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Shear Strengthening of RC T-Beams Using Externally Bonded UHPC Composite Layers with Steel Plates and Geotextiles

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Abstract

This study presents an experimental investigation of reinforced concrete T-beams strengthened using ultra-high-performance concrete (UHPC) with steel plates, and in some cases, UHPC with a geotextile layer. Ten reinforced concrete specimens with the same internal reinforcement but different strengthening methods were tested. These included a control specimen and nine strengthened specimens. Four of the strengthened specimens had grooves in the wooden formwork before pouring to secure the strengthening composite plates inside it, four had it directly attached to the RC beam surface, and the last had vertical lines 10 mm deep to enhance bonding. The external composite plate consisted of four types: the first type included a composite of UHPC and steel plates as strips with 220 × 150 mm at 105 mm, while the remaining types consisted of a plate along the shear zones made of UHPC with steel, geotextiles, or steel and geotextiles. This study also included increasing the number of steel plate layers and the direction of strengthening placement. The results showed that all the strengthened beams failed in flexure, unlike the control specimen, which failed in shear. The strengthening systems improved the load-bearing capacity and overall structural behavior of the tested beams. Among the investigated specimens, beam IR-2S90SS, strengthened with two layers of steel plates, showed the highest improvement, achieving a 39.2% increase in ultimate load compared to the control beam. Debonding was observed in some specimens and was identified as one of the governing failure mechanisms. Overall, the investigated strengthening techniques demonstrated their effectiveness in improving the structural performance of reinforced T-beams.

Keywords: RC T-beams; ultra-high-performance concrete (UHPC); steel plates; geotextiles; and shear strengthening

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1. Introduction

Structural deterioration, increased service requirements, design flaws, and changes in loading conditions can all reduce the shear strength of reinforced concrete beams, compromising the structural integrity and serviceability of existing structures. Consequently, strengthening and restoration techniques have become essential strategies for extending the lifespan of aging infrastructure. Traditional strengthening methods, such as cross-sectional increases, steel cladding, and externally bonded or surface-mounted fiber-reinforced polymer (FRP) composites, have become widely used. However, these techniques may suffer from limitations related to durability, construction time, and incomplete structural effectiveness in some cases [1].