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Entitled

PERFORMANCE OF INVERTED T-BEAMS TOTALLY REINFORCED WITH GLASS FRP REINFORCEMENT

By

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Abstract

Steel-reinforced concrete inverted T-beams (IT-beams) are vital structural members employed in bridge structures and buildings. They support incoming beams on the ledges at the bottom of the section. The loads are transferred from the ledges to the web of the IT-beam and finally to the supports. Swapping steel bars with anti-corrosive FRP (fiber-reinforced polymer) bars in concrete members would minimize corrosion problems, thereby prolonging the life span of the structure. However, FRP material is characterized by its linear behavior until failure and its low modulus of elasticity in comparison with steel. These properties affect the behavior of FRP-reinforced concrete structures. Research on the behavior of FRP-reinforced IT beams, along with deep beam loading conditions that are common in IT-beams, is scarce.

To address these issues, this study was carried out with the objective of achieving an improved understanding of the structural behavior of GFRP (glass-fiber-reinforced polymer)-reinforced IT-beams. The study composes of experimental program and nonlinear numerical modeling. Twelve GFRP-reinforced IT-beam specimens were fabricated and tested to failure. All the beams were simple beams and internally reinforced using GFRP bars with concrete compressive strength, shear span-to-effective depth ratio, and GFRP transverse and longitudinal reinforcement ratios as the study variables. The test results were reported in view of the load-carrying capacity (peak load), deflection, cracking, observed failure modes, and strains in the GFRP bars. Increasing the transverse GFRP reinforcement ratio from 0.0045 to 0.0075 reduced beam diagonal cracks and notably improved the post-cracking stiffness of the beams leading to an enhancement in the peak load by 19%. Likewise, increasing the GFRP longitudinal reinforcement ratio from $2.5\rho_b$ to $4.0\rho_b$ improved the ductility and augmented the peak load of the IT-beam specimens by around 30% and 25%, respectively.

To numerically predict the peak load of the test specimens, three-dimensional nonlinear numerical models were developed. The numerically predicted peak loads agreed well with the test results. The predicted-to-test load-carrying capacity ratio was in the range of 0.91 to 1.07 with an average 1.01, a standard deviation of 0.05 and coefficient of variation of 5%.

Keywords: Concrete inverted T-beams, load-carrying capacity (peak load), Shear span-to-effective depth ratio, GFRP reinforcement ratios, Numerical modeling.