Journal of Constructional Steel Research 79 (2012) 115–126

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Experimental study on seismic behavior of concrete filled steel tube columns under pure torsion and compression–torsion cyclic load

Nie Jian-guo, Wang Yu-hang *, Fan Jian-sheng

Key Laboratory of Civil Engineering Safety and Durability of China Education Ministry, Dept. of Civil Engineering, Tsinghua University, Beijing 100084, China

ARTICLE INFO

Article history:
Received 15 February 2012
Accepted 28 July 2012
Available online xxxx

Keywords:
Concrete filled steel tube column
Pure torsion
Compression–torsion
Combined action
Quasi-static test

ABSTRACT

Based on the quasi-static test on eight CFST columns subjected to pure torsion and compression–torsion cyclic load, the torsion behavior of CFST columns with various section types, steel ratios and axial load levels was studied. The test results showed that the hysteretic curves of CFST columns under pure torsion and low compression–torsion cyclic load are very plump, which indicate that CFST columns have good seismic capacity. The unloading stiffness of CFST columns was equal to the initial elastic stiffness. The torsion capacity of CFST columns could be improved by the low compressive load, and the ductility was also good. But the torsion capacity of CFST columns would be reduced by the high compressive load. When CFST columns subjected to pure torsion, spiral diagonal compressive struts will be created in the in-filled concrete, and the axial components of the diagonal compressive force of the in-filled concrete was equal to the axial tensile force of the steel tube in order to satisfy the axial load equilibrium condition on the section, so the axial strain will be produced in the steel tube. The shear strain has good linear relationship with the rotation angle of the section when CFST columns subjected to pure torsion and compression–torsion combined action. Based on the test results and literatures available, the torsion mechanism of CFST columns was preliminarily analyzed.

1. Introduction

In modern high-rise buildings and long span bridges, concrete filled steel tube (CFST) columns are being widely used due to the advantages compared with conventional reinforced concrete columns, including rapid construction, excellent static and earthquake-resistant properties [1,2].A large number of literatures were available about the mechanical behavior of CFST columns under axial force and bending moment, and reviewed by Gourley et al. [3], Han [4], Schneider [5], etc. But in practice, curved bridges often exist due to the traffic line, and piers are often fixed connected to the girders in order to ensure the integrity of curved bridges as shown in Fig. 1. As illustrated in Fig. 2, the piers of curved bridges with fixed joint are often resisted the torsion action due to the horizontal earthquake action. Furthermore, the columns of complex buildings (particularly at corner) are often subjected to torsion moment due to the eccentric action of the horizontal earthquake on the mass center of the structures.

Beck and Kiyomiya [6], Xu, Gong, Lee, and Zhou et al. [7–10] have carried out tests on CFST members with circular sections under pure static torsion. It was found that, CFST columns had high torsional strength and good ductility because the local buckling of steel tubes was prevented by the in-filled concrete. The steel tube could work well with the concrete together. Han et al. [11,12] have studied the torsional behavior of CFST columns subjected to combined loading using the finite element method. The simplified equations for calculating the static torsion capacity using the regression analysis method were proposed with good agreement. Lee et al. [13] have investigated the mechanical behavior of CFST columns under pure static torsion. A theoretical model to describe the behavior of the entire loading history of CFST columns under pure static torsion was proposed, and it correlated well with the experimental results.

From the literature reviewed above, we can see that the researchers mainly focused on the static torsion behavior of CFST columns, so the static torsion bearing capacity, torsion rigidity, global buckling phenomena and local buckling have been already studied sufficiently, and the calculation methods and design methods for the static torsion behavior of CFST column were proposed based on statistic analysis. However, in seismic regions, the cyclic earthquake load will be often applied on structures. Hence, the mechanical behavior of CFST column subjected to cyclic torsion needs to be studied. In this paper, a self-designed loading set-up was used in order to apply the cyclic torsion load, and the quasi-static test was carried out as an initial study on the seismic behavior of CFST columns with circular and rectangular section subjected to pure torsion and compression–torsion cyclic load. The influences of different loading modes and section types on the behavior of CFST column under cyclic torsion are the main purpose of this paper. Furthermore, the mechanism of the torsion behavior of CFST columns was preliminarily analyzed based on the test results.

* Corresponding author.
E-mail address: wangyh04@mails.tsinghua.edu.cn (Y.H. Wang).

0143-974X/$ – see front matter.
http://dx.doi.org/10.1016/j.jcsr.2012.07.029