Engineering Structures 33 (2011) 3162–3171

Contents lists available at SciVerse ScienceDirect

Engineering Structures

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

Advanced design for trusses of steel and concrete-filled tubular sections

M. Fong [a], S.L. Chan [a,*], B. Uy [b]

[a] Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Hong Kong, China

[b] School of Engineering, University of Western Sydney, Sydney, Australia

ARTICLE INFO

Article history:
Received 15 January 2011
Received in revised form
11 March 2011
Accepted 2 August 2011
Available online 23 September 2011

Keywords:
Concrete-filled steel tubes
Design codes
Effective lengths
Second-order analysis
Trusses

ABSTRACT

This paper presents an experimental and analytical investigation of buckling behavior of bare steel and concrete-filled steel (CFS) tubes used as columns and as members of trusses. The member resistances of the columns and trusses consisting of steel and CFS tubular members are compared to demonstrate the beneficial effects of the in-filled concrete, with their resistances predicted using the conventional effective length and second-order analysis methods of design in various international standards such as Eurocode 3 (EC3), Eurocode 4 (EC4), CoPHK, AISC-LRFD and AS5100. Test results are further used to validate the proposed second-order analysis, which skips the assumption of effective length, for accurate and reliable design of composite members. The present holistic approach of considering composite members as constituting elements in a truss represents a piece of original work on testing and design of structures as a system, rather than designing members in isolation in the traditional member-based design.

1. Introduction

Extensive experiments have been conducted and reported on composite columns to investigate their structural resistances under various loading conditions. Furlong [1] tested concrete-filled steel tubular columns and indicated the local buckling of the steel tube was delayed by concrete infill. Circular and square concrete-filled steel tubes with different slenderness ratios were tested by Knowles and Park [2] to investigate the confinement effect on concrete under various slenderness ratios. The results indicated the benefits on ultimate capacity from the confinement effect of short circular columns. Tomii et al. [3] carried out tests on circular, octagonal and square concrete-filled steel tubular columns, and noted that the concrete core provided confinement effects only on circular and octagonal sections. Shakir-Khalil and Mouli [4] performed tests on concrete-filled steel tubular columns and concluded that higher concrete strengths or larger steel sections provided a greater structural efficiency for composite columns. The shape effect of steel tubes on strength and behavior of concrete-filled steel tubes were studied by Schneider [5]. Fourteen circular, square and rectangular tubes were tested and the results indicated that the circular tubes provided greater ductility than the other two section shapes and the confinement effect on the concrete core was observed only on circular tubes when the yield strength was approached. Kilpatrick and Rangan [6] reported test results on concrete-filled steel tubular columns, and indicated the effects on the behavior and strength of composite columns due to the slenderness and load eccentricity. Li et al. [7] carried out tests on six high-strength concrete-filled square steel tubular columns under bi-axial eccentric load and indicated that both the steel area ratio and slenderness ratio influenced the capacity of the columns significantly. Chan and Fong [8] tested steel and composite trusses with high-strength in-filled concrete to compare the beneficial effect of the in-filled concrete.

From the review on the subject, most previous experiments focused on the behavior of isolated columns under pinned or fixed end conditions, and tests on steel and concrete-filled steel (CFS) tubes acting as members of a frame or truss structures are limited. In this paper, tests on trusses composed of the bare steel and CFS tubes as chords and webs in the truss are reported and compared with the second-order analysis and design method. In order to compare the behavior of the members in an isolated column and in the truss system, the columns with same properties of the members in the truss under pinned and fixed ends are tested. The reported work in this paper is believed to be novel in providing the response of the members in the configuration of a structural system as a truss, which should be a good reference for the future research and design of composite trusses and frames.

Various international design codes provide different methods of design for steel and composite members under different loading conditions such as EC3 [9], EC4 [10], AISC LRFD [11], AS5100 [12] and CoPHK [13]. The accuracy of these design methods have been verified by many researchers such as Wang [14], Al-Rodan [15], Zeghiche and Chaoui [16]. Most comparisons of experimental and predicted results from these codes were focused on isolated

* Corresponding author. Tel.: +852 9025 6814; fax: +852 23346389.
E-mail address: ceslchan@polyu.edu.hk (S.L. Chan).

0141-0296/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engstruct.2011.08.002