Mechanical behaviour and failure mechanism of perfobond shear connectors in steel-concrete hybrid structure

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Summary

Load carrying capacity of perfobond shear connectors in steel-concrete hybrid structure are focused on in this paper. Mechanical behaviour of a perfobond shear connector is influenced by various parameters in steel-concrete structure. To evaluate the behaviour of perfobond shear connectors, push-out tests were carried out. In the experimental program, 24 push-out tests of connectors with 20 mm thickness and with 8 mm thickness, both in different opening and with different transverse reinforcement were accomplished. Based on the load-slip relation of connectors, connection behaviour was analysed and failure mechanism was identified and the load capacity, maximum slip and shear stiffness were quantified. The results of these tests have shown that failure mode of perfobond shear connector changes with different thickness of the perforate plate. Including shear failure of perforate plate, flexural and shear failure of transverse rebar and shear failure of the transverse rebar, three main failure modes of shear connector may occur.

Keywords: steel-concrete hybrid structure; perfobond shear connectors; push-out tests; mechanical behaviour; failure mechanism.

1. Push-out test

In the last 25 years, the mechanical properties of perfobond connectors are increasingly concerned and several authors have studied the behaviour of the perfobond connector based on the evaluation of results from push-out tests. Investigating results show that their structural response is influenced by several geometrical properties such as the diameter of holes, the plate height, length and thickness, the concrete compressive strength, and the diameter of transverse reinforcement present in the concrete slab. Most of researcher focused on behaviour of perfobond shear connector in steel-concrete composite girder, while a few researches investigated the behaviour of perfobond shear connector in steel-concrete hybrid structures. This paper deals with an experimental investigation on the behaviour of prefobond shear connectors in steel-concrete hybrid structures. Based on the failure mechanism of perfobond shear connectors in steel-concrete hybrid structure, new test specimens for push-out test were designed, which including perforated plates, concrete block and transverse rebar. The specimens prepared for push-out tests were produced according to Fig. 1. They consist of a reinforced concrete block held in the vertical position, and

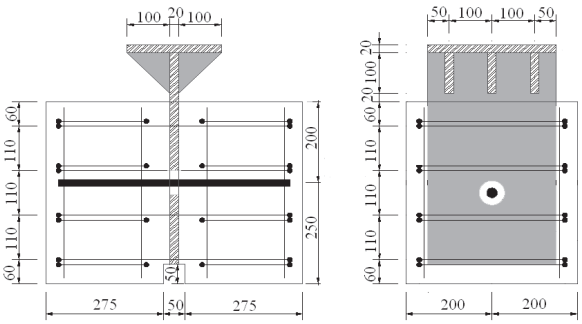

Fig.1 Connectors and specimens geometry for push-out

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a steel plate with a hole inside the block. The concrete block dimensions are 600 mm×400 mm×450 mm. The geometry of the test specimens is always the same, with the variation on the plate thickness and the reinforcement diameter. Two reinforcement diameters were chosen: 16 mm and 25 mm, and two plate thicknesses were chosen: 8 mm and 20 mm. 24 specimens in 6 types of perfobond shear connectors were designed. The vertical load is applied to the specimens using a hydraulic test machine with 5000 kN capacity.

2. Failure mechanism

The load-slip curve can be divided into 3 stages, in the first stage, the perfobond shear connector has a much stiffer behaviour and the load-slip behavior can be considered as elastic almost until the elastic bearing capacity. During the initial part of the test, until the elastic bearing capacity is reached, the values of slip are very small, when compared to stud connectors. In the second stage, the increase in load capacity is slow and very large deformation values are attained. It is different to the load-slip curve obtained from some push-out tests on the perfobond shear connectors in steel-concrete composite beams. During the third phase of the test, the load capacity increase significantly to ultimate bearing capacity and very small deformation are produced. It can be noticed that when the diameter of reinforcement was changed from 16mm to 25mm or the thickness of the perforated plate was changed from 8mm to 20mm, the elastic bearing capacity and ultimate bearing capacity were superior.

Generally, failures of shear connectors start from failure of concrete dowels and end at failure of transverse reinforcement. The results of tests have shown that the failure mode of perfobond shear connector changes with different thickness of perforate plate. Including shear failure of the perforated plate, flexural and shear failure of transverse rebar and shear failure of transverse rebar, three main failure modes of shear connector may occur.

For Concrete dowels, a different failure mode was found related to the plate thickness variations from 8 mm to 20 mm. During testing, concrete between the steel plate and the steel bar was split and tension failure occurred for specimens with 8 mm thickness. Shear failure occurred with double shear on both sides of the perforated plate for specimens with 20mm thickness. With load increasing concrete between the thick steel plate and the steel bar was crushed. For transverse reinforcement, a different failure mode was found related to the varied thickness of perforated plate. Using thin steel plates, the steel plate may contact the steel bar directly, and shear failure occurred with local compression acting at the contact surfaces and double shear on both sides of the perforate plate. Using thick steel plates, the concrete crushed between the steel plate and the steel bar and can spread the load to the steel bar. Flexural and shear failure occurred with distributed load and double shear acting.

3. Conclusions

Compared with steel-concrete composite girders, different push-out tests should be carried out for investigating the mechanical behaviour of perfobond connectors in steel-concrete hybrid joints connections for different mechanism in load transmitting.

Although the elastic bearing capacity is less than ultimate bearing capacity, the elastic bearing capacity was defined as the minimum failure load because the slip rapidly increases to very high values after the elastic bearing capacity is reached.

The transversal reinforcement through the holes plays an important part in increasing shear capacity and keeping large slip displacements for perfobond shear connector

The failure mode of perfobond shear connectors is decided by failure mechanism of concrete dowels and transversal reinforcement. For concrete dowels and steel bars, different failure modes were found related to the perforated plate thickness variation from 8 mm to 20 mm.

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