Experimental Study of Curved SFRC and ECC Composite Beams

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Abstract

In order to investigate the cracking behavior of curved steel-concrete composite mechanical behavior under a hogging moment, two composite box girders with a central angle of 9º were designed and tested under static loads. In the reported test program, the CCB-1 was designed with steel fiber reinforced concrete (SFRC) slab and shear studs. In contrast, the CCB-2 was designed with Engineered Cementitious Composites (ECC) and Uplift-Restricted and Slip-Permitted (URSP) connectors for enhanced crack resistance. The load-displacement curve, strength and displacement ductility, failure mode, and strain distribution were reported in detail. For the test small curvature beams loaded under the hogging moment, the flexural critical failure mode was observed for both specimens, which was governed by compressive yielding of the top steel plate and tensile yielding of the concrete slab. The URSP connectors effectively reduce the stiffness of the interface slip of composite girders, enhance the interface slip capacity, and reduce the crack width of concrete compared with traditional shear studs.

Keywords: Curved composite beam; steel fiber reinforced concrete; Engineered Cementitious Composites; Uplift-Restricted Slip-Permitted connector.

1 Introduction

The steel-concrete composite beam combines the steel beam and the concrete slab through shear connectors. The compressive strength of concrete and tensile strength of the steel plate can be fully achieved in composite beams. Therefore, the composite beams have been widely adopted in many large-scale complex composite structures and ultra-high-rise buildings with reduced self-weight and enhanced mechanical performance. Significant experimental and finite element (FE) simulation has been reported in the existing literatureto investigate the mechanical performance of composite beams as well as concrete beams [1-4]. Recently, in order to reduce the concrete cracking in the continuous composite beam, Nie et al. [5] proposed Uplift-Restricted and Slip-Permitted (URSP) connectors. The URSP connectors were composed of traditional shear studs and low-elastic modulus material. In order to further verify the cracking resistance behavior of URSP connectors, a significant experimental study has been conducted. These tests include hysteretic shear test and pull-out tests [6], two hogging moment tests on steel truss-concrete composite beams [7-8], three continuous composite beams [9], suspension bridge tests [10], and a series of FE simulation of composite frame [11]. Existing test and simulation results showed that the application of URSP connectors at the hogging moment region of the composite beams significantly reduced the cracking behavior of composite beams. In addition, the URSP connectors have been widely adopted in many bridges in China, including the Tianjin Haihe

https://doi.org/10.2749/nanjing.2022.0666
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