ABSTRACT

The phenomenon of shear failure in reinforced concrete members is complex. For shear strengthening of reinforced concrete T-beam, fibre-reinforced plastic (FRP) may be provided in the form of bonded external FRP sheets or strips as web reinforcement. The use of FRP as external web reinforcement for strengthening of beams in shear introduces two additional failure modes: FRP rupture and FRP debonding. These generate additional levels of complexity to the failure behaviour of such beams. In the present study, the characteristics of shear deficient reinforced concrete T-beam retrofitted with FRP composites are explored. The effectiveness of strengthening of beams using FRP is found to depend on several factors like properties of laminate and interface, amount of stirrups, nature of the interface between different constituents of the beam strengthened with FRP, the FRP configuration, the amount of laminate used, the provision of fillets and anchors at the web-flange junction, shear span to depth ratio, size effect, concrete strength and the nature of the bond between the external and internal reinforcements and concrete.

In order to understand the complete shear failure mechanism and how the various parameters influence the over-all structural response, both experimental and numerical studies were undertaken. The concrete and FRP material were characterized, following which testing of shear deficient beams, both with and without FRP strengthening, were performed. The test results yielded information on failure load, variation of crack pattern with mode of failure, deflections at various locations along the beam, strain developments at different points, and the shear strength contributions of concrete, steel and FRP.

A numerical study, using the ABAQUS finite element commercial package supplemented by user subroutines as well as additional code, was also conducted. The material and interface models were calibrated using experimental results. The objective was to achieve a better understanding of laminate rupture and debonding failure and the influence of interfacial parameters such as interfacial stiffness, cohesive strength and fracture energy on damage in the surface concrete. The influence of laminate properties and the quantity of shear steel reinforcement was also studied. The numerical results were validated using experimental results. Further numerical experimentation yielded more detailed information on, and understanding of, the failure mechanism and failure mode in FRP wrapped concrete beams. The contributions of steel and FRP to the shear resistance were found to be inter-related, thereby revealing the limitations of an additive approach that assumes that the contribution of FRP to the shearing resistance can be evaluated independently of the amount of transverse steel reinforcement, while the contributions of concrete and steel to the shearing resistance do not depend on the properties on the FRP wrap.

Key words: *RC T-beam, Debonding, Fracture energy, Interface, Shear strengthening, FRP sheets.*