RESIDUAL STRESSES OF BOX-SECTION STUB-COLUMNS MADE OF SBHS700

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1. INTRODUCTION

In the Kobe Earthquake, 1995, two rectangular-section steel bridge piers collapsed due to the rupture of the welded corners. To solve this problem, cold-formed structures are considered as a potential solution. However, due to the strain aging effects, the cold-forming method also brings disadvantages such as the loss of ductility and toughness. SBHS (Steels for Bridge High-performance Structure), which has high yield strength, toughness, and workability, is considered as the good material for cold working. Although extensive research has been conducted on the cold-formed structures, there is still a lack of data regarding the residual stresses for SBHS. Residual stress plays a significant role in the steel structure design that is used to determine the steel columns' behavior and strength because it affects the load-carrying capacity of the structures. Therefore, the objective of this study is to investigate the residual stresses of box-section stub-columns made of SBHS700.

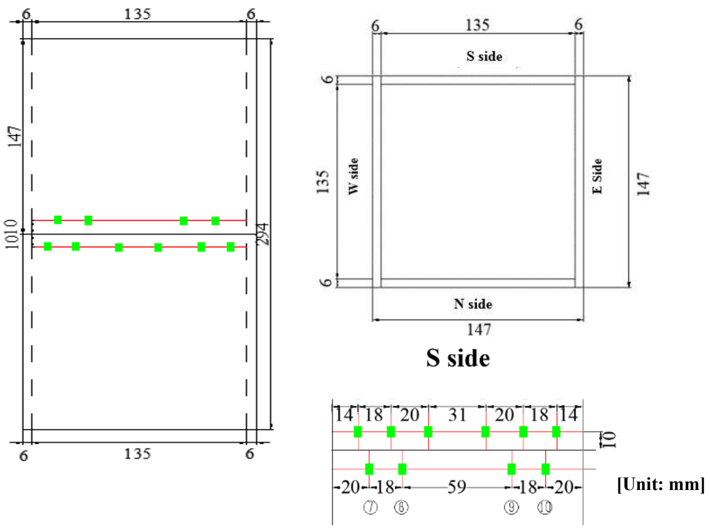

Fig 1. Cross-section and strain gauge distribution of welded box-section

2. TEST SPECIMENS

There are two types of test specimens. One is the welded stub-column and the other is the cold-formed stub-column. The welded specimen was manufactured by welding four flat plates at the corners as shown in **Fig 1**. The cold-formed specimen was manufactured by welding two cold-formed plates as shown in **Fig 2**. The yield strength(σ_y) of the two specimens is 828 MPa according to the Mill Test Certificate.

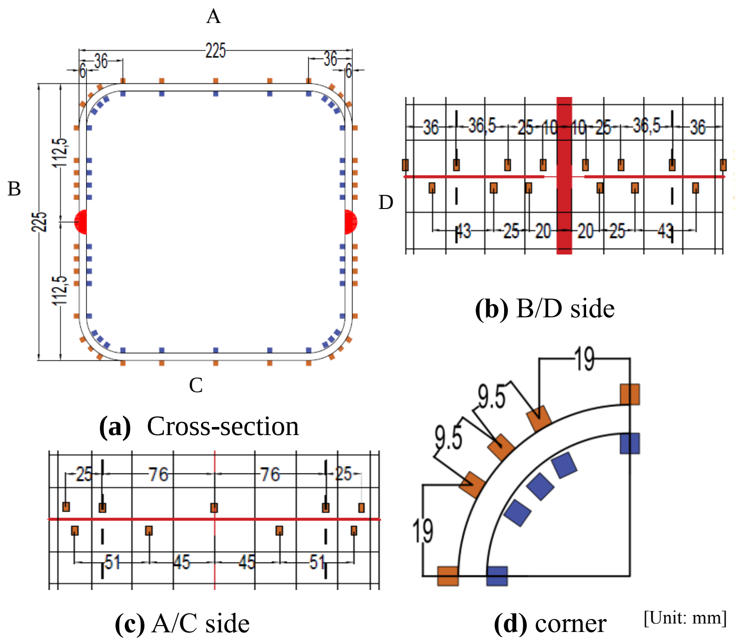

Fig 2. Cross-section and strain gauge distribution of cold-formed box-section

3. EXPERIMENT METHOD

As shown in **Fig 1** and **Fig 2**, the strain gauges were attached to both surfaces at the same location. For the cold-formed box-section, strain gauges were attached especially at the corners and the regions near the welding to observe the distribution of residual stresses correspondingly. The initial strains (ε_0) was first measured after the strain gauge was attached. Then the specimens were cut at the mid-height and the saw-cutting method was conducted to release the residual stresses. The saw-cutting method[2)] describes the process of cutting the strain gauge section by a handsaw, and checking the change in the strains until the values converge. The strains after the saw-cutting method were recorded as (ε). Based on the measured strains, the residual stresses (σ_r) can be determined with **Equation (1).**

$$\sigma_r = -E\Delta\varepsilon = -E(\varepsilon - \varepsilon_0) \qquad \textbf{(1)}$$

4. RESULTS AND DISCUSSIONS

4.1 *Results*

4.1.1 *Welded box-section*

As for the welded box-section, the distribution of the residual stresses is shown in **Fig 3**. The residual stresses on the outside and inside surfaces do not have a significant difference as compared with **Fig.5**. The residual stresses near the welding were around 350 MPa. Except the regions near the welding, the residual stresses were around -80 MPa.

Keywords: Residual stress, SBHS700,Welded section, Cold-formed box-section

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In comparison to the yield strength σ_y, the average normalized residual stresses of the welded box-section near the welding were around $0.3\sigma_y$ and except the regions near the welding, the residual stresses were around $-0.1\sigma_y$ as shown in **Fig 4**. However, it is assumed that the average residual stresses closer to the regions near the welding may be larger than $0.3\sigma_y$.

4.1.2 *Cold-formed box-section*

The residual stress distribution of the cold-formed box-section is shown in **Fig 5**. In the regions around the corner, there was a significant difference in the residual stress distribution between the inside and outside surface, which was around 200 MPa outside and -300 MPa inside. Regarding the average residual stress, there was no significant change in the regions except the regions near the welding. As for the regions near the welding, the average residual stresses were up to 400 MPa.

The normalized residual stresses near the corner were $0.25\sigma_y$ on the outside surface and $-0.4\sigma_y$ on the inside surface. The normalized residual stresses were around $0.4\sigma_y$ near the welding regions. As for the rest of the cross-section, the normalized residual stresses were around $-0.1\sigma_y$. The average normalized residual stresses were around $0.4\sigma_y$ near the welding regions and $-0.1\sigma_y$ on the rest of the cross-section including the corner regions, which is shown in **Fig 6.** Also, it is assumed that the average residual stress may continue to increase and exceed $0.4\sigma_y$ as it approaches the welding regions.

4.2 Discussion

The average residual stresses around the bending corner regions of the cold-formed sections have a negligible fluctuation, but the residual stress on each surface was highly influenced by the bending. After bending, the inside was subject to compressive strain and the outside subject to tensile strain. This leads to the uneven distribution of inside and outside residual stresses. The effect caused by the difference in outside and inside residual stresses on the bending corner regions will be investigated in the future studies.

As for the average normalized residual stresses distribution in the compression, the two specimens do not have a significant difference.

5. CONCLUSIONS

From this study, the following conclusions can be made. Large tensile residual stresses exist near the welding region. According to the bending corner region, compressive and tensile residual stresses exist on the inside and outside surface. As for the regions except the regions near the welding, the average normalized residual stresses in the compression for the two specimens were around $-0.1\sigma_y$.

ACKNOWLEDGMENTS

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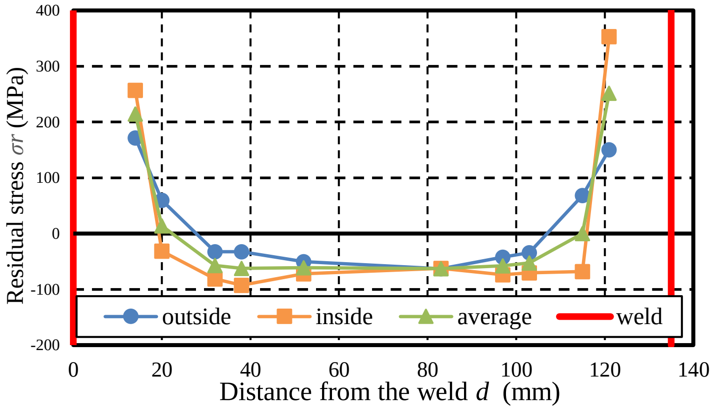

Fig3. Residual stress distribution of the welded box-section

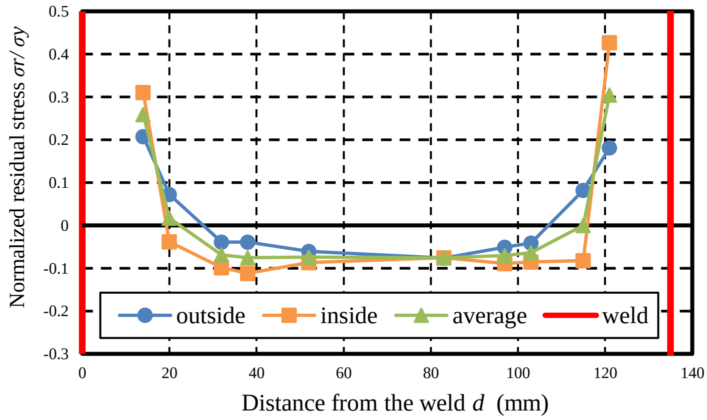

Fig 4. Normalized residual stress distribution of the welded box-section

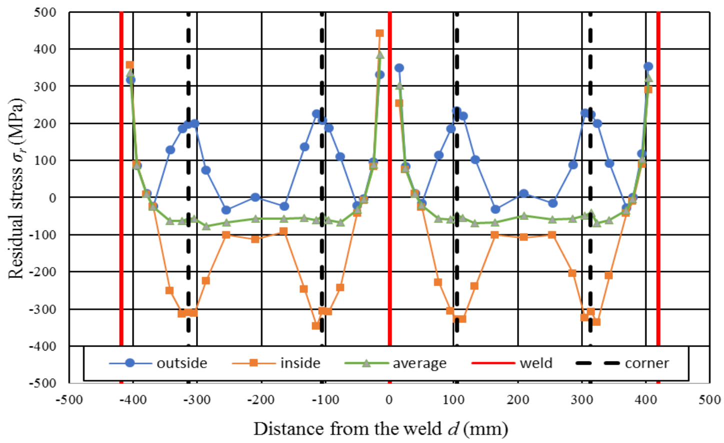

Fig 5. Residual stress distribution of the cold-formed box-section

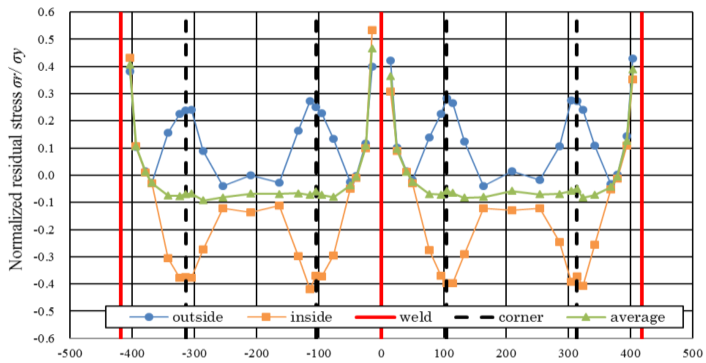

Fig 6. Normalized residual stress distribution of the cold-formed box-section