EXPERIMENTAL INVESTIGATION OF FATIGUE BEHAVIOR OF REINFORCED CONCRETE BEAMS STRENGTHENED WITH CFRP[1]

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Abstract: Reinforced concrete beams used in bridges, viaducts, and industrial structures are subjected to repeated moving loads throughout their service life, which may lead to fatigue-induced deterioration in structural strength and bond performance. Moreover, external factors such as corrosion, temperature fluctuations, and overloading accelerate the adverse effects of fatigue, leading to severe damage and even sudden failure at load levels below the ultimate load-carrying capacity. In recent years, carbon fiber-reinforced polymer (CFRP) materials have been widely adopted for strengthening reinforced concrete beams owing to their high strength-to-weight ratio, excellent corrosion resistance, ease of application, and negligible increase in the member's cross-sectional dimensions. In this study, the fatigue behavior of reinforced concrete beams strengthened with externally bonded CFRP strips was experimentally investigated. A total of four 1/3-scale reinforced concrete beam specimens, with a cross-section of 100 × 150 mm and a length of 1200 mm, were fabricated. The tensile reinforcement consisted of 2Ø10 longitudinal bars, while the compression reinforcement comprised 2Ø4 longitudinal bars. Shear reinforcement was provided using Ø4 stirrups spaced at 200 mm. One unstrengthened specimen was tested under monotonic static loading, while another unstrengthened specimen was tested under cyclic fatigue loading as the reference specimen. The remaining two specimens were strengthened with externally bonded CFRP strips and subsequently tested under fatigue loading. The experimental variable was selected as the spacing of the CFRP strips. Accordingly, CFRP strips with a width of 50 mm were applied at a spacing of 150 mm and 200 mm. All specimens were tested under a four-point bending test. The experimental results showed that the unstrengthened reference specimen reached an ultimate load capacity of 23.8 kN under static loading. The second reference specimen, subjected to cyclic fatigue loading between 10 and 18 kN, collapsed after 1800 loading cycles. In contrast, the CFRP-strengthened specimens were tested under a substantially higher cyclic load range of 16-32 kN, corresponding to approximately 78% higher maximum load than that applied to the reference specimen tested under fatigue loading. Under these loading conditions, the specimen strengthened with 150 mm strip spacing collapsed after 1480 cycles, whereas the specimen with 200 mm strip spacing collapsed after only 265 cycles. The findings demonstrate that reinforced concrete beams strengthened with externally bonded CFRP strips can sustain significant fatigue performance even under cyclic loading levels that exceed the monotonic static load-carrying capacity of the reference specimen. Furthermore, reducing the spacing between CFRP strips markedly improved the fatigue life of the strengthened beams.

Keywords: Reinforced Concrete Beam, CFRP Strengthening, Fatigue Loading

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