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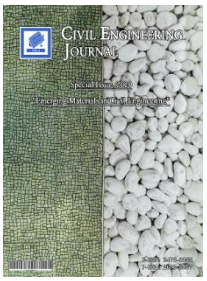

Long-term Deflections of Hybrid GFRP/Steel Reinforced Concrete Beams under Sustained Loads

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Abstract

One of the solutions to improve the flexural behavior of Glass fiber reinforced polymer (GFRP) reinforced concrete (RC) beams is the addition of tensile longitudinal steel reinforcement. The numerous studies to date on hybrid GFRP/steel RC elements have mainly focused on the static and short-term responses, very little work has been done regarding the long-term performance. This paper presents experimental results of time-dependent deflections of cracked GFRP and hybrid GFRP/steel RC beams during a 330-day-period in natural climate conditions. Three hybrid GFRP/steel and one GFRP RC beams with dimensions 100×200×2000 mm were tested in four-point bending. Different steel reinforcement ratios were used to evaluate the effect of the steel reinforcement on the long-term behavior of the beams. Experimental results show that the immediate deflections are inversely proportional to the additional steel reinforcement. With the same initial instantaneous deflection, the total deflection increases when increasing the steel reinforcement ratio. Also, temperature (T) and relative humidity (RH) significantly affect the long-term deflection of the tested beams. The measured long-term deflections were found to be in good agreement with the theoretical values calculated from the proposed method. However, there was an overestimation when using ACI 440.1R-15 or CSA-S806-12 procedures.

Keywords: GFRP; Hybrid; Concrete Beam; Long-term; Time-dependent; Sustained Load; Deflection.

1. Introduction

With many outstanding advantages, traditional steel reinforcement is widely used for RC structures. However, in cases where non-conductive, nonmagnetic and corrosion-resistant structures are required, steel reinforcement cannot be used. In these cases, fiber reinforced polymer (FRP) can meet the requirements. Commonly used FRPs include Glass (GFRP), Carbon (CFRP), Aramid (AFRP) and Basalt (BFRP). However, the high cost of FRP limits their applications in practice. Compared with CFRP, BFRP and AFRP bars, GFRP bars are cheaper and more widely used, especially for bending elements. Although GFRP bar has high strength, the low modulus of elasticity causes large deflection and cracks [1-4]. Therefore, in order to meet the second limit state requirements, GFRP RC beams are often designed over-reinforced, which increases material and labor cost [5, 6]. Many researchers tried to implement additional steel bars to the tensile zone of GFRP RC beams to increase bending stiffness, thereby reducing deflection, crack width of beams. In this case, the steel reinforcement is located deep inside the section with a large concrete cover to avoid corrosion from the outside environment. As a result, the hybrid GFRP/steel RC beam is formed. In addition, hybrid FRP/steel RC concrete structures can be found in the form of RC structures strengthened with FRP.

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