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Application of Probabilistic Analysis in Finite Element Modeling of Prestressed Inverted T-Beam with Web Openings

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Abstract: Recent trends of structural mechanics applications in finite element analysis demonstrate an increasing demand for efficient analysis tools. This paper presents a probabilistic analysis approach applied in finite element analysis for modeling prestressed inverted T-beams with web openings structure used in building service system (mechanical, electrical, communications, and plumbing). The experimental program reported in this paper tested four prestressed inverted T-beams with circular web openings to failure to evaluate the openings' effect on various beam behaviors. Using ANSYS, finite element models were developed to simulate beam deflection behavior. Comparison of analytical results with the available experimental results for load-deflection relationships showed good agreement between both results. Probabilistic analysis methodology could predict the response (i.e., deflection, stress, strain etc) due to various combination of input variables (i.e., Poisson`s ratio, modulus of elasticity, etc). In reality, uncertainties exist in a system and environment that may make the application of deterministic design unreliable which causes the values of the variables that are acting on the system cannot be predicted with certainty. As such, probabilistic approach was applied to the model after deterministic analysis. In this study, the probabilistic analysis approach was applied to account for the variability in fabrication. Probabilistic methodology applied in finite element modeling provides another alternative ways of structural analysis of preststressed inverted T-beams with web openings to achieve a robust and reliable design in a more efficient way. In this study, Monte Carlo simulation was used to analyze the effect of parameter uncertainty for the prestressed inverted T-beams with web openings. From the analysis results, it was observed that the changes in prestressing force, elastic modulus of prestressing steel, ultimate tensile strength of prestressing steel and beam width tend to be the most influencing parameters, which need to be tightly controlled. As a result, from deterministic analysis and probabilistic analysis, it was found that probabilistic analysis tends to be closer to reality than deterministic methods and gives a way of designing for quality.

Key words: Finite Element Modeling, Monte Carlo Simulation, Prestressed Inverted T-Beams, Probabilistic analysis