Experimental and analytical analysis of pretensioned inverted T-beam with circular web openings

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ABSTRACT
This paper presents the results of a research project aimed at providing standard circular web openings to the popular precast pretensioned inverted T-beam. The main advantage of these openings is that mechanical equipment can pass through the webs of inverted T-beams. Another advantage is a slight reduction in inverted T-beams weight that would improve the demand on the supporting frame both under gravity loading and seismic excitation. Opening size and placement and required materials strengths were investigated. Also, the effects of using straight tendons, rather than two-point depression and one-point depression, of the prestressing strands were investigated. In this paper the nonlinear analysis and design of simply supported pre-tensioned inverted T-beam with circular web openings are presented. Two design parameters are varied such as: opening location and numbers of openings. The results from a nonlinear finite element analysis are substantiated by test results from five pretensioned inverted T-beam with web opening and one solid beam. Good agreement is shown between the theoretical and the experimental results. The effect of openings on the behavior of such beams at different stages of loading is presented. The test results obtained from this investigation show that the performance of the specimens with web openings was almost identical to that of the specimen without web openings. A simple design method for estimating the cracking load for the different crack patterns is proposed. Based on these tests, design recommendations are made that will allow the addition of web openings to inverted T-beam with minimal additional calculation.

KEYWORDS
Prestressed concrete; Inverted T-beams; Web openings

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