Numerical Simulation of the Nonlinear Flexural Behavior of Pretensioned Void Slabs with Different Concrete Constitutive Laws

Tao Wang, Kai Qiang Guo, Zhao Liu

School of Civil Engineering, Southeast University, Nanjing, China

Contact: mr.liuzhao@seu.edu.cn

Abstract

To investigate the numerical simulation for the nonlinear flexural behavior of pretensioned void slab beams, the three-dimensional finite element models (FEM) of the existing pretensioned void slabs were established and verified through tests. Firstly, based on the concrete constitutive laws in Chinese code and *EN 1992-1*, the damage factors in concrete damaged plasticity (CDP) models derived from energy equivalent model were incorporated. Meanwhile, the constitutive models of reinforcement and prestressing tendons were calibrated in accordance with the yield strength and tensile strength data obtained from the tests. Then, the flexural loading history of the beams were numerically analyzed, and the simulation outcomes were compared with the test results. Finally, the impact of constitutive laws and the damage factors on the calculation accuracy and efficiency of numerical simulation analysis were studied.

Keywords: concrete structure; pretensioned void slab; flexural behaviour; nonlinear analysis; concrete damaged plasticity; test verification.

1 Introduction

Pretensioned void slab has been widely adopted in highway and municipal bridges because of its low deck height, cost effective and convenient construction. It can offer a depth-to-span ratio as low as 1/20. However, the de facto overloading in many road traffic network may render the slab decks into cracking or even nonlinear response to some extent [1]. Accordingly, effective and accurate nonlinear analysis of void slab should be further developed for the whole loading history.

Extensive research efforts have been made to study the nonlinear behavior of concrete slabs using finite element analysis method. Azizian et al [2] investigated punching shear in solid and void slabs, and established their nonlinear finite element models (FEM) validated based on a comparison with experimental specimens under static loading to predict their punching response. Attia et al [3] studied the flexural behavior of a new one-way concrete slab system, and adopted the finite element analysis model to predict the nonlinear structural behavior of the slab strip. Khouzani et al [4] studied the bending behavior of a new biaxial voided slab system proposed, and compared the moment capacity results of numerical simulations with the results through various concrete codes. Nguyen et al [5] conducted shear tests of precast, prestressed concrete hollow core slabs. Also, Finite element models considering concrete damaged plasticity were developed to simulate the web-shear responses of slabs and study the influence of design variables on web-shear behavior of slabs numerically.

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