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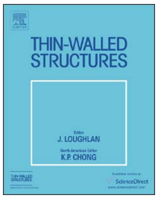

Full length article

Seismic performance of a non-through-core concrete between concrete-filled steel tubular columns and reinforced concrete beams

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ABSTRACT

This paper aims to investigate the seismic behavior of a new type of non-through-core connection between a concrete-filled steel tubular (CFST) column and steel reinforced concrete (SRC) beams. In this original connection, the U-shaped steel corbels are welded to the CFST column. A strengthening ring beam is used to enhance the stiffness of the connection. Cyclic loading tests were conducted on two beam-column connection specimens. A finite element (FE) model was then developed and validated by a comparison with the experimental results. The results of the FE analysis are in good agreement with the experimental results, which demonstrated the rationality of the proposed formula for concrete damage variable based on the elastic modulus in the FE analysis. Based on the test and numerical results, the hysteretic response, the skeleton curves, the strain, ductility, stiffness degradation and energy dissipation are discussed. It is shown that the proposed connection has a favorable seismic performance. The effect of the axial compression ratio (n) on the seismic behavior of the connection is also discussed through parametric studies.

1. Introduction

Concrete-filled steel tubular (CFST) columns are known to exhibit excellent structural behavior such as high load carrying capacity and ductility, leading to their increasing use in high-rise buildings especially when seismic considerations are of importance. With the benefits of CFST, the use of CFST column is becoming more popular and the performance of concrete-filled steel tubes has caught more and more research attentions [1–6].

The existing researches on CFST structures were mainly concentrated on the performance of CFST columns. However, one of the most important and problematic components of a CFST frame structure is the connection between the beams and columns, which plays a vital role in the resilience of a building during an earthquake. Therefore, many types of connections of CFST columns with composite beams have been proposed and investigated. Qin et al. [7] investigated the seismic behavior of a through-diaphragm connection with concrete-filled rectangular steel tubular columns by testing of four full-scale specimens. The variables in the experiments including the geometry of the through-diaphragm, the horizontal stiffeners, and the methods of connecting the beam webs to the column were also studied in [7]. Qin et al. proposed connections with good seismic performance in which the plastic hinge was significantly moved away from the column face. Wang et al. [8] studied the seismic response of extended end plate connections with circular or square CFST columns using blind bolts. The results indicated that the proposed connections showed the satisfactory ductility and energy dissipation. The thickness of end plate and the section type of column have a significant influence on the mechanical and seismic performance of the proposed joints based on the cyclic test results. He et al. [9] conducted an experimental study on the seismic behavior of a composite frame system that consists of CFST columns and steel beams with bolted endplate connections. Patel et al. [10] presented a numerical model for the nonlinear inelastic analysis of high strength thin-walled rectangular CFST slender beam-columns under constant axial load and cyclically varying lateral loading, and it was found that the suggested numerical model well predicted the experimental phenomenon. Nie et al. [11] and Bai et al. [12] proposed a through-beam connection system with concrete encased CFST columns and RC beams, in which the steel tube was completely curtailed in the connection zone and the steel reinforcement bars in the RC beams were continuous in the floor. This study demonstrated that this through-beam connection had superior seismic performance. Qin et al. [13] demonstrated the load transfer mechanism in through-diaphragm connections between concrete-filled rectangular tube columns and hollow structural sections beams, and proposed two mechanical models to calculate the shear stiffness and yield shear

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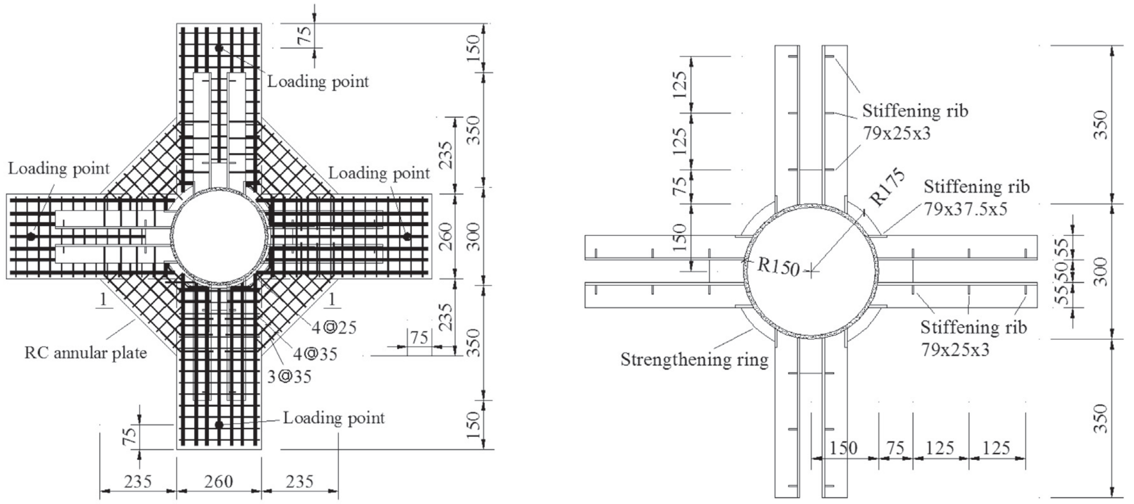
Nomenclature

A_s	area of steel tube
A_c	area of concrete core
E_c	elastic modulus of concrete
E_s	elastic modulus of steel
E'	energy dissipation ratio
h_e	equivalent viscous damping ratio
μ	displacement ductility ratio
f_{cu}	compressive cube strength of concrete
f_y	yield strength of steel
Δ_y	estimated yield displacement corresponding to P_y
P_y	estimated yield load by FE model
P_{max}	ultimate vertical load by experiment
l	beam length
b	beam width
h	beam depth
n	axial compression ratio
N_0	axial compressive load
P_i	vertical load of beam
D_1	damage variable of elastic modulus
D_2	energy damage variable
d_t	tensile damage variable
d_c	compressive damage variable
υ_s	poisson's ratio of steel
υ_c	poisson's ratio of concrete
w_c	recovery factor of compressive stiffness
w_t	recovery factor of tensile stiffness
ε_0	peak strain of concrete

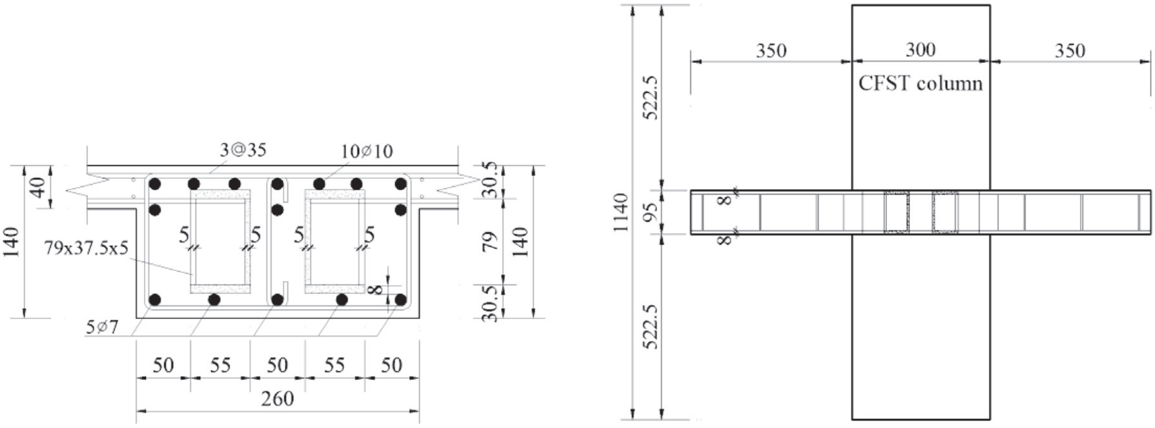
strength.

Recently, a new type of non-through-core connection between CFST columns and steel reinforced concrete (SRC) beams based on an actual project (Guangzhou Harbor Plaza located in the Pearl River north in Guangzhou, China), as shown in Figs. 1 and 2, has attracted the interest of structural engineers and researchers. In this connection system, the steel tube isn't cut at the corresponding beam location, and the U-shaped steel corbels with vertical and horizontal stiffeners are welded to the steel tube. Reinforced concrete (RC) flat beam was adopted to encircle the U-shaped corbels to increase the integral stiffness and stability of the joint core.

The object of the current paper is, therefore, to present a comprehensive study of the seismic behavior of this new type of connection. Cyclic loading tests of two specimens are reported. Based on the



(a) Layout of reinforcement. (b) Top view of U-shaped corbels.



(c) 1-1 Section. (d) Elevation view of steel structure.

Fig. 1. Details of specimen 4NT; units=mm.