Behavior and FRP Strengthening of RC Beams Having Rectangular Openings near the Shear Zone

Abstract:

Due to different architectural and mechanical reasons, openings in Reinforced Concrete (RC) beams are needed. The behavior of an RC beam with an opening is; in somehow, different from that of solid beams whether these openings are located at mid-span or near the maximum shear zone. In well-coordinated projects, the openings' locations and sizes are determined during the design phase of the project. Accordingly, the beam's dimensions and reinforcement are determined considering the existence of the openings. However, in many cases, the decision of making an opening in an existing RC beam may come a while after the construction due to different reasons such as changing the function of the building which needs architectural or mechanical modifications. This, in turn, results in the need for strengthening the beam at the opening area to overcome the expected loss of the load carrying capacity of the beam in flexure or in shear. This research aims to obtain a better understanding of the behavior of RC beams with rectangular openings near the shear zone and to introduce a strengthening technique with Fiber Reinforced Polymers (FRP) strips. Both experimental and numerical studies have been carried out to investigate the behavior of such beams under four points bending. For the experimental study, a qualitative experimental program including testing of five RC beams of the same dimensions and steel reinforcement has been carried out. One of them has no openings; the control beam, and the others have openings. A strengthening wrapping technique using CFRP strips has been applied in two beams. It was found that, the purposed CFRP strengthening system has succeeded to decrease the loss of the load carrying capacity but failed in provide a significant enhancement to its load-deflection behavior. On the other hand, a step-by-step nonlinear Finite Element (FE) analysis has been carried out including conducting a parametric study in order to obtain a comprehensive understanding about the behavior of such beams with

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