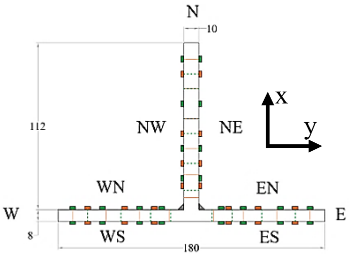
RESIDUAL STRESSES IN T SECTION AND ANGLE SECTION MADE FROM STAINLES STEEL

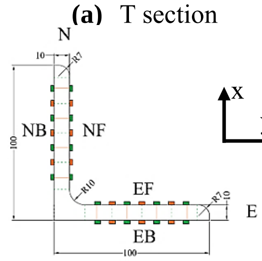
Waseda University	Student Member	○Shranay Sthapit
Waseda University	Student Member	Atsushi Matsuo
Waseda University	Regular Member	Kiyoshi Ono
Public Works Research Institute	Regular Member	Atsushi Shibuya
Japanese Society of Steel Construction	Regular Member	Yasumi Shimura
Japan Bridge Association Inc.	Regular Member	Yusuke Kobayashi

1. INTRODUCTION

Corrosion damage has become an increasingly important consideration in the design of steel bridge members, such as sway bracings and lateral bracings. Stainless steel can be applied to these bridge members due to its corrosion resistance, and can significantly reduce maintenance costs. However, it is essential to investigate its material properties. Specifically, residual stresses induced from the manufacturing process are known to deteriorate load carrying capacity. Although extensive research has been conducted on the residual stresses for conventional steel[1), 2)], there is still a lack of data regarding the residual stresses for stainless steel. Therefore, the purpose of this study is to obtain data on the residual stress distributions of T section and angle section made from stainless steel. This study focuses on austenitic stainless steel SUS316.



(a) T section



[units: mm]

(b) Angle section

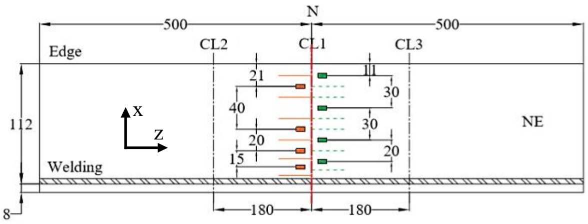
Figure 1 Cross section of test specimens

2. TEST SPECIMENS

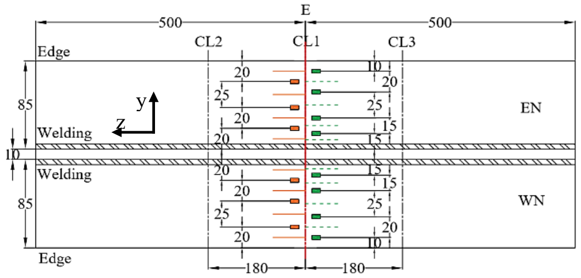
The test specimens consist of a T section fabricated by welding two plates, and a hot-rolled angle section. Tensile tests were conducted to obtain the mechanical properties of each plate and section. Three tensile test coupons were obtained for each plate and section, and the average values of the Young's modulus, yield strength, and tensile strength were calculated for each plate, as shown in **Table 1**. The yield strength (σ_y) was calculated by the 0.2% offset method ($\sigma_{0.2}$). The cross-sectional layout for each specimen is shown in **Figure 1**. In order to obtain accurate data on the residual stress distributions, the test specimens were prepared with sufficient length of 1 meter, as shown in the longitudinal layouts of **Figure 2**.

Table 1 Mechanical property of test specimens

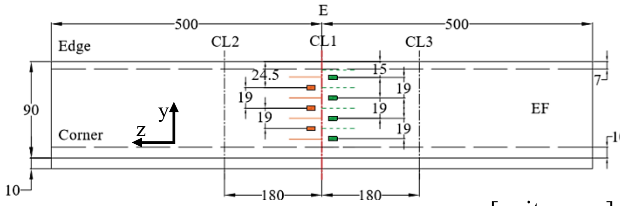
Steel type	Section	Plate Position	Young's modulus E (GPa)	Yield strength $\sigma_{0.2}$ (MPa)	Tensile strength σ_u (MPa)
SUS316	T section	N	193	292	632
		W	189	269	591
		E			
	Angle section	N	194	260	575
		E			



(a) T section NE surface



(b) T section EN and WN surfaces



[units: mm]

(c) Angle section EF surface

Figure 2 Strain gauge layouts

3. EXPERIMENTAL METHOD

As shown in **Figure 1** and **Figure 2**, strain gauges were attached to both surfaces at the same location for each plate, and initial strains (ε_0) were measured. As shown in **Figure 2** by "CL 1", the test specimens were cut at a sufficient distance of 500 mm from the ends of the test specimen to ensure the residual stress distribution are not affected by the ends. For the ease of sectioning, the test specimens were

Keywords: Residual stress, Stainless-steel, SUS316, T section, Angle section

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

then cut 180 mm from the center, as shown in **Figure 2** by “CL2” and “CL3”. The strains were recorded to monitor the change in the residual stresses. The saw-cutting method was used near the strain gauges (the dotted and dark lines of **Figure 2**) to release the residual stresses. The sections were first cut by 20 mm, and then an additional 10 mm. The total length of the cut was 30 mm. The strains were measured twice during each point in order to ensure no sudden changes occurred in the residual stresses, and to confirm that the residual stresses were fully released. Once the final strains (ε) were measured, **Eq. 1** was used to calculate the residual stress at each strain gauge.

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

4. RESULTS AND DISCUSSION

The residual stress distributions obtained for the T section and angle section are summarized in **Figure 3** and **Figure 4**, respectively. The figures show the normalized residual stresses (σ_r/σ_y) on each surface and its average value. Positive values correspond to tensile residual stress, and negative values correspond to compressive residual stress. For the T section’s north plate, the value for the average residual stress is 0.2σ_y near the edge, -0.5σ_y near the center, and 0.8σ_y near the welds. In comparison, the T section’s east and west plates exhibit smaller magnitudes of residual stress, with approximately -0.1σ_y near the edges and 0.2σ_y near the welds. Furthermore, larger discrepancy was found between the residual stresses on each surface for the T section’s east and west plate. For the angle section’s north plate and east plate, the magnitudes of the average residual stresses were considerably smaller, ranging from -0.1σ_y to 0.1σ_y. Compressive residual stress was found at the plate’s edge, and tensile residual stress was found near the plate’s center. Near the corner of the plate, the residual stress was tensile for the north plate and compressive for the east plate. However, the overall patterns of the residual stress distribution for both sections are in good agreement with the distributions investigated in previous studies[1), 2)].

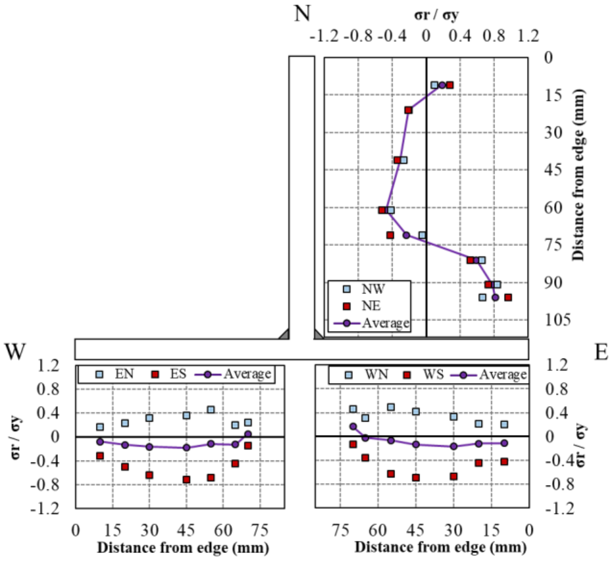


Figure 3 Residual stress distributions for T section

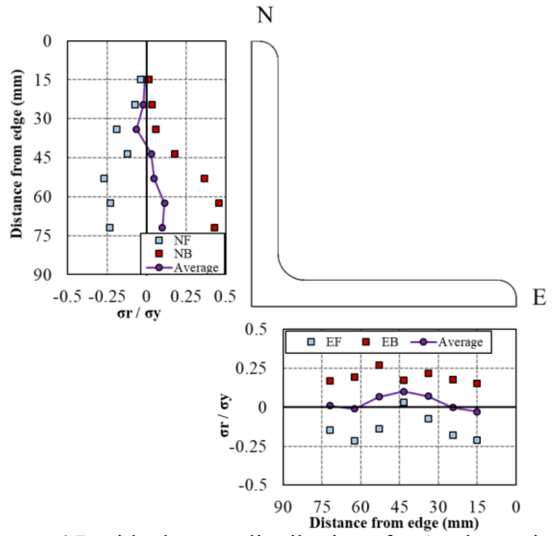


Figure 4 Residual stress distributions for Angle section

5. CONCLUSIONS

The following conclusions can be made from this study:

- The residual stress distribution for the T section and angle section made from stainless steel are consistent with the residual stress distributions for conventional steel.
- The magnitude of the residual stresses in the T section’s north plate were considerably larger than in the T section’s east and west plate or the angle section.

For the angle section, although the overall patterns of the residual stress distributions follow the distributions investigated in previous studies, the residual stresses for each individual point on the surfaces are scattered, and its distributions are not the same for the north and east directions. Therefore, this suggests that further investigations need to be carried out in order to confirm the accuracy of the results.

ACKNOWLEDGEMENTS

This investigation is a part of a collaborative research with the Public Works Research Institute, Japanese Society of Steel Construction, and Japan Bridge Association Inc. The authors wish to express their sincerest gratitude to all participants in the collaborative research program.

REFERENCES

1) Masubuchi, K. (1980). *Analysis of Welded Structures: Residual Stress, Distortion, and their Consequences*, Pergamon Press Ltd, London.
2) European Convention for Constructional Steelworks (ECCS). (1976). *Manual on stability of steel structures, Part 3.1.5 angles,* 2nd Ed., ECCS, Brussels, Belgium.