AN EXPERIMENTAL STUDY ON THE EFFECT OF STIFFENERS OF DIFFERENT STRENGTHS ON LOAD-CARRYING CAPACITY AND DUCTILITY OF BOX SECTION STUB COLUMNS

Waseda University	Student Member	○	Jiaping Liu
Public Works Research Institute	Regular Member		Kenta Ono
Waseda University	Regular Member		Kiyoshi Ono

1. INTRODUCTION

In order to improve the seismic performance of existing steel bridges, additional stiffeners are sometimes applied as a seismic retrofitting technique for steel members[1]. This experiment aims to examine the effect of adding stiffeners made of different steel materials on the load-carrying capacity and ductility of box section stub columns. Compression tests were conducted on four stub column specimens, including one without any ribs and the rest three with four L-shaped ribs attached by high-strength bolts. Based on the experimental data, it is expected that the three specimens with additional stiffeners of different strengths can show higher strength and better seismic performance than the one with none.

2. TEST SPECIMENS AND METHODS

Table 1 shows the four test specimens' steel materials, mechanical properties and buckling parameters and **Figure 1** shows their configurations. The main body of the four specimens is made of the same material, SM400A, and they have the same box section stub-column design. The only difference is that three have four ribs with different steel materials while one has no ribs. The one without any ribs is named S_0, and the three with ribs made of SM400A, SUS316, and SBHS700 are named S_1, S_2, and S_3, respectively. Displacement transducers were set around the specimen surfaces to measure the out-of-plane deformation and at four top corners to measure the axial displacement. The compressive axial force was loaded at an increasing rate of 0.5 mm/min using a large-scale structural member universal testing machine.

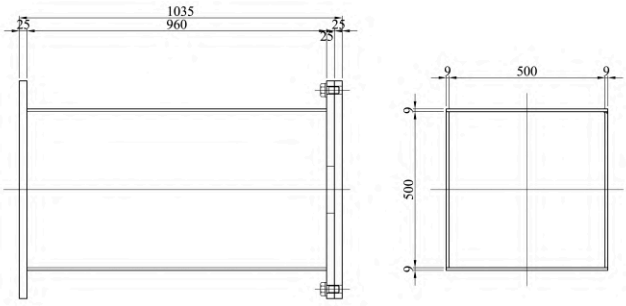
3. RESULTS

Figure 2 shows the comparison of the load-axial displacement curves of the four specimens. It can be observed from the figure that the specimens sustained more compression load with the reinforcement of ribs. The three specimens with ribs reached a higher maximum load P_{max} and showed a larger vertical displacement at P_{max}. Besides, the shape of the P-δ curves is also different. For the specimen without any rib, its steel plates buckled in the elastic range, and a rapid decrease in strength was observed after P_{max}. On the other hand, for the specimens with ribs, when the vertical deformation increases, the decrease in the load-carrying capacity after P_{max} was gradual and sustained at a high level, which signifies that the specimen remains stable under high compressive loads.

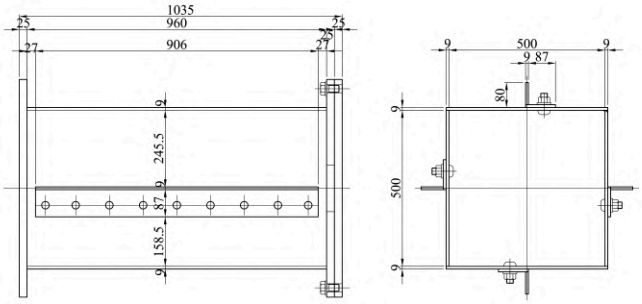
Table 1 The mechanical property of test specimens

Specimen	Matierial of ribs	Yield strength of ribs σ_y (MPa)	Width-to-thickness ratio parameter R_R
S_0	—	—	1.16
S_1	SM400A	314	0.58
S_2	SUS316	249※	0.58
S_3	SBHS700	784	0.58

※ Yield strength of SUS316 is defined as 0.2% proof stress.



(a) S_0 (without ribs) [Unit: mm]



(b) S_1, S_2, S_3 (with ribs) [Unit: mm]

Fig. 1 Configurations of the test specimens

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Contact address : 3-4-1 Okubo, Shinjuku, Tokyo 169-8555, Japan, Tel : +81-3-5286-3387

It is worth noting that among the three specimens reinforced by ribs, specimen S_3 has the highest ductility since it reached the largest P_{max} with the largest axial displacement δ compared with that of S_1 and S_2, which can be clearly seen in **Figure 2**.

In order to investigate the reason behind this, the plate with the largest out-of-plane deformation was selected for each specimen to show the progression of out-of-plane deformation of the four specimens, which is shown in **Figure 3**. The four specimens showed two different kinds of buckling modes. Out-of-plane deformation with one sine wave shape can be observed on the plates of S_0, while out-of-plane deformation with a half-sine wave shape can be observed on the plates of S_1, S_2, and S_3. This leads to the assumption that the L-shaped ribs attached prevent the plates from deforming toward the center. The difference can also be found in the magnitude of deformation. Significant out-of-plane deformation occurred on the four plates of S_0. However, only one plate or two plates of S_1, S_2, and S_3 showed obvious out-of-plane deformation. From S_2 to S_1 to S_3, as the yield strength of their ribs increases, the degree of deformation they exhibit decreases. This is probably the reason why S_3 reinforced by ribs made of SBHS700 showed the highest load-carrying capacity and the highest ductility among the three specimens.

In addition, ribs attached at the centerline of each plate led to the width-to-thickness ratio parameter R_R becoming half of that of S_0 as shown in **Table 1**, and the decreased width-to-thickness ratio caused an increase in load-carrying capacity.

4. CONCLUSIONS

This experiment investigated the effect of applying stiffening ribs to a box section stub column through axial compression tests. The specimen with stiffeners showed higher load-carrying capacity and higher ductility than the specimen without any stiffeners. Further experimental and analytical studies will be conducted on the strength of more specimens with different dimensions.

REFERENCES

[1] MATSUMURA, M., KODA, S. and Ono, K.: Compression Tests on Buckling Prevention Effects of Steel Plate Panels with Stiffeners Bolted. *Steel Construction Engineering*, Vol.21, No.84. (2014)

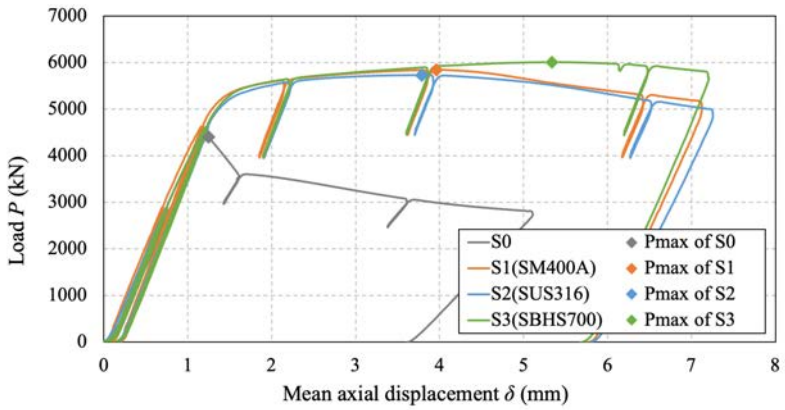
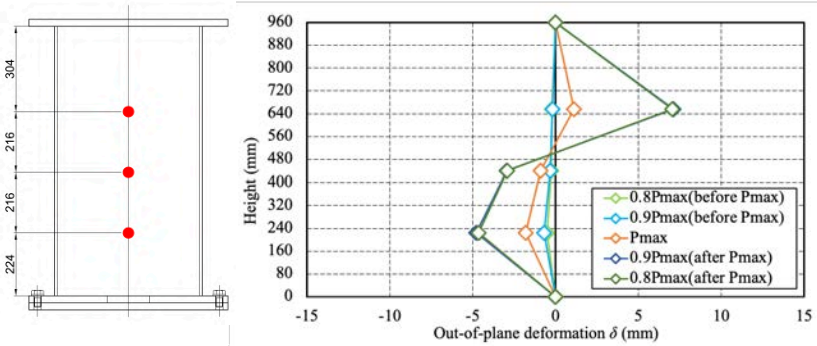
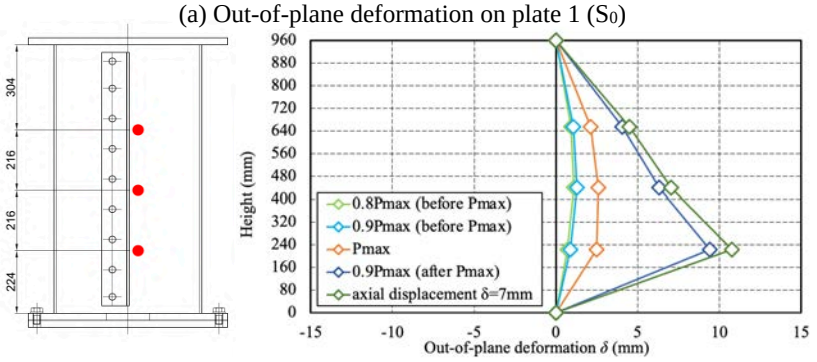


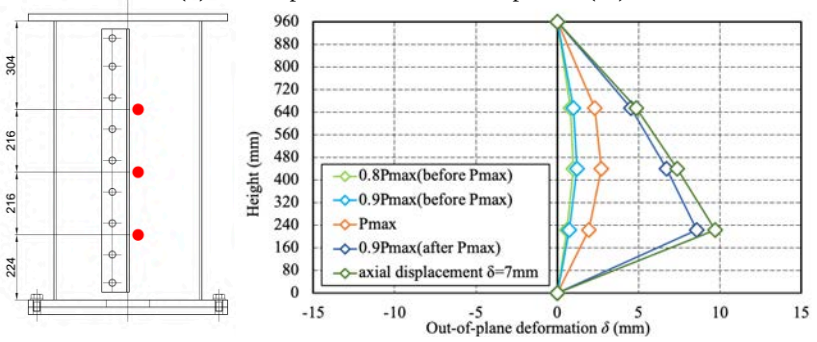
Fig. 2 Comparison of P-δ curves



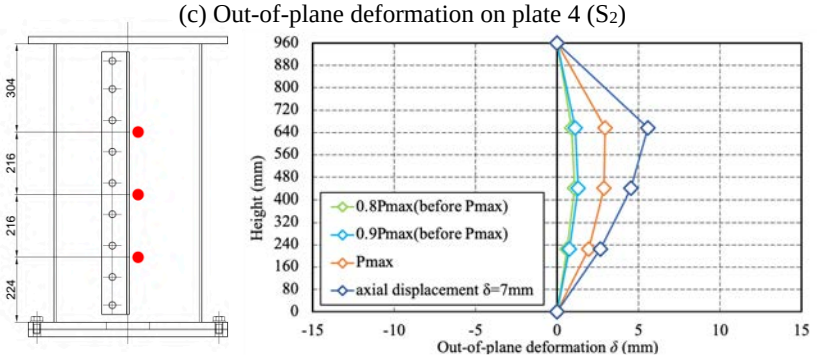
(a) Out-of-plane deformation on plate 1 (S_0)



(b) Out-of-plane deformation on plate 4 (S_1)



(c) Out-of-plane deformation on plate 4 (S_2)



(d) Out-of-plane deformation on plate 1 (S_3)

Fig. 3 Comparison of out-of-plane deformation