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Research on special-shaped concrete-filled steel tubular columns under axial compression

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ABSTRACT

Six L-shaped and twelve T-shaped concrete-filled steel tubular (CFST) stub columns subjected to axial compression were experimented in this paper. The L-shaped CFST stub columns were welded vertical stiffener at the concave corner. The T-shaped CFST stub columns were stiffened by steel plate stiffeners. During the test, the experimental phenomenon and failure mode of special-shaped CFST stub columns were observed. According to axial load-displacement curves, mechanical properties such as stiffness, bearing capacity and ductility were compared and analyzed. According to the load-strain curves and load-stress curves, strain and stress development of steel tubes and constraint effect for concrete provided by steel tubes were studied. The test results show that the stiffeners can effectively delay the local buckling of steel tubes, increase the buckling capacity, and increase the constraint effect for concrete. The cross-sectional dimension of specimens has no obvious effect on the ductility and the failure modes of T-shaped CFST stub column due to the restriction of steel plate stiffener, while obviously affects the stiffness and the bearing capacity. Finite element (FE) software ABAQUS was used to analyze special-shaped CFST columns subjected to axial compression and the simulated results were in good agreement with the experimental results. Further parameter analysis with ABAQUS was carried out to study the influences of the steel ratio α, steel yield strength f_y, concrete strength f_{ck} and slenderness ratio λ. Based on the experimental results and FE analysis, design formulae for calculating sectional bearing capacity and stability bearing capacity of special-shaped CFST columns are proposed.

1. Introduction

Rectangular cross-sectional columns in traditional frame structures in Fig. 1(a), with extended corners to indoor space, normally have larger cross-sectional depths than those of adjacent infilled walls, leading to reduction of usable indoor space and disturbance to indoor environment. Recently, special-shaped columns, as an improved architectural approach, have been increasingly introduced into residential and official buildings. Smooth connection between special-shaped columns and adjacent infilled walls guarantees increased efficiency of indoor space and availability to furniture arrangement (in Fig. 1(b)).

Research and extensive engineering practice have been carried out on reinforced concrete (RC) special-shaped column. Early study mainly focused on the static behavior of T-shaped and L-shaped columns subjected to concentric compressive load or biaxial eccentric compressive load, based on which, interaction curve of *M-N* resistances for practice was proposed [1–6]. Since 2000, to adapt to development of housing industry, extensive study carried out by Chinese researchers [7–9] has concentrated on comprehensive static and seismic behaviors, especially for RC special-shaped columns in frame structure or frame-shear wall structure.

The irregular cross section of special-shaped column brings about disadvantages in its mechanical behavior, leading to strict limitations in seismic design: (1) the RC special-shaped columns can only be applied to 8-degree seismic zones (0.2 g) or below; (2) its applicable maximum building height is rigorously restricted, compared with that of rectangular RC columns (listed in Table 1), based on the China codes - Technical specification for concrete structures with specially shaped columns (JGJ 149-2006) [10] and Code for design of concrete structures (GB 50010-2010) [11]. In order to improve the scope of application of special-shaped columns, this paper considers the use of special-shaped CFST columns to improve the performance of special-shaped columns.

Recent research mainly focused on mechanical behavior of stiffened special-shaped CFST columns. A plate rib, which is the most commonly used stiffener in square or circular CFST column, has been introduced into the L-shaped CFST columns by Shen et al. [12], reinforcing the

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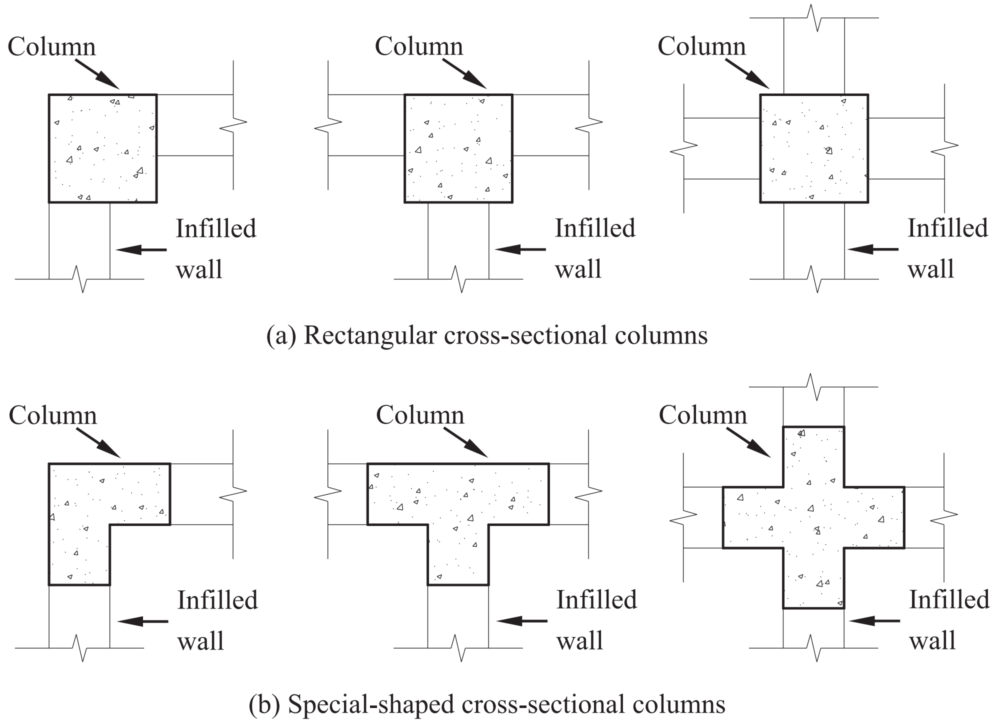

Fig. 1. Rectangular and special-shaped cross-sectional columns in frame structures.

Table 1
Maximum building height of special-shaped and rectangular columns in frame structures.

Section	Non-seismic design	Aseismic design					
		6-degree	7-degree		8-degree		9-degree
		0.05 g	0.1 g	0.15 g	0.2 g	0.3 g	0.4 g
Special shape	24 m	24 m	21 m	18 m	12 m	–	–
Rectangular shape	70 m	60 m	55 m	55 m	45 m	45 m	25 m

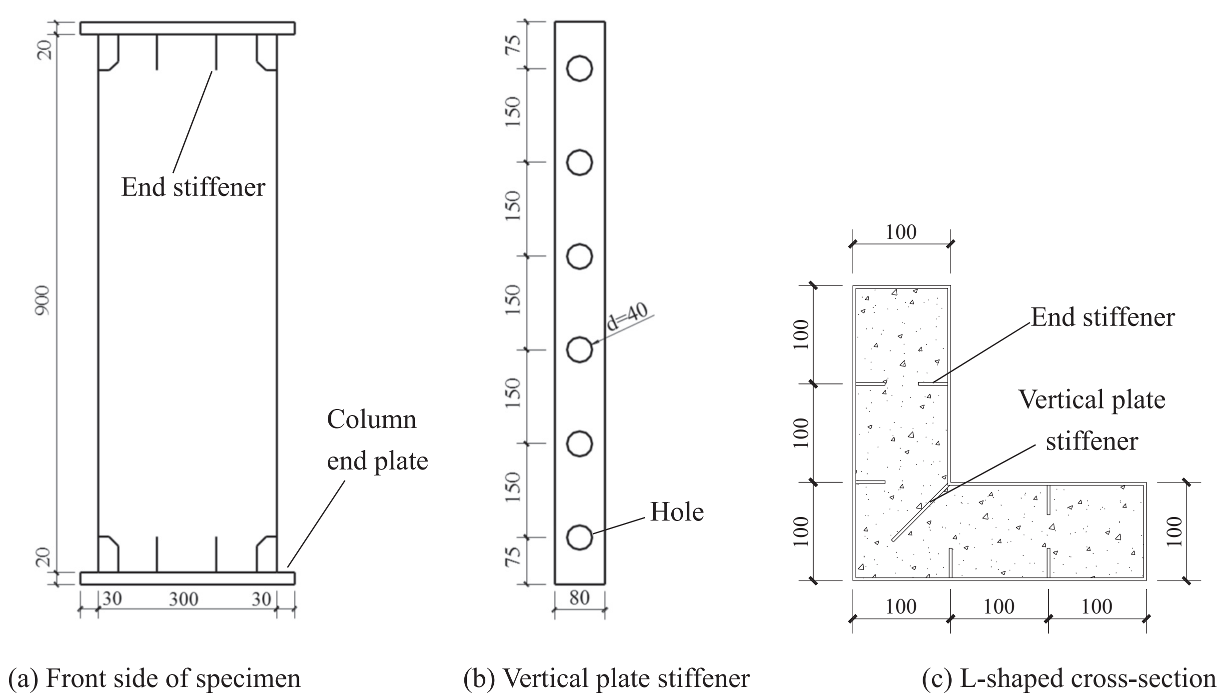

Fig. 2. Dimensions of L-shaped CFST stub columns (unit: mm).