Mechanical Effect of Steel Fiber Reinforced Concrete on Stud Shear Connector in Composite Bridge

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Summary

The push-out tests on the static and fatigue behavior of the frequently used stud connector in composite bridges with steel fiber reinforced concrete (SFRC) were executed. The effect of SFRC on static behaviour of stud was not obvious according to the static push-out test results. However, the cyclic push-out test results showed that steel fibers in concrete could improve the fatigue behavior of stud especially when cyclic load range was small. Hence engineers should notice that the favourable effect of SFRC on stud connector may be influenced by the cyclic load range.

Keywords: Steel fiber reinforced concrete (SFRC), stud, static behaviour, cyclic behaviour.

1. Introduction

Steel-concrete composite girder has been usually applied in bridge structures, mostly consisting of concrete slab, steel girder, and the shear connector. In the negative flexural region of continuous composite girder, tensile concrete cracks may easily happen and the entire mechanical behavior of composite girder is unfavorably influenced. There have been many ways dealing with the induced structural durability problems. And the steel fiber reinforced concrete (SFRC) which is characterized by its considerable material hardening capability and ductility has also been researched in this perspective. On the other hand, shear connector is quite important to steel and concrete composite bridge. The steel concrete interlayer interactions are actually governed by the shear connector. However, there has been little corresponding evaluation of the shear connector in composite bridges with steel fiber concrete. Therefore, several static and cyclic push-out tests on the frequently used stud connector in SFRC were executed in this study. The stud shank diameter and height were 19 and 150mm, respectively. The concrete compressive strength was designed around 40MPa. And its aspect ratio was 48.

2. Experiment setup

Table 1 summarizes the specimens for tests. Particularly, two kinds of volume percentages of steel fibers in concrete were introduced (1.5 and 1.0%). The specimen layout is shown in Fig.1. Two studs were welded on each steel flange. The stud horizontal spacing was 100mm. The nominal concrete compressive strength was 40MPa. The length of the steel fiber was 30mm, and its diameter was 0.62mm. The steel fiber's ultimate tensile strength was approximately 1080MPa.

Table 1: Specimen basic information

Push Load	Normal Concrete	SFRC	
		1.5%	1.0%
Static	SN1	SF1,	-
Cyclic	CN1, CN2	CF1, CF2,	CF3

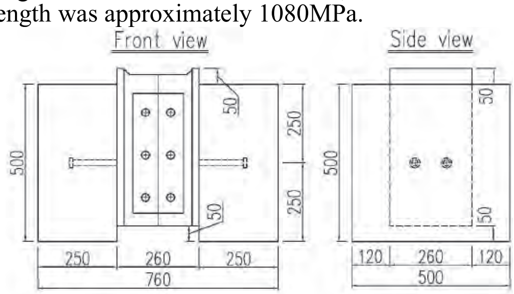


Fig.1: Specimen layout (mm)

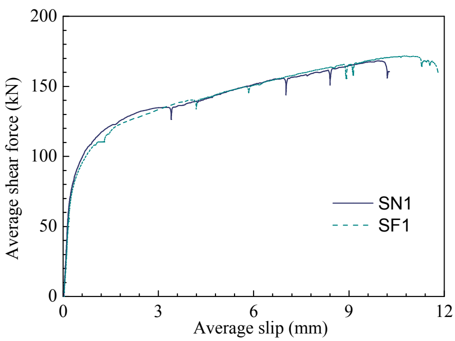
As to the cyclic load pattern, there were three types of cyclic load ranges which were 241.0 and 203.6kN. They were approximately 40 and 30% percent of the stud strength in static test. The cyclic mean load was 30% of the strength. Displacement sensors were mounted to monitor the slips between steel flanges and concrete. They symmetrically distributed at the four corners in a specimen.

3. Test results

As shown in Fig.2, shear fracture at stud root and crushes of surrounding concrete were the main failure mode. The effect of SFRC on the failure mode was not remarkable.

a. Stud root(SN1) b. Concrete crushes(SN1) c. Stud root(CN1) d. Stud shank in concrete(CN1)

Fig.2: Failure modes



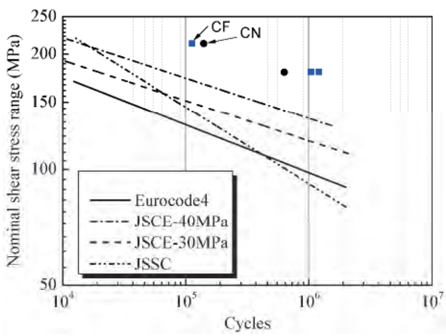


Fig.3: Load-slip curves in static tests *Fig.4: S-N curves and fatigue life*

Fig.3 represents the load-slip curves derived from static tests. Generally, the effect of SFRC on stud static behaviour is not so obvious. The tested fatigue lives are shown in Fig.4. It shows that steel fibers tends to increase the stud fatigue resistance when cyclic load range is small. It may be explained by that lower cyclic load ranges can be resisted by steel fibers bonded with concrete. As to the larger cyclic load range, the failure of bonding between steel fibers and concrete may appear thus the effect of SFRC on stud fatigue resistance cannot be attained. In this sense, engineers should notice that the favourable effect of SFRC on stud connector may be influenced by the cyclic load range. Meanwhile, the fatigue S-N curves based on specifications are left-below the test result points. The evaluation results kept obvious safety redundancy for studs in both normal and steel fiber reinforced concrete.

4. Conclusions

The effect of SFRC on the stud static stiffness and strength was not obvious. On the other side, steel fibers tended to increase the stud fatigue resistance in SFRC espcially when cyclic load range was small. Engineers should notice that the favourable effect of SFRC on stud connector may be influenced by the cyclic load range.

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