and Prestressed Concrete

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Summary

This paper summarizes the experimental work on FRP-reinforced prestressed concrete tension specimens. These tests were performed to determine the contribution of the bonded FRP composite laminate to the strength and stiffness of the prestressed concrete tension members. Simple tension specimens, consisting of prestressed concrete prisms with externally-bonded FRP composite laminates, using pre-glued aggregates to the FRP composite laminates, with five levels of prestressing (0, 25, 50, 75 and 100%), were prepared and tested.

The experimental results showed that the interfacial shear strength between the FRP composite laminates and the concrete substrate, using pre-glued aggregates on the surface of the FRP composite laminates, was about 1.8 MPa. The final failure occurred in the aggregate-bonded depth in the concrete prisms, which demonstrated a relatively strong interfacial link between the FRP composite laminates and the concrete substrate.

The tensile strength at initial cracking in the simple FRP-reinforced specimen was almost twice that of the control specimens (without FRP composite laminates). The FRP composite laminates provided additional strength and stiffness to the system and enhanced the initial cracking load.

Keywords: Bond characteristics; cast-in-place concrete; durability; hybrid FRP composite; FRP-reinforced concrete; prestressing of FRP.

1. Introduction

Bond characteristics between the FRP composite laminates and cast-in-place concrete (with and without prestressing) were investigated in this experimental study. The main objective of this research program was to evaluate the contribution of the FRP composite laminates to structural strength and overall behaviour of prestressed cast-in-place concrete tension member. To evaluate the effectiveness of FRP composite laminates in prestressed concrete construction, twelve prestressed FRP-reinforced tension specimens were prepared and tested. Subsequently, these specimens were subjected to uniaxial tension; the experimental data were analyzed, and the stress and strain distributions at different load levels were evaluated.

2. Experimental Program

Twelve prestressed FRP-reinforced tension specimens were constructed to investigate the response of the prestressed concrete with FRP composite bonded laminates. A 1500 mm long, prestressed concrete prism, 100 x 100 mm in cross-section, reinforced with a symmetrically placed 9.5 mm

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(3/8”) diameter seven wires, prestressing steel strand, and with two 700 mm long FRP composite laminates placed on two opposite faces of the specimen were cast and tested. As part of the construction procedure, the prestressing strand was pre-tensioned with varied level of prestressing (0, 25, 50, 75, and 100%). The FRP composite laminates were then placed on two opposite sides of the mold, and concrete was cast into the mold.

The specimens were instrumented to monitor the strain variation in the FRP composite laminates and the prestressing steel strand, at different loading stages. The specimens were tested under tension load, applied though the prestressing strand gripped in the machine jaws using special couplers.

The behaviour of prestressed tension specimens was linear up to the first crack, irrespective of level of prestressing, with an average stiffness of about 1080 kN/mm for the FRP-reinforced prestressed and 544 kN/mm for the simple prestressed without the FRP reinforcement; thus the stiffness of the un-cracked FRP-reinforced specimen was about twice that of the specimen without FRP reinforcement. The cracking load was a function of the level of prestressing, which was basically the pretensioning load plus the required to crack the concrete cross-section. After cracking of the specimens with 100% level of prestressing, the applied load decreased slightly and then increased again, until the peak load was attained before the failure.

The FRP-reinforced specimen, with no prestressing, cracked at 33.50 kN, while the control specimen cracked at 18.78 kN; thus FRP-reinforced resulted in an increase of 80% in the cracking strength. An examination of the load-deflection curves for all of the specimens shows an increase in the cracking load and the axial stiffness after cracking with an increase in the level of prestress and incorporation of the FRP reinforcement.

The load – strain curves for the prestressing steel and the FRP reinforcement show the same trends as observed for the load – axial deformation characteristic for all of the specimens. Again, the beneficial effects of the level of prestressing and the FRP reinforcement can be noted.

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