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An Experimental Study of the Flexural Behavior of Continuous RC Beams Strengthened with Plates of Different Concrete Types, Dimensions and Bonding Techniques

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Abstract

An experimental study was conducted to investigate the flexural behavior of continuous beams strengthened with precast concrete plates. Ten rectangular concrete beams with a cross-section of 210 × 150 mm and a total length of 2400 mm were tested under four-point loads. One specimen, without any strengthening, acted as the control, while the remaining nine were strengthened at both the positive and negative moment zones. The variables in this study were: strengthening plate thickness, length, type of bonding (epoxy or mechanical connector), bonding method (surface bonding or 10 mm grooving), type of concrete used (UHPC, SFRC, or SIFCON), and finally, the steel fiber ratio. The failure mode, cracking modes, ultimate load, load–deflection curve, stiffness and ductility were analyzed. The results showed the effectiveness of the strengthening methods, as they improved the flexural strength of the beams by 15.7% to 53%, as well as their stiffness by 15% to 173.8%, and reduced crack propagation. Also, decreasing the thickness and length of plates reduced the flexural strength by 7.28% and 23.5%, respectively. When the bonding methods were compared, the beam with mechanical bonding showed 5.7% more flexural strength than the one using epoxy. However, it was noted that all cracks in the strengthening plates were located at the bolt positions. Additionally, the use of SIFCON plates enhanced flexural strength more than UHPC and SFRC plates. However, for the SFRC plate, increasing the steel fiber content from 1.5% to 2% improved the strength by 1.2%, but this high percentage also caused cracking in the SFRC plate due to the inhomogeneity of the concrete mixture. As for the initial stiffness, the sample in which epoxy was used showed the highest value, with an increase of 173.8%, due to the uniform bonding at the connection surface. Finally, it was observed that the reference beam had the highest ductility due to the high ultimate displacement resulting from the numerous cracks that occurred in the beam, which were reduced in the strengthened beams.

Keywords: ultra-high-performance concrete (UHPC); steel fiber reinforced concrete (SFRC); slurry infiltration fiber reinforced concrete (SIFCON); continuous beam; near surface method (NSM); strengthening plate

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1. Introduction

Concrete constructions are made to work effectively for the duration of their design life. However, the structure may be weakened by a number of issues, including poor construction, defective materials, design mistakes, neglect of continuous maintenance,