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Deflection and cracking behavior of RC beams externally reinforced with carbon fiber laminates

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Abstract

This article presents the results and discussions of experimental and analytical work on CFRP-strengthened RC beams investigating the cracking and deflection performance. The aim of this study is to evaluate the time-dependent behavior by different degrees of strengthening scheme and two types of sustained loads. Eight RC beams were cast and tested under sustained loads for cracked and uncracked section. An analytical method based on EMM is developed to predict the time-dependent behavior of CFRP externally bonded RC beams. A simplified tension stiffening model for calculating the time-dependent deflection is modified for CFRP-reinforced concrete beams.

Keywords

RC beams, time-dependent deflection, CFRP laminates, sustained loading, tension stiffening

Introduction

Strengthening, upgrading and retrofitting of existing concrete structures, alongside the development of fiber-reinforced composite materials has led to the development of an advanced strengthening approach; in which carbon fiber reinforced polymers (CFRP) are bonded to the tensile face of the member. One of the main applications of FRP strengthening is to improve the flexural and shear capacities of beams, slabs, concrete box-girder bridges and shear wall by bonding CFRP composites laminates to the concrete surface as externally bonded reinforcement. Strengthening with FRP materials provides an outstanding combination of physical and mechanical properties including smaller weight-to-volume ratio, high strength-to-weight ratio, corrosion-resistant properties, excellent tensile strength, modulus, negligible clearance loss, and consequently the easiness of application in the construction industry. Due to their different mechanical properties, the behavior of FRP-strengthened reinforced concrete (RC) beams is quite different to that of traditional steel RC beams. The linear stress–strain diagram of FRP up to failure can be the cause of more fragile rupture. Because of the lower stiffness of FRP bars, the design of concrete beams reinforced with FRP materials is often governed by the serviceability limit states. The bonding of steel plates for the strengthening and rehabilitation of RC structures was a popular strengthening method in the past few decades.[1–3] Reinforcing steel in concrete structures is susceptible to corrosion that severely affects the serviceability and the safety of the structure. The extent of the steel corrosion and the resulting concrete degradation depend on the environment and the type of the structure. The need is, therefore, very great for a new material such as fiber-reinforced polymer (FRP) composites, which would offer excellent resistance to corrosion. In the recent years, a relatively new technique involves replacement of the steel plates by FRP composites in

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