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PERFORMANCE PREDICTION OF CONCRETE DEEP BEAMS CONTAINING CUTOUTS INTERNALLY-REINFORCED WITH COMPOSITE BARS

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Abstract

The development of code provisions for the use of strut-and-tie model (STM) in structural design has been hindered by great uncertainties due to the lack of experimental evidences. The problem becomes more complex when the conventional steel reinforcing bars around disturbed regions are replaced by non-metallic composite reinforcement. This research aimed to investigate the structural behavior of concrete deep beams with cutouts internally-reinforced with glass fiber-reinforced polymer (GFRP) bars around regions of discontinuities. Different STMs were developed for the design of GFRP-reinforced concrete deep beams. The models were analyzed through the use of ACI 318 (2014) and CSA S806 (2012) provisions. Laboratory tests were conducted to examine the accuracy and validity of the STM predictions. The installation of a web opening in the shear span significantly reduced the shear resistance of concrete deep beams internally-reinforced with GFRP bars. The installation of GFRP reinforcement around regions of discontinuities in concrete deep beams improved the shear response. The reinforcing scheme with diagonal GFRP reinforcement in the top and bottom chords was the most effective scheme in improving the shear resistance. In contrast, the scheme with diagonal GFRP reinforcement in the top chord only was the least effective one. The effect of inclusion of GFRP reinforcement around regions of discontinuities on the shear resistance was more significant for the deep beams with the greater opening depth. The increase in the shear resistance due to an increase in the concrete grade was more sensitive to the opening depth rather than the GFRP reinforcing scheme. Increasing the concrete grade had more significant effect on the shear strength of the deep beams with the smaller opening depth. The STM based on both provisions of ACI 318 (2014) and CSA S806 (2012) provided conservative prediction for the nominal load capacity of the solid beam. For the specimens with the lower concrete grade of 31 MPa having cutouts, the STM based on provision of ACI 318 (2014) provided accurate/conservative prediction for the nominal load capacity, except for two specimens where the load capacity was overestimated by approximately 25%. The STM based on provision of ACI 318 (2014) tended to overestimate the nominal capacity of the specimens with the higher concrete grade of 45 MPa. The STM based on the provision of CSA S806 (2012) provided conservative prediction for nominal load capacity of all of the tested specimens. It tended, however, to provide less conservative, yet more accurate, predictions for the specimens with the higher concrete grade of 45 MPa.

Keywords: deep beams, cutout, GFRP reinforcement, STM.