The 2017 World Congress on
Advances in Structural Engineering and Mechanics (ASEM17)
28 August - 1 September, 2017, Ilsan(Seoul), Korea

FEA on the structural behaviour of square CFST beams

Muhammad F Javed[*a], Nor Hafizah Binti Ramli[a], Niaz B Khan[a] and Sardar Kashif[a]

[a] *Department of Civil Engineering, Faculty of Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia*
**arbabf1@gmail.com*

ABSTRACT

This paper presents the finite element (FE) analysis and modeling of square concrete-filled steel tube (CFST) members subjected to a flexural load. The developed FE model can accurately predict the load–deflection curve and the ultimate moment capacity of the square CFST members subjected to flexural loads. A parametric study is conducted using the verified FE model to study the effect of the depth-to-thickness (D/t) ratio (18.75, 25, and 30), the compressive strength of infilled concrete (60, 80, and 100 MPa), and the yield strength of the steel tube (410, 500, and 600 MPa) on the flexural behavior of the square CFST members. Decreasing the D/t ratio (from 30 to 18.75) can significantly increase the ultimate capacity of the square CFST members (up to 25%) while having a marginal effect on the initial stiffness of the CFST members. The ultimate bending capacity of the CFST members increases by up to 55% when the yield strength of the outer steel tube increases from 410 MPa to 600 MPa. However, the flexural capacity increases by only 12% when the compressive strength of the infilled concrete increases from 60 MPa to 100 MPa, hence showing a marginal effect. Results of the parametric studies are used to assess the current design models, and Han's model predicts the most accurate flexural capacity.

Keywords: Flexural behavior; square concrete-filled steel tube; finite element analysis; D/t ratio; beam

1. Introduction

Several researchers have presented different procedures to study the effect of static and dynamic loads on different composite systems (Cui and Shao 2015; Hanif, Ibrahim et al. 2016; Kashif Ur Rehman, Ibrahim et al. 2016). Numerous problems are encountered when dealing with the modeling of composite systems that combine two different materials, such as ductile steel and brittle concrete. The modeling of such composite sections should capture the relative stiffness of each material properly. Concrete-filled steel tube (CFST) is a composite material that is composed of a steel tube filled with concrete. The use of CFST columns and beams in constructing

*Note: Copied from the manuscript submitted to
"Steel and Composite Structures, An International Journal" for the purpose of presentation at ASEM17/ANBRE17.

buildings has increased exponentially in the recent decades (Han, Li et al. 2014; Hua, Wang et al. 2014; Kiymaz and Seckin 2014). As suggested by structural engineers, CFST members are the most interesting composite members for several modern building projects (Liew and Xiong 2012; Liew, Xiong et al. 2014). This type of composite member has more advantages than conventional hollow steel/concrete members, such as faster construction work because of the omission of reinforcing bars and framework, low structure cost, conservation of environment, high ductility, and strength capacity (Qu, Chen et al. 2015); this type also has good damping merits and excellent seismic resistance (Yang 2015; Yu, Hu et al. 2016). Different types of concrete, including recycled aggregates, can be used as an infill in CFST, thus contributing to a clean environment (Yang and Ma 2013; Chen, Xu et al. 2014; Aslam, Shafigh et al. 2015; Han, Xu et al. 2015; Hamidian, Shafigh et al. 2016; Silva, Jiang et al. 2016).

Numerous researchers (Liew, Xiong et al. ; Chithira and Baskar 2014; Xiamuxi, Hasegawa et al. 2014; Denavit, Hajjar et al. 2016; Khan, Sheikh et al. 2016; Patel, Uy et al. 2016) have investigated the structural behavior of circular CFSTs. However, only a few studies on the numerical analysis of the structural performance of circular CFSTs are available in the literature (Hu, Su et al. 2010; Kvedaras, Sauciuvenas et al. 2015). Hu et al. (Hu, Su et al. 2010) proposed a material constitutive model for circular CFST columns subjected to pure bending. They performed a finite element analysis (FEA), validated the theoretical results with the experimental data, and concluded that concrete is an ideal material that resists compressive loading in typical applications when the depth-to-thickness (D/t) ratio is greater than 74. The infilled concrete has no significant effect on the strength of CFST columns when the D/t ratio is less than 20.

Lakshmi and Shanmugam (Lakshmi and Shanmugam 2002) proposed a semi-analytical method using an iterative process, and the relationship among the moment, curvature, and thrust was determined to investigate the behavior of CFST columns. They considered different cross-sections, including the square, rectangle, and circle of the compact section, in the FEA. The pin-ended columns subjected to biaxial or uniaxial loads were studied. They verified the theoretical and experimental results and concluded that the moment capacity of the columns decreases with the increase in axial load. Liang et al. (Liang, Uy et al. 2005) studied the behavior of simply supported composite beams subjected to combined shear and flexural loads using the finite element (FE) method. A 3D FE model that considers the material and the geometric nonlinear behavior of composite beams was developed and verified by experimental results. The verified FE model was then used to study the effects of different factors on the combined moment and shear capacities of concrete slabs and composite beams. The effect of the shear connection degree on the vertical shear strength of deep composite beams was also studied. Design models for the vertical shear strength were proposed, including the contributions from composite actions and concrete slabs. Ultimate moment–shear interaction was proposed for the design of simply supported composite beams under combined bending and shear. The proposed design models provided an economical and a consistent design procedure for simply supported composite beams.

Lu and Kennedy (Lu and Kennedy 1994) examined the effects of different D/t ratios and shear-span-to-depth ratios on 12 square and rectangular steel beams. They