nodes pairs in the composite structure were introduced to equilibrium equation. Multi-point constraint equations of different type elements were constructed theoretically, and followed by which the dynamic FEM model of the high speed railway's slab track was thereby established. The reliability of the FEM model based on Timoshenko-type shell theory and direct introduction method is reliable by the comparison between numerical analysis and real measured results, and meanwhile the model produces good connections among different layers of the structure, eliminating irrational additional stress generated in conventional methods.

Key words:double-block ballastless track; FEM; constraint equation; direct introduction method