Thin-Walled Structures 129 (2018) 404–417

Contents lists available at ScienceDirect

Thin-Walled Structures

journal homepage: www.elsevier.com/locate/tws

Full length article

Analytical behavior of special-shaped CFST stub columns under axial compression

Fa-Cheng Wang*, Lin-Hai Han

Department of Civil Engineering, Tsinghua University, Beijing 100084, PR China

A R T I C L E I N F O

Keywords:
Concrete filled steel tube (CFST)
Special-shaped section
Stub column
Axial compression
Finite element analysis

A B S T R A C T

Special-shaped CFST columns are becoming increasingly attractive as alternative solutions to engineering design. Three-dimensional FE models are developed and verified against experimental results in terms of failure modes, load-deformation curves and ultimate loads, where circular, triangular, Fan-shaped, D-shaped, 1/4 circular and semi-circular sections are considered. In light of the FE simulations, the composite actions between the special-shaped steel tubes and concrete cores have been investigated through load-deformation and interaction stress-deformation histories. Possible parameters affecting specimens loading behaviors have been studied. The studies generally show that the failure modes, composite behaviors and load-deformation histories of the axially loaded special-shaped CFST stub columns are similar to those of SHS/RHS specimens.

1. Introduction

Concrete filled steel tubular (CFST) columns with circular, square and rectangular hollow sections (CHS, SHS and RHS) have been commonly used in numerous engineering structures due to their excellent composite actions between the steel tube and concrete infill. Extensive analytical and laboratory investigations have been carried to study the composite behaviors of their constituent components, such as Han et al. [1–3], Ellobody et al. [4], Lam and Williams [5], Hajjar and Gourley [6] and Tao et al. [7].

To provide better corrosion resistance and structural response, materials of stainless steel and aluminum and section type of concrete filled double skin tube, T-shape and L-shape have been used in optimizing CFST specimens. Comprehensive experimental and numerical investigations have been conducted accordingly. The structural behaviors of axially loaded concrete filled stainless steel tubular columns have been studied by Tao et al. [8], Lam and Gardner [9] and Uy et al. [10]. Zhou and Young [11,12] investigates the structural response of concrete filled aluminum tubular columns under axial compression. Behaviors of concrete filled double skin tubular columns have been studied by Han et al. [13,14], Romero et al. [15], Liew et al. [16] and Huang et al. [17]. The structural responses of T- and L-shaped CFST stub columns to axial loadings are investigated by Yang et al. [18] and Xiong et al. [19].

However, the structural behaviors of special-shaped CFST members which have been practically applied in industry have not been systematically studied. As shown in Fig. 1(a), round-end CFST columns consisting of D-shaped or semi-circular sections are usually employed as bridge piers to increase column transverse stiffness [20]. As given in Fig. 1(b), multi-cell CFST columns are commonly used in skyscraper to improve concrete construction quality, where constitutive special-shaped sections may be consistent of interconnected plates with acute angles and potentially arc elements in the future. With continually increase in demands for multi-function and symbolic architectures in urban developments [3,21], more applications of special-shaped CFST columns including triangular, Fan, D-shaped, 1/4 circular and semi-circular sections, as illustrated in Fig. 2, are expected.

Ren et al. [22] carry out a series of special-shaped CFST stub column tests, where triangular, Fan-shaped, D-shaped, 1/4 circular and semi-circular sections are considered and the corresponding cross-sectional strengths and failure modes are presented. Liu et al. [23] conduct cyclic experiments on special-shaped CFST column to steel beam connections where cross-shaped columns and I-section based beams are considered.

Existing literature indicates that further investigations through finite element (FE) analyses are needed to understand the fundamental structural response of axially loaded special-shaped CFST columns, especially the interaction behaviors between the special-shaped steel tubes and the concrete core. Only by doing so can rationally understand the composite actions between their constituent components and provide design recommendations accordingly.

Finite element analysis (FEA) has become invaluable part of most structural studies, since it can be used as efficient tool to investigate the structural behaviors, especially the composite actions between components of CFST specimens, provided that appropriate models are

* Corresponding author.
E-mail address: wangfacheng@tsinghua.edu.cn (F.-C. Wang).

https://doi.org/10.1016/j.tws.2018.04.013
Received 25 December 2017; Received in revised form 14 March 2018; Accepted 18 April 2018

Nomenclature

A_c	Cross-sectional area of concrete
A_s	Cross-sectional area of inner carbon steel tube
CFST	Concrete-filled steel tube
f_y	Yield stress of steel
f_{scy}	Composite stress of steel tube and concrete core
f_{ck}	Characteristic concrete strength ($f_{ck} = 0.67 f_{cu}$ for normal strength concrete)
f_{cu}	Concrete cube strength
$f_c^{'}$	Concrete cylinder strength
N_u	Ultimate strength of column
$N_{u,Exp}$	Measured ultimate strength of column
α_n	Ratio of steel tube to concrete area
p	Interaction stress
t	Wall thickness of steel tube
ε_{cu}	Longitudinal strain at ultimate strength
ξ	Confinement factor ($=A_s f_y / A_c f_{ck}$)
ψ	Dilation angle of concrete
e	Flow potential eccentricity of concrete
f_{b0}	Concrete compressive strength under biaxial loading
ν_c	Poisson's ratio of concrete
ν_s	Poisson's ratio of steel

Fig. 1. Special-shaped CFST applications.

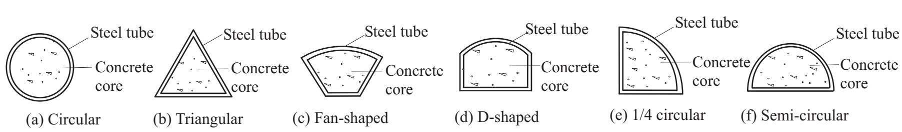

Fig. 2. A schematic view of CFST cross-sections.

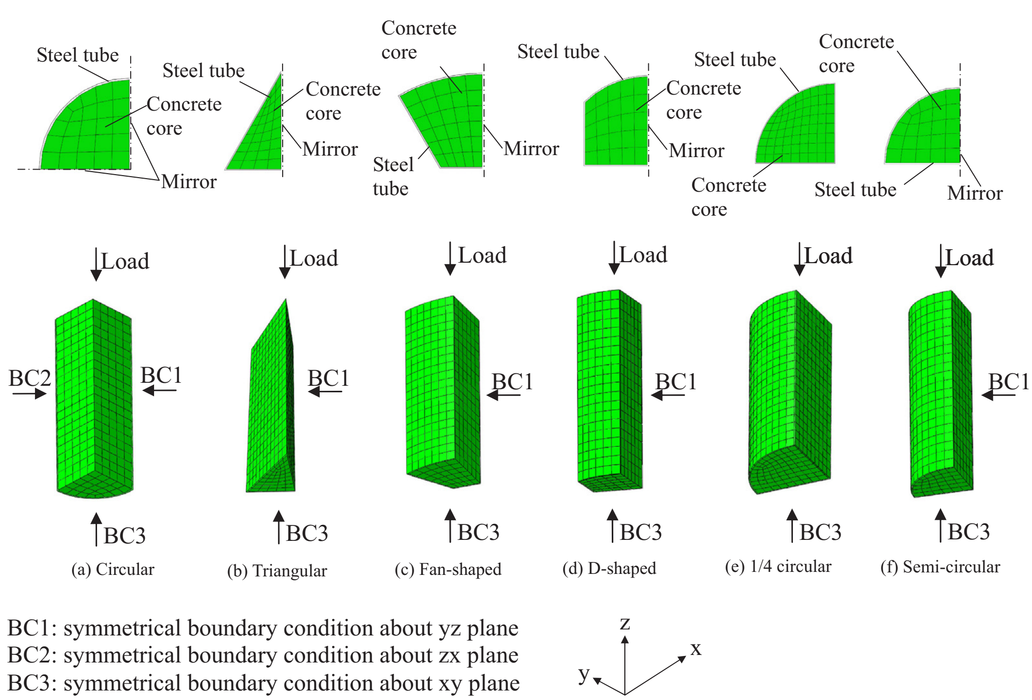

Fig. 3. Schematic view of mesh configurations.