AN EXPERIMENTAL STUDY ON THE BUCKLING STRENGTH OF COLD PRESS-BENT BOX STUB-COLUMN MADE OF SBHS700

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1. INTRODUCTION

The rupture of welded joints under unexpected loading is one of the reasons for bridge failure. Accordingly, the cold-formed structures are proposed as potential solutions. Cold-working may improve the design flexibility and workability, while it could also lead to the loss of ductility and toughness due to the strain aging effects. The design of the inner radius based on the Specifications for Highway Bridges is conservatively 15 times of plate thickness, while exceptional design of 5t is specified for steel materials with lower nitrogen content than 0.006% and higher Charpy absorbed energy than 200J[1)]. The development in steelmaking and increase of toughness has led to the possibility of reducing the inner radius[2)]. Moreover, the load-carrying capacity of cold-formed sections were tested through experimental studies[3)] and FEM analyses[4)]. However, similar research on high performance steel for bridges is rarely found in the literature. SBHS (Steels for Bridge High performance Structure) is remarkable for its high yield strength, toughness and workability, which is considered suitable for cold-working. In fact, cold-formed structures only have few cases of application on bridge piers[5)]. Therefore, the purpose of this study is to investigate the buckling strength of a cold press-bent box stub-column made of SBHS700 in comparison to the welded box-section.

2. METHODS AND DESIGNS

The test specimens can be seen in Fig. 1. The cold press-bent section B11R was designed with an inner radius of 5t, while the welded box-section B11 was designed with the same dimensions as shown in Table 1. The width-to-thickness ratio parameter R_R is calculated by the following equation. Strain gauges and vertical/horizontal displacement transducers were attached on the test specimens to obtain load-displacement relationships, principal stresses, and so on. The compression was applied at a rate of 0.005 mm/s by a universal testing machine.

$$R_R=\frac{b}{t}\sqrt{\frac{\sigma_y}{E}\cdot\frac{12(1-\nu^2)}{\pi^2 k_R}} \tag{1}$$

σ_y: Yield strength (Mill Test Certificate, 830 MPa)
E: Young's modulus (2.00×10^5 N/mm^2)
ν: Poisson's ratio (0.3)
k_R: Buckling coefficient (4.0)

3. RESULTS

The normalized load-displacement relationships of both test specimens are shown in Fig. 2. Both test specimens did not reach the yield load calculated based on the yield strength, while the maximum load of B11R was 13% higher than that of B11. The development of out-of-plane deformation is shown by seven points during the loading in Fig. 3. Differences were found in the buckling behaviors, such that the buckling mode of B11R was close to the shape of a half-sinusoidal wave, while that of B11 was similar to a sinusoidal wave. The out-of-plane deformation of B11R gradually developed before reaching the maximum load, while more sudden out-of-plane deformation was observed for B11 in an elastic manner after reaching the maximum load.

Table 1: Dimensions of the test specimens

	b [mm]	t [mm]	r [mm]	L [mm]	R_R	P_y [kN]	δ_y [mm]
B11R	225	6	30	450	1.22	4080	1.8
B11	225	6	---	450	1.22	4362	1.8

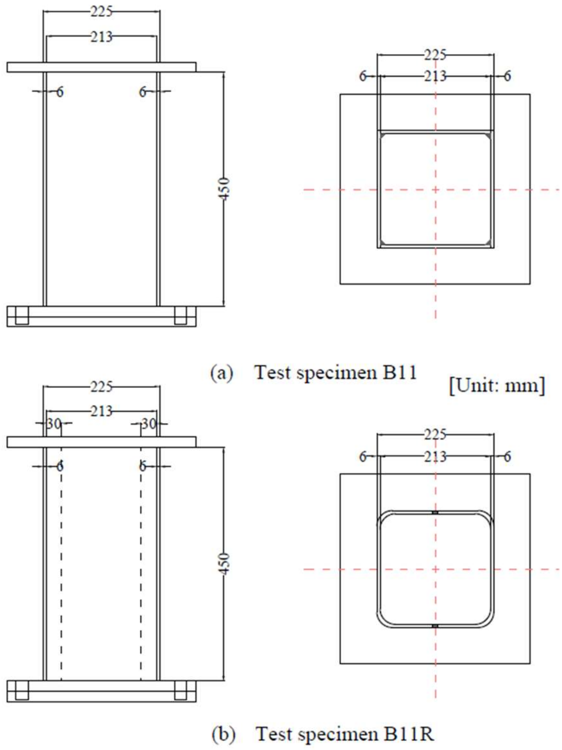

Fig. 1 Test specimens

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Further, the load carrying capacity can be evaluated and compared according to the σ_{cr}/σ_y - R_R relationship as shown in Fig. 4, based on the current design specification[1)] as well as an ultimate strength curve for box-sections by Fukumoto et al[6)]. As can be observed, both test specimens made of SBHS700 reached higher capacity than the current ultimate strength curves in Japan, which indicates the possibility of application. Data of box-sections with smaller R_R (B04 and B07) were obtained in our previous experiments. Comparing to the welded box-sections of smaller R_R, the ultimate strength tends to be lower with a bigger R_R. The difference in the buckling modes could be one reason which led to the higher load-carrying capacity of B11R, yet further investigations should be conducted in detail. Given the above experimental results as well as the previous literature[3)], it can be understood that the current international design codes have the possibility to be conservative for the cold-formed structures. In the future, experimental studies and parametric analyses will be conducted to generate more data, in order to improve the design specifications and widen the applications of high performance steel and cold-formed structures.

4. CONCLUSIONS

The buckling strength of a cold press-bent box-section was tested in comparison to that of the welded box-section made of the high performance steel SBHS700. The former test specimen reached higher strength than the latter one, and both satisfied the current ultimate strength curves. The possibility of evaluating the cold-formed steel structures made of high performance steel SBHS700 using the current design specifications is indicated, and further experimental and analytical studies will be conducted.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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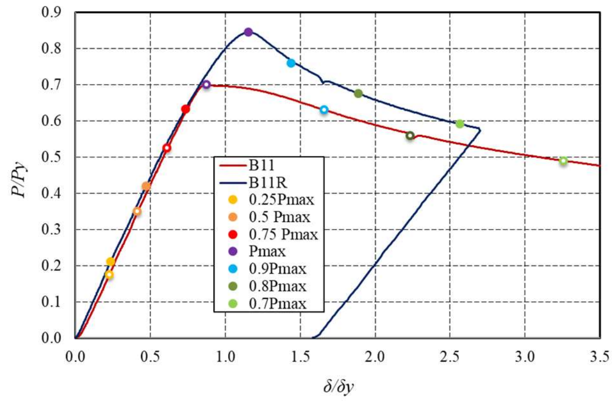
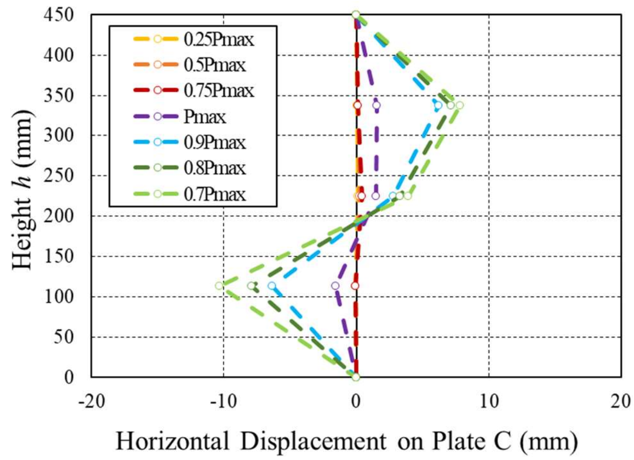
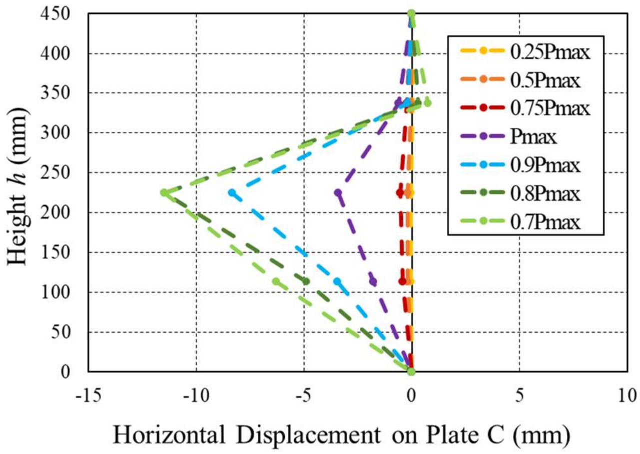


Fig. 2 Normalized load-displacement relationship



(a) B11



(b) B11R

Fig. 3 Comparison of the buckling modes

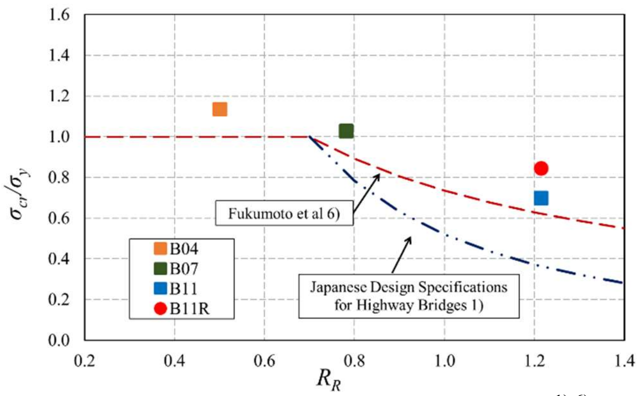


Fig. 4 Comparison with the previous studies[1),6)]