Journal of Constructional Steel Research 73 (2012) 66–79

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Seismic performance of CFST column to steel beam joint with RC slab: Joint model

Wei Li, Lin-Hai Han *

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

ARTICLE INFO

Article history:
Received 27 September 2011
Accepted 28 January 2012
Available online 7 March 2012

Keywords:
Concrete filled steel tubes (CFST)
Joint
Seismic behavior
Hysteretic model
Joint macro element

ABSTRACT

Based on the previous experimental and numerical investigations presented in Han and Li (2010)and Li and Han (2011), this paper studies the joint model for the composite joint consisted of circular concrete filled steel tubular (CFST) column and steel beam with external diaphragm. The elastic shear stiffness and the shear deformation of the joint panel zone are investigated by parametric study using the finite element analysis (FEA) model. A hysteretic model incorporating the shear stiffness, shear strength, shear deformation and the hysteretic rules is proposed for the panel zone of the composite joint. This hysteretic model is then integrated in a fiber-based joint macro element. The joint macro element is validated by both FEA and experimental results. The overall and the local behavior of CFST joints and frame with macro elements are investigated. The proposed model is featured with a favorable accuracy and amenable modeling method, and could be applied to simulate the seismic behavior of large-scale and complex composite structural systems.

1. Introduction

The concrete filled steel tubular (CFST) structures have gained a widespread usage in constructions all over the world. It is well known that the beam to column joint in frame is constraint by other members, and the behavior of this region may have an influence on the nonlinear seismic performance of the whole structure. Therefore it is of great importance to study the load versus deformation relation of the joint, as well as the simplified model for the overall structural analysis that could reflect the joint behavior.

The behavior of the panel zone is the key issue on the behavior of the CFST composite joint. Previous research works had revealed that the shear capacity of the panel zone was contributed by the “compressive strut” mechanism of the inner core concrete and the shear mechanism of the outer steel tube (Li and Han [1]) , as shown in Fig. 1. The analytical shear versus shear deformation (V_j–γ_j) relation of the panel zone is usually obtained by the superposition of relations of the steel tube and core concrete parts. Fukumoto and Morita [2] suggested V_j–γ_j relations for circular and square CFST joints, where tri-linear relations were applied for both steel tube and core concrete. Cheng and Chung [3] considered that the shear relation for the steel tube could be expressed as a similar tri-linear relation, and a nonlinear relation for the core concrete was applied. Qin [4] established a V_j–γ_j relation for the square CFST joint. A tri-linear relation for the steel tube and a nonlinear relation for the core concrete were applied, where the σ–ε relation for confined concrete suggested by Han [5] was used. Fukumoto and Morita [2] and Qin [4] also proposed hysteretic rules for the V_j–γ_j relation of the panel zone.

For the overall analysis of CFST structures, basically two kinds of analytical models were developed in current research. One used 3-D continuum finite element analysis (FEA) elements to represent the detailed behavior, and the other used simplified elements with concentrated or distributed plasticity. It is convenient to obtain an accurate and detailed results using fine FEA model. However, it is more suitable to apply the simplified model in the overall structure analysis. In the simplified model, the beam and the column are usually simulated by using beam elements, and the wall and the floor are usually simulated by using shell elements. In the previous studies on CFST frames, Hajjar et al. [6] investigated the cyclic behavior of CFST column to beam assemblage with distributed plastic elements. Tort and Hajjar [7] proposed an analytical model for composite frames composed of rectangular CFST columns and steel beams. The column elements were simulated using distributed plasticity beam elements, and the steel tube and the core concrete were considered separately with the inter-slip behavior. Valipour and Foster [8] conducted the static and cyclic analysis on CFST column with 1-D fiber element.

In these researches, various simplified models for the structure were proposed though the deformation of joint was usually neglected. The CFST joint was usually treated as “common nodes” shared by beam and column elements or a “rigid” one. It is necessary to apply the hysteretic models from experimental or numerical researches for structural members and joints, so as to obtain accurate results in some key region with a favorable efficiency. Fukumoto and Morita [2] proposed a beam to column connection element for CFST frame analysis, where the panel zone and the connector element within the joint region were included with the beam and column elements. Zhao et al. [9] studied the macro model on the simulation of the nonlinear behavior of square CFST column to steel concrete composite beam joints, and the model was shown to be available on the nonlinear analysis of CFST structures.

* Corresponding author. Tel.: +86 10 62797067; fax: +86 10 62781488.
E-mail address: lhhan@tsinghua.edu.cn (L.-H. Han).

0143-974X/$ – see front matter
doi:10.1016/j.jcsr.2012.01.011