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Flexural Performance of Composite Ultra-High-Performance Concrete-Encased Steel Hollow Beams

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Abstract

Composite members have been widely used in the construction of medium- and high-rise buildings. The results of the development of a new structural member by experimental investigation of the flexural behavior of hollow composite beams are presented in this paper. This research aims to exploit the properties of composite sections and their strength in developing a new approach for overcoming the problems of service pipes in buildings. A hollow steel section encased fully in concrete is used to form a composite hollow beam. The structural benefit provided by the steel section (composite part) is adopted to increase the stiffness of the member. The hollow part is employed to provide services and economic benefits by reducing the amount of expensive ultra-high-performance concrete (UHPC) used and decreasing the self-weight of the member. The flexural strength of 11 UHPC beams is tested under two-point loads. The variables in this investigation include the type of hollow core mold material and the size, location, and shape of steel hollow sections in the middle and tension zones of the cross-section. Experimental results are compared and discussed. The tested results show that the flexural capacity and stiffness of the UHPC-encased steel hollow beams are 109% and 23.5% higher than those solid beams, respectively.

Keywords: Ultra-High Performance Concrete; Hollow Beams; Composite Beams; Longitudinal Opening; Position of Hole.

1. Introduction

Generally, studies on structural engineering aim to search for materials whose properties can be effectively used in construction. Therefore, materials characterized by strength, stiffness, workability, and economic feasibility are utilized to obtain the best performance of concrete structures. Given that no single material can satisfy all structural requirements, two or more materials are combined to take full advantage of their properties and obtain one structural element with desirable properties. The advantages of different materials are combined to produce a member with high carrying capacity known as a composite member.

The most common composite member in structural engineering usually consists of a concrete slab attached to a steel I-section beam, as shown in Figure 1a. However, recent studies have focused on the use of a composite member (composite-encased beam) composed of a steel I-section embedded in the middle of the concrete section, as shown in Figure 1b, to take advantage of the bonding between the steel and surrounding concrete and to allow them to act as one unit.

In the design of the high reinforced concrete structures, (1) hollow concrete beam is usually used to reduce the self-

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