Journal of Constructional Steel Research 128 (2017) 405–415

Contents lists available at ScienceDirect

Journal of Constructional Steel Research

Compression test and analysis of multi-limbs built-up cold-formed steel stub columns

Fangfang Liao *, Hanheng Wu, Ruizhi Wang, Tianhua Zhou

School of Civil Engineering, Chang'an University, Xi'an 710061,China

A R T I C L E I N F O

Article history:
Received 26 April 2016
Received in revised form 24 August 2016
Accepted 14 September 2016
Available online xxxx

Keywords:
Cold-formed thin-walled steel
Multi-limbs built-up stub columns
Compression tests
Finite element analysis
Width to thickness ratio
Screw spacing

A B S T R A C T

Multi-limbs built-up cold-formed steel stub column is a main structural member consisting of a single C-shaped and U-shaped basic component connected by self-drilling screws. Axial compression bearing capacity tests and finite element analysis of nine multi-limbs built-up cold–formed steel stub columns with three different section forms were conducted in this paper. The results of finite element analysis are close to the test results, which verify the accuracy of the finite element analysis. In order to study the influence of width–thickness ratio and screw spacing on the bearing capacity of the build-up column, the parametric analysis was carried out on the maximum width–thickness ratio of the plates and the screw spacing. The results show that the failure modes of all specimens are local buckling and distortional buckling. Multi-limbs built-up cold-formed steel stub columns consisting of a few basic components can work in harmony, the integral behavior is desirable. The axial load bearing capacity of the multi-limbs built-up section stub column increases when the maximum width–thickness ratio of the plates decreases; the screw spacing has a little impact on the ultimate axial compressive capacity and the buckling capacity of the multi-limbs built-up cold-formed steel stub columns.

1. Introduction

At present, the research and application of the cold-formed thin-walled steel residential structure have started from low-rise building to multistory building. In multi-layer cold-formed thin-walled steel structure, basic components with C-shaped and U-shaped cross sections are connected by self-drilling screws to form built-up members with a variety of complex cross sections, which are commonly used as the main bearing members [1–2]. According to Australian/New Zealand Standard [3] based on the experimental research and analysis, the change of the screw spacing will influence the ultimate bearing capacity of the I-shaped built-up member. Young et al. [4] studied two Σ-shaped cold-formed thin-walled steel built-up columns and compared the axial compression bearing capacities under different assumptions of the flange stiffener by using the direct strength method. Shen et al. [5] studied the axial compression capacity of the closed square member built-up with opening C-shaped components. When the slenderness ratio of the closed square axial compression member is greater than 30, the member built-up with two opening C-shaped components can work cooperatively. However, in the technical codes of cold-formed thin-wall steel structures established by China, Australia, Canada and America et al., the detail calculation methods, regulations and related requirements are proposed only for the basic components of a single limb, regulations and related requirements for cold-formed thin-wall steel built-up columns are very few [6]. Nowadays, there have not been any researches on the axial compression properties of multi-limbs built-up cold-formed thin-walled steel stub columns.

Axial compression bearing capacity tests and finite element analysis of nine multi-limbs built–up cold–formed steel stub columns with three different section forms were conducted. The results of finite element analysis are close to the test results, which verify the accuracy of the finite element analysis. Then the influences of the width-thickness ratio and screw spacing on the axial compression properties of the multi-limbs built-up cold-formed thin-walled steel stub columns were studied.

2. Experimental program

2.1. Specimen design

In this test, the length of each specimen is 450 mm, the thickness of each component is 1.6 mm. The specimens are divided into three kinds according to the section form. The first kind with section 1 is closed two-limbs built-up member, the second kind with section 2 is half-closed

* Corresponding author at: School of Civil Engineering, Chang'an University, Xi'an, Shaanxi Province, 710061, China.
E-mail address: fangfangliao@chd.edu.cn (F. Liao).

http://dx.doi.org/10.1016/j.jcsr.2016.09.005
0143-974X/

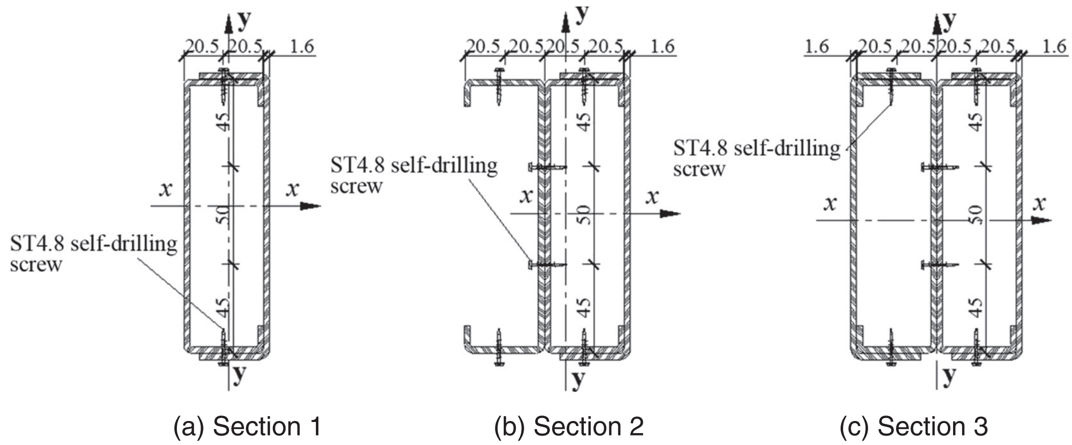

Fig. 1. Section forms of the specimens.

and half-opening three-limbs built-up member, the third kind with section 3 is closed four-limbs built-up member. Each kind has three specimens, thus there are nine specimens in total. The cross-section forms of the specimens are shown in Fig. 1, basic components are C-shaped (140 × 41 × 14 × 1.6) and U-shaped (144 × 34.5 × 1.6), respectively. The dimensions of the two basic components are shown in Fig. 2. The 4.8 mm self-drilling screws were used to connect multi-limbs to build up the specimens (see Fig. 3). The lengths of the C-shaped and U-shaped basic components are all 450 mm (see Fig. 4). The connection spacing of the specimens along the longitudinal direction is 150 mm. The connection at the column bottom end of each specimen is strengthened, the strengthened length is 100 mm. The number of each specimen is shown in Table 1.

2.2. Material properties

The material of the multi-limbs built-up cold-formed thin-walled steel stub column specimens in this test was the same material used in literature and thus the coupon test results presented in literature [7] were adopted in this paper. The stress-strain curves and failure characteristics of the coupon test specimens are shown in Figs. 5 and 6, respectively. The main indicators of the steel material properties are show in Table 2.

2.3. Initial imperfections and residual stresses

Due to the corrective action of the basic components in the assembling process, the initial imperfections of the built-up specimens were so little that could not be measured.

The residual stress distribution of the cold-formed thin-walled steel cross section is curved. According to the research in literature [8], the curved residual stresses of the forming channel steel with edges are less than 7% of the yield strength. The residual stresses can counteract the increase of the whole section strength resulted by the increase of the yield strength and tensile stress in the angle of the section in the cold forming process. Therefore, the effect of the residual stresses on the compression bearing capacity of the cold-formed thin-walled steel stub columns is expected to be moderate and thus was ignored in current paper.

2.4. Test setup

The test setup is shown in Fig. 7 (a). The specimens were loaded by YE–2000A hydraulic universal material testing machine (see Fig. 7 (b)). TDS - 602 data acquisition instrument was used to automatically collect the test data (see Fig. 8). Fixed rigid block boards and testing machine pedestal were arranged on the tracks at the two ends of the specimen during the test.

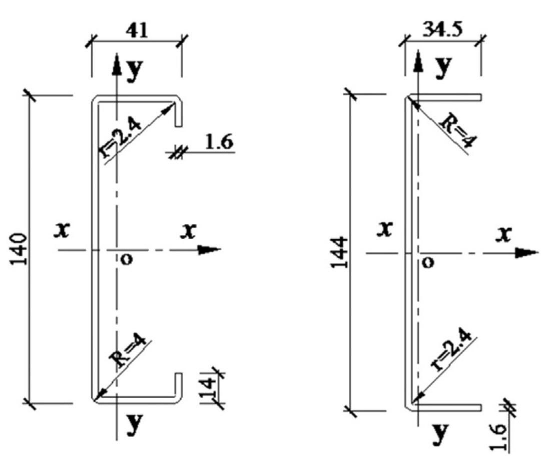

Fig. 2. Dimensions of the basic components.

Fig. 3. Self-drilling screws.