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Concrete Structures Reinforced with FRP BAR

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Abstract: Fiber reinforced polymer (FRP) bars have been widely used in civil engineering used as a substitute for steel reinforcement because it has many advantages such as high strength-to-weight ratio, electromagnetic neutrality, light weight, ease of handling and no corrosion. Moreover, the productive technology becomes more and more mature and industrialized so that FRP has become one economic and competitive structure material. Based on the recent researches, this paper mainly introduces progress in the studies on concrete structures reinforced with FRP bars. These contents in this paper includes the bond performance of FRP bars in concrete, Compression Behavior, flexural behavior, and ductility of concrete structure reinforced with FRP bars in the past few years in the world .
Keywords: FRP Bars, Concrete Structure, Bond Performance, Pullout Behavior, Compression Behavior, Flexural Behavior, and Ductility.

I. INTRODUCTION

Infrastructure decay due to corrosion of embedded reinforcing steel stands out as a significant challenge worldwide. The use of FRP bars as reinforcement for concrete elements seems to be an effective solution for overcoming durability problems of traditional steel reinforced concrete structures due to the corrosion of metallic bars. For this reason, the replacement of steel with FRP bars is gaining popularity worldwide. It has many advantages such as high strength-to-weight ratio, electromagnetic neutrality, light weight, ease of handling, no corrosion, low weight to strength ratio (1/5 to 1/4 times of the density of steel), high longitudinal tensile strength, and non-magnetic characteristics. Although the initial cost of FRP reinforcement is higher than steel reinforcement, the total life cycle cost of the structure or structural components reinforced with FRP is lower, as significantly less maintenance costs are required for structures or structural components reinforced with FRP. The application of FRP bars in civil engineering can be divided into two classes. One is to substitute steel bars in concrete structures, and the other one is to maintain and strengthen old structures. In the past few years, with the development of FRP material technique, more and more scholar began to focus on the application research work on FRP. This paper mainly introduces progress in the studies on concrete structures reinforced with FRP bars. These contents in this paper include the bond performance of FRP bars in concrete, shear resistance, flexural behavior, compressive behaviour and ductility of concrete structure reinforced with FRP bars in the past few years in the world.

II. BOND STRENGTH AND ITS FACTORS

The mechanics of bond stress transfer between FRP reinforcement and concrete has been investigated extensively. Bond stress is the shearing stress whose direction is parallel to the interface plane of FRP bars and concrete. The bond of an embedded bar, regardless of material, resists pull-out via three main mechanisms. The first is chemical adhesion between the two materials at their interface. The second is the friction bond which is due to coarseness in the surface of the bar.
Pullout behavior of FRP bar with different strength of concrete
The bond performance of 88 concrete pull-out specimens prepared according to ACI 440.3R-04 and CSA S806-02 standards with FRP bars were investigated by Banat.

A. Flexural behavior of Reinforced concrete beams with FRP bars

Several experimental studies were conducted to investigate the flexural behavior of FRP reinforced concrete beams and comparison with that of steel reinforced concrete beams. Investigated flexural behavior of CFRP (Carbon fiber reinforced polymer) reinforcement RC beams and normal RC beams and compared the results of both. Test results show that the structural behaviors of CFRP reinforced concrete are similar to normal RC in many aspects. The CFRP RC beams displayed good bond between the reinforcement bars and concrete, with no signs of bond failure or slip. Beams failed due to concrete crushing at almost double the loads on the other hand steel RC beams failed due to steel yielding.

B. Compressive behavior of Reinforced Concrete columns with FRP bars

Few experimental studies were conducted to investigate the influence of replacing steel bars with GFRP bars on the behaviour of square and circular concrete columns. H. Karim . Investigated the behaviour of concrete columns reinforced with FRP bars. A total of five circular concrete columns of 205 mm in diameter and 800 mm in height were cast and tested under axial compression. The specimens were reinforced either with GFRP bars and GFRP helices or only with GFRP helices. The experimental results showed that the GFRP-RC columns experienced two peak axial loads.

C. Durability of FRP bars under different temperature in Concrete

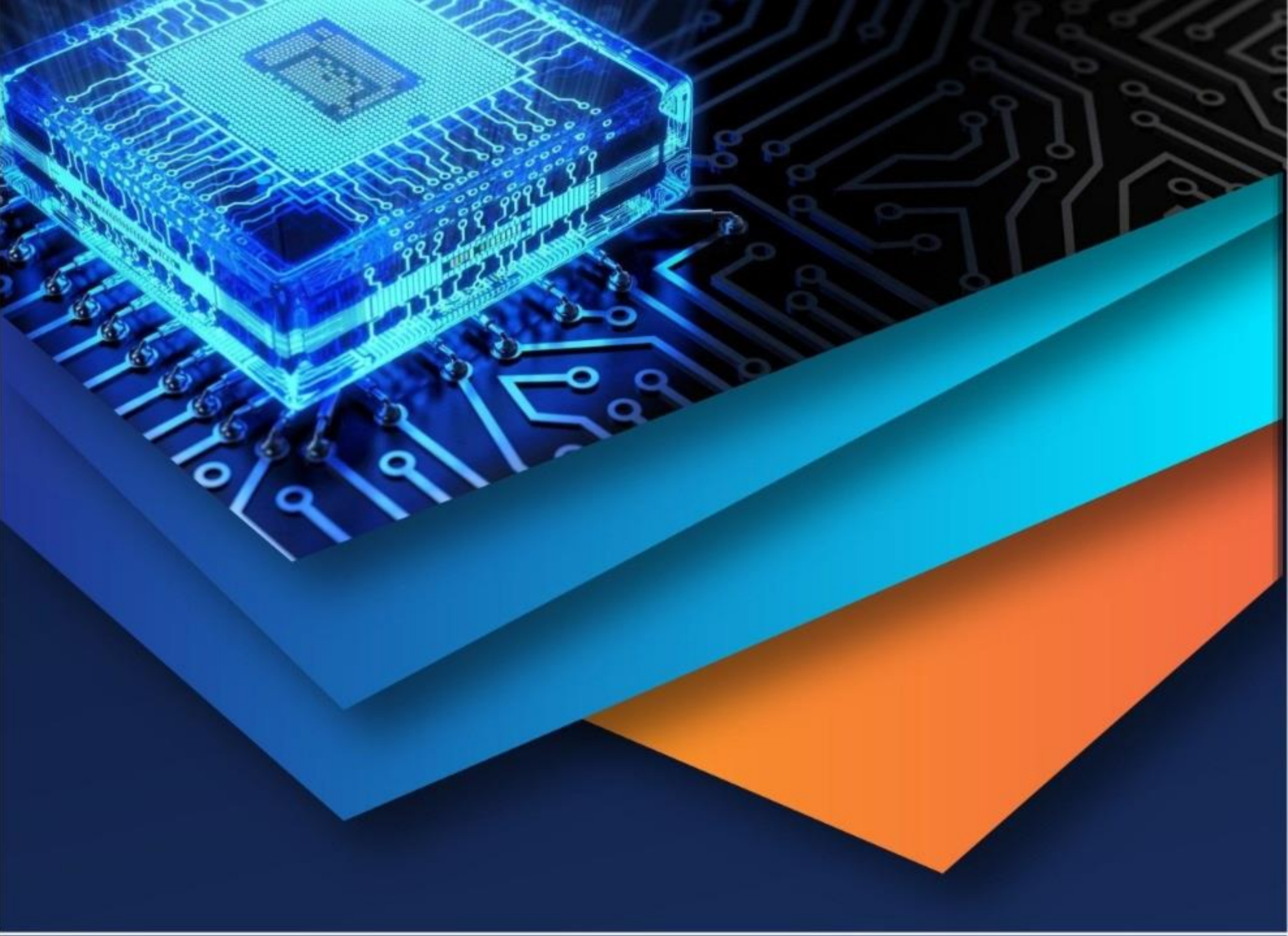
Investigation was carried out on concrete specimens reinforced with a FRP bar and subjected to thermal cycles with a maximum temperature value of 70°C and Galati et. al. also observed that the most of the specimens the thermal treatment induced a slight degradation in the bond performance in terms of ultimate load and more extended micro cracking of the concrete (due to the different CTE (coefficient thermal expansion)) of GFRP bars and concrete when the bars are placed at a lower cover

D. Role of Ductility in FRP reinforced concrete structures

The ductility and confinement efficiency can be better improved by using small GFRP spirals with closer spacing rather than larger diameters with greater spacing. Ignoring the contribution of GFRP bars in the design equation underestimated the maximum capacity of the tested specimens.

III. CONCLUSIONS

With 20 years' studies on the mechanical behaviors of FRP bars RC structure, great progress has been made, and lots of design codes have been published worldwide. The corrosion of steel reinforcement in concrete and the resulting deterioration of structures prompted research on FRPs as potential reinforcement for concrete. State of art in research indicate that FRP reinforcement can be effectively used in beams and column in new concrete structural elements. There has been a significant progress in understanding the behaviour of FRP (GFRP mostly) bars in concrete but, the focus of most of these studies has been the modification in the flexural and shear strength capacities of concrete beams reinforced with FRP bars. The effectiveness of FRP reinforcement as main reinforcement and hoops steel in columns has also been reported. The level of understanding of structural behavior has reached a stage where several codes and design guidelines have been issued and developed around the world. FRP bars as reinforcement improve the flexure and shear behaviour but the analysis of onset and progression of cracking in FRP reinforced concrete beams by the complementary use of NDT techniques for the characterization of mechanical performance is still untouched. Therefore, studies are still needed to be investigated on the FRP bars RC structures, especially bond behaviors, flexural behaviour and compressive behaviour.



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