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Seismic performance of end-plate connections between T-shaped CFST columns and RC beams

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ABSTRACT

An innovative end-plate connection is proposed by welding an H-shaped steel corbel to the end-plate and the end-plate is connected to the special T-shape concrete-filled steel tubular (CFST) column using a number of high-strength bolts. This paper presents experimental and numerical studies on the seismic performance of the new end-plate connection between T-shaped CFST columns and reinforced concrete (RC) beams with slabs. Tests of seven specimens are conducted: a specimen is tested under the monotonic loading in order to obtain the load-displacement curve and the development of strains until the failure; and six specimens are tested under cyclic loading. The seismic behaviour of the connections in terms of strength, ductility, energy dissipation, strength degradation and stiffness degradation are evaluated. The experimental results demonstrate that the proposed connections exhibit good seismic performance and that the length of the H-shaped steel corbel and the diameter of the high-strength bolt played important roles in improving the seismic behaviour of the connections. A finite element (FE) model based on ABAQUS is developed and validated by the experimental results for the numerical investigation of the seismic behaviour of the proposed end-plate connections. It has been found that the reinforcement ratio of beam and the concrete strength of the beam and slab can affect the seismic performance of the specimens, but the effect of the axial compressive force ratio of the column on the seismic performance can be neglected.

1. Introduction

Concrete-filled steel tubular (CFST) columns are widely used in high-rise buildings and bridges because of convenience in construction and excellent structural behaviour including their excellent seismic performance such as high bearing capacity and favourable ductility [1–3]. However, the width of the conventional CFST columns is greater than that of walls, which leads to the inefficient use of space and harms internal beauty of buildings. To overcome the problem, some special-shaped (L-shaped, T-shaped, Cross-shaped) CFST columns having the same width as walls have been developed to improve the layout of space [4,5] such as shown in Fig. 1. Yang et al. [6,7] proposed three types of T-shaped CFST columns and these columns were tested under concentric compressive load and eccentric compressive load. The main results of the study showed that the tensile bar stiffeners were able to postpone the local buckling of steel tube, increase the buckling resistance of CFST column and improve the compressive strength of concrete. Tu et al. [8] studied the hysteretic behaviour of eight improved multi-cell T-shaped CFST columns and one conventional T-shaped CFST column under low frequency cyclic loading. The experimental results showed that the high load bearing capacity, ductility and energy dissipation capacity of the improved multi-cell T-shaped CFST columns were better than those of the conventional T-shaped CFST column. The seismic behaviour of L-shaped CFST columns was investigated by Shen et al. [9]. Six L-shaped CFST columns were tested under axial load and cyclic load. The results indicated that the axial load level was able to significantly influence the ductility, strength and stiffness degradation of the columns. Moreover, the energy dissipation and ductility of all columns was favourable. Xu et al. [10] investigated the fundamental structural behaviour of L-shaped CFST columns connected by steel linking plates, and the results indicated that the slenderness ratios, eccentricities and steel connection plates influence the ultimate carrying capacity of the columns. Zhou et al. [11] have examined the seismic performance of L-shaped CFST columns and steel beams, and three specimens consisting of two storeys and a single span were tested. The result indicated that the specimens have an excellent seismic performance which achieves the

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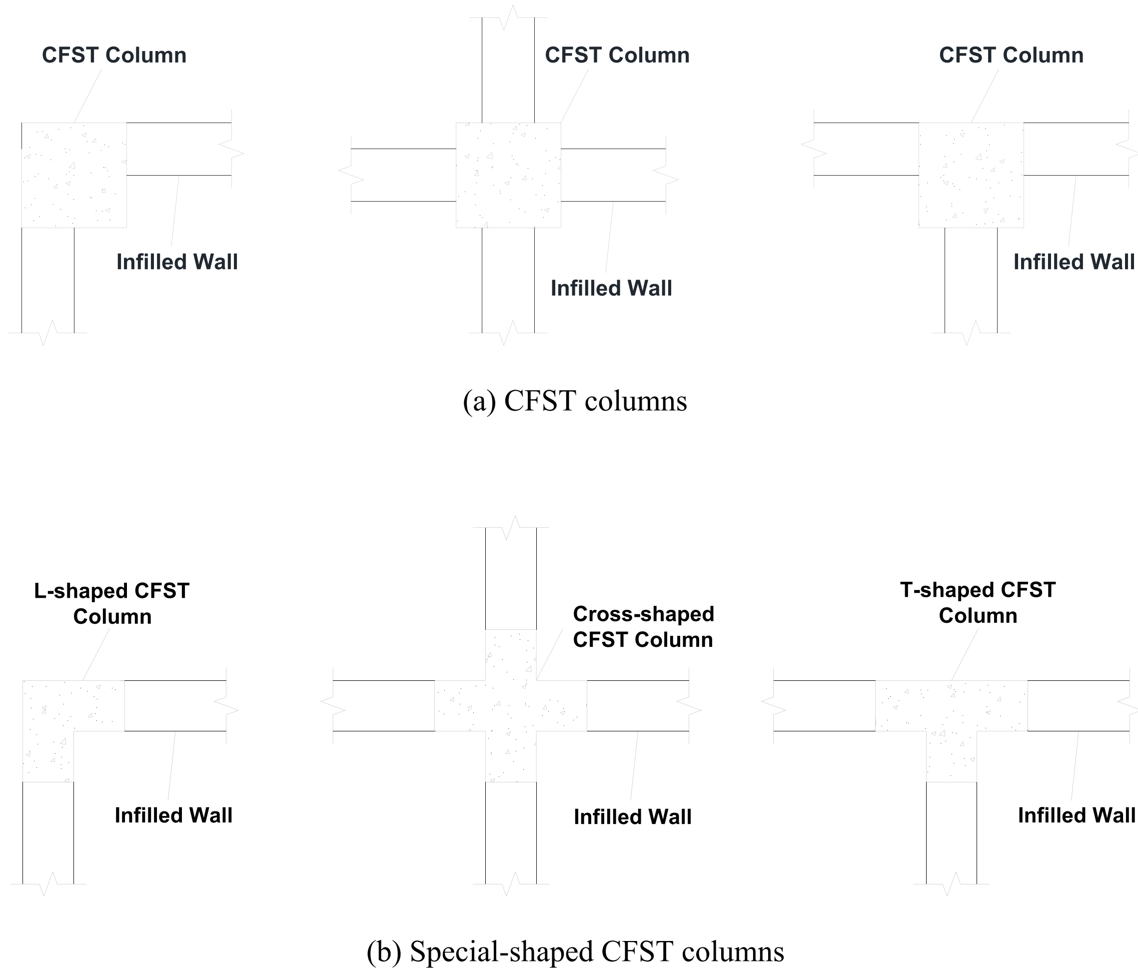

Fig. 1. CFST columns and special-shaped CFST columns in frame structure.

desired objective during seismic design. Most of these studies have been focused on static and seismic behaviour of the special-shaped CFST columns or the connections between special-shaped CFST columns and steel beams. However, research for the connections between special-shaped CFST columns and RC beams is quite limited in the literature.

This paper proposed a new end-plate connection for connecting the RC beams with special T-shaped columns. Xu et al. [12] proposed a welded rectangular composite T-shaped (WRC-T) CFST column, as shown in Fig. 2a and tested 34 WRC-T CFST columns. Based on the test results, a formula for determining the bearing capacity of axial compression was proposed. The results indicated that these two rectangular steel tube columns could effectively work together, and the calculation results from the proposed formula agree well with the test results. Huang [13] proposed an improved WRC-T CFST column, which was

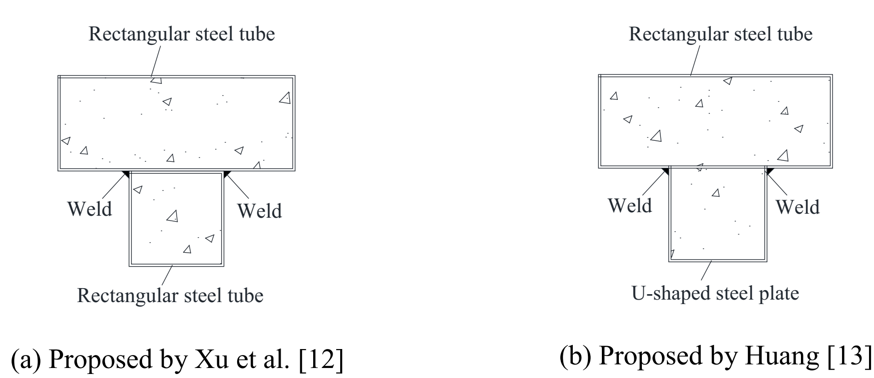

Fig. 2. Two types of T-shaped CFST column.