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Torsional Behavior of Steel-Concrete-Steel Sandwich Beams with Welded Stirrups as Shear Connectors

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Abstract

The structural performance of a steel-concrete-steel sandwich beam (SCSSB) with welded stirrups to the steel skin plates as shear connections exposed to a pure torsion load was studied in this paper. Eight SCSSB specimens were fabricated and tested under pure torsion. The effects of the compressive strength of the concrete core, 26 and 35 MPa, the thickness of the top and bottom steel skin plates, 2 and 4 mm, and the degree of shear interaction, which represents the number of beam stirrups, between the steel skin plates and the concrete core are 75, 100, and 125%. The experiment beams revealed a similar mode of failure for all SCSSB specimens regarding all considered variables, which started with inclined cracks along the specimens' side faces and ended with local separation between one of the steel skin plates (top or bottom) and the concrete core. In addition, the experiment results showed an increase in the torsional strength with the increase in the shear connection ratio and the thickness of the steel skin plate, as well as with the increase in the strength of the concrete core. However, it was observed that the torsional ductility of the tested beams is proportional directly to the steel skin plate thickness and degree of interaction and inversely with the concrete compressive strength. The results showed that the use of steel skin plates with welded stirrups as a shear connection could reduce the negative effect of increasing the compressive strength of the concrete core on the torsional ductility of SCSSB.

Keywords: Sandwich Beam; Shear Connection; Torsional Strength; Torsional Ductility; Pure Torsion.

1. Introduction

Nowadays, the use of steel-concrete-steel sandwich beam (SCSSB) has become popular in the construction of infrastructure as well as other types of concrete structures, especially those subjected to blast or impact loads. This type of structure is made from a concrete core sandwiched between two steel plates. However, the efficiency of such composite beams depends primarily on how the developed forces between the concrete core and steel skin plates are transferred. In order to ensure a proper connection between steel plates and concrete cores, interrelated materials or shear connectors are commonly used. Besides, the use of shear connectors demonstrated the superior performance of SCSSB compared with traditional concrete beams in applications requiring high ductility, strength, impact resistance, or blast resistance [1-4].

Extensive previous experimental and analytical studies have been conducted to investigate the behavior of SCSSB through the examination of different proposed kinds and configurations of shear connections. Leng & Song [5] investigated the shear performance of SCSSB by using round steel bars to connect the skin plates together and the concrete core in addition to headed studs. Nine slender beams with different shear span-to-depth ratios were tested under the action of static loads. It was found that the shear resistance of such beams is dependent on the strength of the steel plate, vertical reinforcement, and stud connectors. Experimentally, Wang et al. [6] examined the structural behavior of

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