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Load-carrying capacities of cold-formed steel cut stub columns with lipped C-section

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Abstract

Cutting roll-formed steel lipped C-sections may produce different extent of cross section distortion along the lengths of the sections and may lead to additional initial geometric imperfections. Ten stub columns cut from two different sections were tested under axial compression. Flanges of the stub columns experienced distortional mode of failure, whereas the webs showed signs of local buckling failures. Ultimate compressive strengths obtained from the test results were 75–77% of the strengths estimated based on BS5950:Part 5. This indicates that geometric imperfections caused by cutting may significantly reduce the ultimate strength of stub columns.

Keywords: Cold-formed steel; Lipped C-section; Cut; Stub columns; Compressive testing; Ultimate strength; BS5950

1. Introduction

Cold-formed steel sections are increasingly used in the construction industry in warehouses, steel storage rack structures and other forms of low-rise buildings. One common type of cold-formed steel section is the lipped C-section. It is characterized by the high width-to-thickness ratios of the web and/or flange. As a result, a lipped C-section stub column is vulnerable to local or distortional buckling. Load-carrying capacity and modes of failure of a stub column are sensitive to both magnitude and distribution of the initial geometric imperfection. Initial geometric imperfection of a cold-formed steel section could be introduced in the process of manufacturing, delivering and piling up of the steel members. Although, one advantage in using cold-formed steel sections is that they can be easily cut to the desirable lengths, the process of cutting may lead to cross section distortion and initial geometric imperfection [1,2]. It is the objective of this study to assess the load-carrying capacities of lipped C-section stub columns with the initial geometric imperfections caused by the process of cutting.

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Compression tests on cold-formed steel C-section stub column were performed, see Refs. [3–15]. Hancock [16] also discussed the distortional buckling of steel storage rack columns. However, there exist limited studies to examine the effect of initial geometric imperfections on the axial load-carrying capacities of stub columns. This is also not considered in the design codes and specifications, such as BS5950:Part 5 [17]. In this study, compression tests were carried out on stub columns cut from roll-formed steel lipped C-sections. The test results were compared with BS5950:Part 5 [17] to highlight the influence of initial geometric imperfections caused by the cutting process on the load-carrying capacities and modes of failure of stub columns.

2. Stub columns with initial geometric imperfections

Two types of stub columns were considered in this study: C150 and C100. These are identified in accordance with the respective nominal dimensions, namely C150 × 65 × 13 × 1.6 and C100 × 50 × 10 × 1.6, as shown in Fig. 1. All the stub columns were cut from five specimens: C150-0, C150-1, C100-1, C100-2 and C100-3. These were all steel lipped C-sections roll-formed from zinc-coated Grade

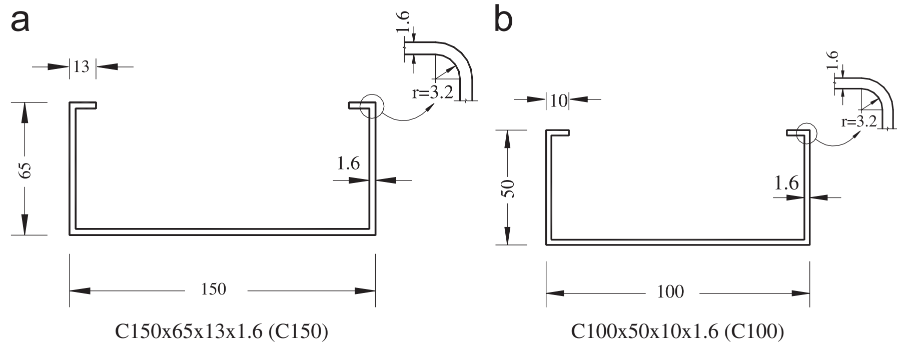

Fig. 1. Dimensions of specimens.

Table 1
Specimens and cut stub columns

Specimen	C150-0	C150-1	C100-1	C100-2	C100-3
Section	C150	C150	C100	C100	C100
Length	1800	3000	2500	2500	2500
Segment number	4	7	8	3	3
Cutting times	3	6	7	2	2
Stub column labels	C150-0-0–3	C150-1-1–7	C100-1-1–8	C100-2-1~3	C100-3-1–3
Stub column lengths	All columns:420	C150-1-8:480	C100-1-8:400	C100-2-1:1200	C100-3-1:1200
		Others:420	Others:300	C100-2-2:300	C100-3-2:300
				C100-2-3:900	C100-3-3:900

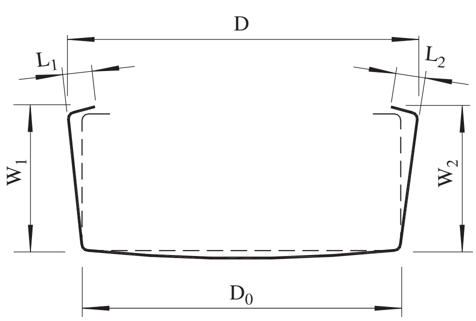

Fig. 2. Sectional dimensions.

Table 2
Dimensions of cut stub columns

Stubs	Section	D_0	D	$(W_1+W_2)/2$	$(L_1+L_2)/2$	S	L_0
C150-0-1	C-150	150.7	152.5	67.0	14.5	299.0	418
C150-0-2	C-150	150.4	151.6	67.1	15.1	298.7	417
C150-1-3	C-150	150.7	152.1	67.6	15.3	299.3	423
C150-1-5	C-150	150.2	149.8	67.4	15.1	299.1	424
C100-1-3	C-100	101.2	103.7	53.5	14.0	219.0	300
C100-1-4	C-100	101.1	104.9	53.6	13.9	219.4	302
C100-1-5	C-100	101.2	104.9	53.5	13.8	219.8	302
C100-1-6	C-100	101.2	105.7	53.4	14.1	219.1	301
C100-2-2	C-100	101.3	104.2	53.1	14.0	219.3	301
C100-3-2	C-100	101.3	104.6	53.3	14.1	219.2	303

G450 structural steel sheet, having a nominal yield stress at 450 N/mm^2.

The stub columns were identified as "specimen label + segment number". Information related to the specimens and stub columns is listed in Table 1. Specimens C150-1 and C100-1 were cut to 7 and 8 stub columns respectively. A stub column was cut at the mid-lengths of specimens C100-2 and C100-3. Stub columns C150-0-1 and C150-0-2 were from the mid-lengths of the specimen C150-0. Out of the 19 stub columns, 10 were tested in this study. Principal dimensions of the tested stub columns are defined in Fig. 2, and the values are compiled in Table 2. In the table, S and L_0 are the sectional length and longitudinal length, respectively.

The process of cutting a roll-formed steel section to specified length to form a stub column may lead to cross section distortion and initial geometric imperfection [1]. In our previous study [2], a laser transducer was used to measure the geometric imperfections at 13 measurement points (as shown in Fig. 3) along the length of the stub columns. Table 3 summarizes maximum values of the initial geometric imperfections at measurement points 2, 7 and 12 for the 10 stub columns. In the table, L_m is the distance between the two measurements ends and is approximately equal to the length of the stub columns. Measurement points 2 and 12 have the largest initial geometric imperfection at $L_m/200$ to $L_m/350$ from an end.

Material properties of the stub columns were determined by carrying out tensile tests on coupons. Test coupons were prepared from the specimens C150-1 and C100-1. These were divided into four groups and are identified as Flat 1, Flat 2, Corner 1 and Corner 2 (see Fig. 4). Flat coupons