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Load-bearing capacity of occlusive high-strength bolt connections

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ABSTRACT

Based on the conventional high-strength bolt connection, a new occlusive high-strength bolt (OHSB) connection was developed. In this paper, tests on eighteen connections including four conventional high-strength bolt connections and fourteen OHSB connections were carried out. The main failure mode of these conventional high-strength bolt connections was the shear rupture of bolts, while the main failure mode of these OHSB connections was the dislocation of plates and the loose of bolts. It is found that the load-bearing capacity of OHSB connections was improved significantly. Moreover, both the bolt pretension and the groove size had an important effect on the bearing behavior of OHSB connections. Finite element (FE) models implemented in the non-linear code ABAQUS were established and were verified against the experimental results. It is indicated that the FE models can be used effectively to describe the mechanical performance of OHSB connections, including the failure modes and load–displacement curves. To develop a further understanding, parametric analyses which consider the influence of the bolt pretension and the groove size on the load-bearing capacity of OHSB connections were performed.

1. Introduction

As a major connection form in the building structures [1–4], the bolt connection is usually classified into two types including the ordinary bolt connection and the high-strength bolt connection. Compared with the ordinary bolt connection, the high-strength bolt connection has been wildly used in the building structures recently because of its easier installation, higher bearing capacity, and better anti-fatigue performance. According to the difference of the force transmission patterns, the high-strength bolt connection could be designed as bearing type and friction type. For the bearing type, the bearing capacity of connection depends on the bearing resistance of hole wall and the shear resistance of bolts. For the friction type, the force is transmitted by friction between the faying surfaces of plates. The resistance of the connection of the bearing type is usually higher than the one of the friction type. However, the connection of the bearing type is not suitable for the fatigue load and the dynamic load directly.

To solve the aforementioned limitations of conventional high-strength bolt connections, numerous efforts have been devoted to high-strength bolt connections. He et al. [5] proposed a pre-stressed tube bolted connection whose initial rotational stiffness, ultimate bending resistance, and ductility are better than the conventional high-strength bolt connection. Ma et al. [6–7] investigated the seismic performance of high-strength bolt connections with slotted holes through experimental studies and found that with the help of the slotted hole, the ductility of the connections is improved obviously. Tizani et al. [8] conducted a testing program to assess the performance of a newly developed blind-bolt connection. Wang et al. and Tizani et al. [9–11] carried out a series of further researches for the mechanical behavior of the different blind-bolt connections. Annan et al. [12–13] found that the zinc-based metallized faying surfaces could improve the slip resistance of high-strength bolt connections significantly. In addition, from the structural point of view, the concept of advanced researches has been gradually focused on innovative joints. Guo et al. [4, 14] developed a new type joint system, namely, a bolted ball–cylinder joint. The bolted ball–cylinder joint has a better illuminative effect and

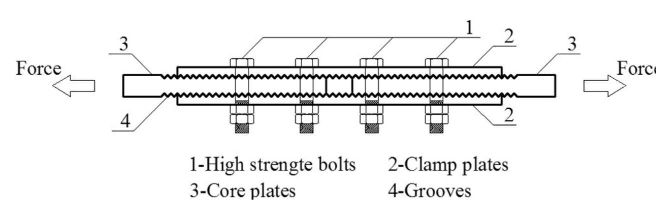

Fig. 1. Occlusive high-strength bolt connection.

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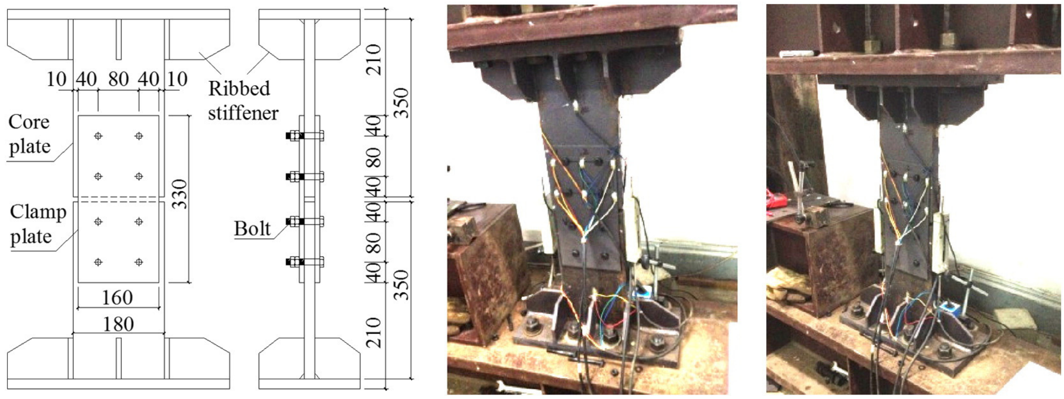

Fig. 2. Overall configurations of conventional connection specimens.

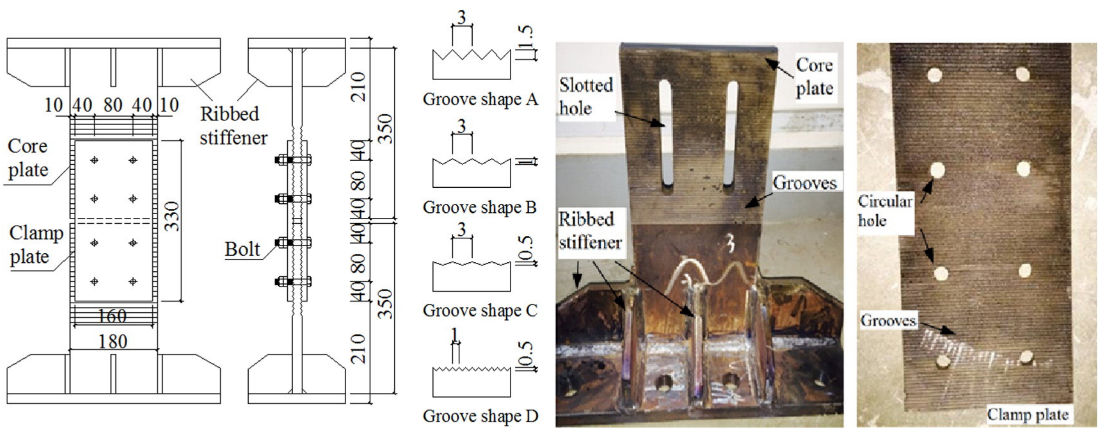

Fig. 3. Overall configurations of OHSB connection specimens.

could achieve considerable material savings for the space truss structure. Feng and Yong [15–17] proposed a new concrete-filled stainless steel tubular joint. Compared with the conventional tubular joint, the concrete-filled stainless steel tubular joint has a lot of advantages, including high corrosion resistance, high strength, and stiffness. Guo et al. [18] studied the mechanical behavior of aluminum alloy gusset joints systematically. Recently, the aluminum alloy gusset joint has been widely used in the aluminum single-layer latticed shell.

For the further development of innovative high-strength bolt connections, a new occlusive high-strength bolt (OHSB) connection was proposed in this paper, as shown in Fig. 1. The OHSB connection is usually composed of high-strength bolts, clamp plates, and core plates. The clamp plates and core plates are manufactured with grooves. Due to bolt pretension, the clamp plates and core plates connect with each other tightly. Therefore, the force could be transmitted through the grooves of faying surfaces stably. To meet the requirements of erection

Table 1
Detailed information of measured parameters.

No.	Bolt pretension	Surface treatments	Bolt diameter (mm)	Core plates (mm)			Clamp plates (mm)		
				Length	Width	Thickness	Length	Width	Thickness
CLJ-A1–A4	0.8P	Sand blasting	10.05	350	180	30	330	160	9.7
NLJ-A1	0.1P	Groove shape A (3 × 1.5 mm^2)	11.6	348	180	18.57	330	161	7.87
NLJ-A2	0.4P								
NLJ-A3	0.6P								
NLJ-A4	0.8P								
NLJ-B1	0.1P	Groove shape B (3 × 1 mm2)	11.6	348	180	19.50	331	160	5.88
NLJ-B2	0.4P								
NLJ-B3	0.6P								
NLJ-C1	0.1P	Groove shape C (3 × 0.5 mm^2)	11.6	350	180	18.85	330	160	6.15
NLJ-C2	0.4P								
NLJ-C3	0.6P								
NLJ-D1	0.1P	Groove shape D (1 × 0.5 mm2)	11.6	345	180	18.57	332	161	4.87
NLJ-D2	0.4P								
NLJ-D3	0.6P								
NLJ-D4	0.8P								