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Strengthening Reinforced Concrete Beams Using Carbon Fibre Reinforced Polymer Strips

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Abstract : Strengthening of reinforced concrete beams in flexure using externally bonded composite laminate of high tensile strength is easy and of the minimum cost compared to traditional methods such as increasing the concrete section depth or reinforcement that requires formwork and curing which affect the structure usability. One of the main limitations of this technique is debonding of the externally bonded laminate, either by end delamination or by mid-span flexural crack-induced debonding. ACI 440.2-08 suggests that using side-bonded FRP laminate in the flexural strengthening of RC beams may serve to limit the extent and width of flexural cracks. Consequently, this technique may decrease the effect of flexural cracks on initiating the mid-span debonding; i.e. delays the flexural crack-induced debonding. Furthermore, bonding the FRP strips to the side of the beam may offer an attractive, practical solution when the soffit of this beam is not accessible. This paper presents an experimental programme designed to investigate the effect of using externally bonded CFRP laminate on the sides of reinforced concrete beams and compares the results to those of bonding the CFRP laminate to the soffit of the beams. In addition, the paper discusses the effect of using end anchorage by U-wrapping the CFRP strips at their end zones with CFRP sheets for beams strengthened with soffit-bonded and side-bonded CFRP strips. Thus, ten rectangular reinforced concrete beams were tested to failure in order to study the effect of changing the location of the externally bonded laminate on the flexural capacity and ductility of the strengthened beams. Pultruded CFRP strips were bonded to the soffit of the beams or their sides to check the possibility of limiting the flexural cracking in mid-span region, which is the main reason for mid-span debonding. Pre-peg CFRP sheets were used near the support as U-wrap for the beam to act as an end-anchorage for the externally bonded strips in order to delay/prevent the end delamination. Strength gains of 38% and 43% were recorded for the soffit-bonded and the side-bonded composite strips with end U-wrapped sheets, respectively. Furthermore, beams with end sheets applied as an end anchorage showed higher ductility than those without these sheets.

Keywords : flexural strengthening, externally bonded CFRP, side-bonded CFRP, CFRP laminates
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