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Cyclic behaviour of novel blind bolted joints with different stiffening elements

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ABSTRACT

Because of the difficulty of accessing the interior of structural hollow sections, emerging technology using blind bolts has been recently developed for fabricating connections to concrete-filled steel tubular (CFST) columns. However, two issues limit the structural benefits of this joint system including the limited transfer of hogging moment and high susceptibility of the steel tube to local failure. Therefore, the authors proposed four methods to enhance the CFST column's stiffness in the connection region, namely, using inner binding bars, welding two internal rings, externally welding two C-shaped channels, and internally embedding a short segment of I-section in the steel tube. A total of 6 joints were tested under cyclic loading accordingly. The experimental results are analysed in this paper to evaluate the efficiency of different stiffening methods. It indicates that the C-shaped channels and embedded I-section are very effective in enhancing the performance of the joint, and the joint's strength and deformation capacity can be significantly improved with large bending deformation developed in the end plate. In contrast, welding binding bars or internal rings has only moderate influence on the joint performance.

1. Introduction

Concrete-filled steel tubular (CFST) columns have been widely used in multi-storey and high-rise buildings in many countries owing mainly to the high structural efficiency, and significant savings of cost and construction time of this type of construction [1]. Due to the difficulty of accessing the inside of the hollow section, many different types of connections have been developed and used to connect steel/composite beams to CFST columns including fully-rigid/fully-welded connections and pinned/fin-plate connections [2]. However, for fully-welded connections, the fabrication costs are quite high and the in-situ welding quality can vary considerably depending on the weather conditions, difficulties of high-altitude operation and the skill of the welder. On the other hand, for pinned/fin-plate connections, the flexural stiffness and flexural resistance of the connections are relatively limited, which will result in a high beam deflection and low load-carrying capacity of the whole structure [3].

In recent years, blind bolted joints to CFST columns were proposed to improve the constructability since blind bolts can be easily inserted and fastened from outside the tube whilst normal standard bolts are only applicable for open sections [4–7]. Loh et al. [5] and Wang et al. [6,7] conducted a series of tests to investigate the monotonic and cyclic behaviour of blind bolted joints to CFST columns. They found that joints to square CFST columns often failed by cracking at the corner of the steel tube in the connection region and/or development of severe outward deformation of the steel tube, whilst only slight deformation of the end plate and column wall could be observed for joints to circular CFST columns. The measured flexural stiffness and resistance for blind bolted joints to circular CFST columns were also higher than those of the joints to square CFST columns. It highlights that square steel tubes and plane end plates are much easier to develop plastic deformation at the locations of tension bolts than circular steel tubes and curved end plates.

To enhance the performance of blind bolted joints, Goldsworthy and Gardner [8] studied the tensile behaviour of joints to circular CFST columns where a straight or hooked reinforcing bar was welded as an extension to the blind bolt. They found that this strengthening method could effectively improve the strength and stiffness of the T-stub to CFST column joint under tension, but special care should be taken to avoid the weld failure between the extension and the bolt head. Meanwhile, anchorage failure of a straight extension would still happen if the length of the extension was only 60 mm. This was further confirmed by the test results

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reported by Wang and Guo [7] and Wang et al. [9], where 50-mm-long straight extensions were used for the blind bolts. Tizani et al. [10] proposed to use modified blind bolts to replace normal blind bolts in CFST columns, where the original bolt shank was replaced by a longer one and a tailor-made anchor head was attached to the end of the new bolt shank to enhance the anchorage. They found that the failure mode changed from bolt pull-out to bolt shank tensile fracture. Further research was recently conducted by Agheshlui et al. [11] on the so-called anchored blind bolts and similar conclusions were reached.

To eliminate the need to modify commercially available blind bolts, the authors of this paper previously proposed a strengthening

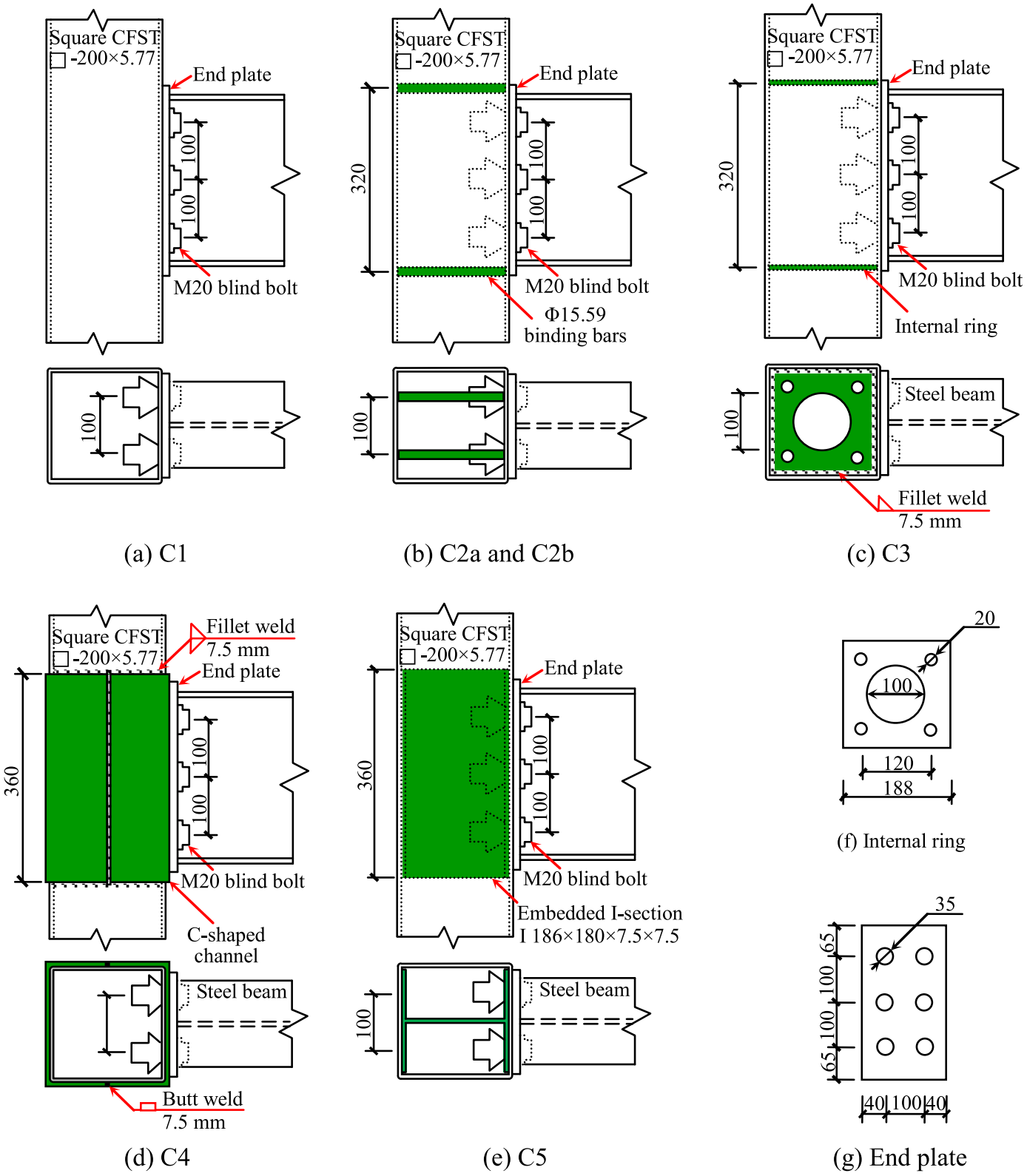

Fig. 1. Details of joint specimens (unit: mm).