Shear reinforcement of Steel I-beams using CFRP composites

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Abstract

This paper presents an investigation on the shear strengthening of steel I-beams with carbon fiber-reinforced polymer (CFRP) materials, particularly using SikaWrap® - 600, and its bonding with steel surfaces using epoxy Sikardur® - 300. Six CFRP installation configurations were tested on a 6" x 3" recycled S235 I-beam (1.3 m) under four-point bending. Configurations consisted of bonding CFRP wrap to the web only, to the web and radii of the beam, and wrapped all around the beam in both a vertical and diagonal orientation.

Vertical and diagonal orientation configurations increase the shear area of the web of the steel section by 140 mm^2 and 170 mm^2, respectively. It was shown that 1.2 mm CFRP strengthening material has the potential for enhancing shear strength at yield by a minimum of 21.42% (for configuration 1) and up to a maximum of 37.5% (for configuration 4). This upper limit enhancement would be equivalent to welding a 2.8 mm S275 steel plate using EN 1993-1-1:2006 guidelines.

Keywords: CFRP Shear Strengthening; Retrofitting; Load-Carrying Capacity; Bond Behaviour, Failure Mechanisms.

1 Introduction

Typically, within any relatively modern building or structure, I-beams will be used as the structural steel. However, if further reinforcement within an existing structure is required, be it due to material fatigue or additional loading requirements, additional steel plates may be welded to the beam to enhance strength and stiffness. This not only presents practical installation difficulties but also can induce tensile residual stresses which may weaken the fatigue performance of the section [1].

Shear failure typically occurs when the shear force exceeds the shear capacity of the beam. The aim of this study is to explore the possibilities offered by the application of externally bonded carbon fibre reinforced polymer composites (CFRP) as an alternative means of strengthening I-beams in shear. This approach may be preferable when shear strengthening is required within locations where welding which produces heat, sparks, and gases is prohibited or not advisable due to safety risks. However, CFRP comes with its own drawbacks, such as cost implication and time required to achieve full strength which may also be an issue. Despite this, the use of CFRP composites for shear strengthening I-beams may have additional benefits given that CFRP materials are lightweight, corrosion-resistant, and have excellent durability. These properties make them attractive for retrofitting existing structures without significantly increasing the overall weight or compromising the long-term performance of the reinforced elements [2].

The study aims to contribute to the body of knowledge regarding alternative methods for structural reinforcement and provide insights into

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