EVALUATION OF LOW CYCLE FATIGUE STRENGTH OF CORNER WELDED JOINTS BASED ON EFFECTIVE NOTCH STRAIN

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1. INTRODUCTION

In the previous studies[1] which investigated the low cycle behavior of concrete-filled steel piers with box section, fatigue cracks were observed at corner welds of the piers as shown in Fig. 1, which were initiated from weld root tips by cyclic out-of-plane bending deformation of flange and web plates.

In this study, in order to develop the low cycle fatigue assessment method for corner welded joints simulating a connection between flange and web plates as shown in Fig.2, fatigue test were performed under large cyclic bending deformations. Based on the results, the low cycle fatigue strengths of the joints were evaluated by using effective notch strain approach.

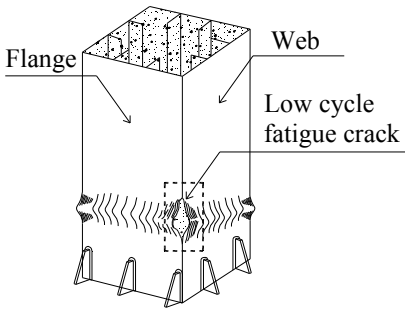


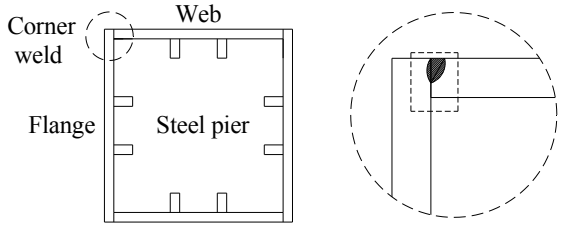
Fig. 1 Low cycle fatigue crack at the corner welded joints

2. LOW CYCLE FATIGUE TESTS

Fig. 3 shows the configuration and dimension of the specimens. Three types of specimens were used in the tests, which have different sizes of weld root face, as shown in Table 1. Fig. 4 shows the test setup. Loading devices were attached to both the upper and lower side of specimen. Cyclic bending deformations can be applied to the specimen by moving the devices up and down. The constant displacement ranges of 12~18mm were applied to the specimen. According to the size of the weld root face (0mm, 4mm and 8mm in design) and the displacement range (12mm, 15mm and 18mm), the specimen are named. For example, C4-12 represents 4mm in the weld root size and 12mm of the displacement range, respectively.

3. EXPERIMENTAL RESULTS

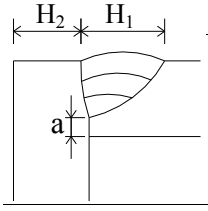
Fig. 5 shows the crack initiation and propagation behavior observed at the side surface of the specimen C8-12. A small crack was first detected at the weld root tip, and the crack gradually propagated to the thickness direction with the loading repetitions.



(a) Cross section of steel pier (b) Corner weld

Fig. 2 Typical welding type of corner welded joints

Table 1. Average values of weld profiles (unit: mm)



Specimen	a	H_1	H_2
C0	1.10	20.0	14.0
C4	4.75	17.5	14.0
C8	8.00	11.5	15.0

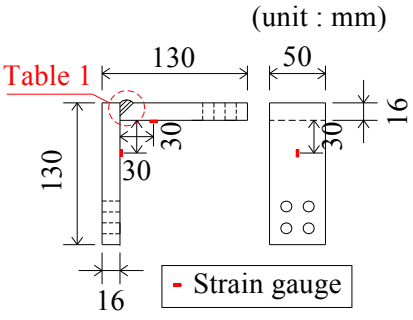


Fig. 3 Dimension of specimen

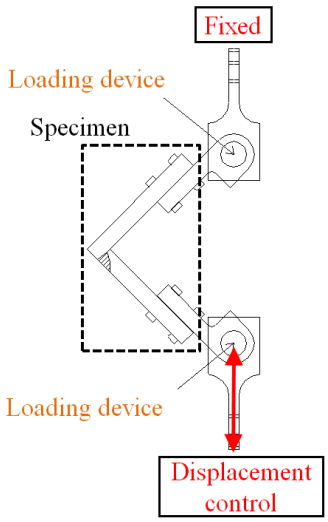


Fig. 4 Test setup

Keywords: corner welded joints, low cycle fatigue strength, effective notch strain

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The test results are in Fig. 6, which shows the relationships between the displacement range applied to the specimen and the fatigue life. The fatigue life is the number of cycles when the maximum load drops by 20% because the maximum load tends to decrease rapidly after approximately a 20% load drop. The specimens with enough weld penetration have significantly longer fatigue life than others. Therefore, it is indicated that the low cycle fatigue strength of the corner welded joints strongly depends on the size of the weld root face.

4. FINITE ELEMENT MODELING

Elasto-plastic finite element analyses were conducted by using ABAQUS program under the same condition of the experiment to investigate strain distributions around a weld root tip in the specimen. Fig. 7 shows an example of the analysis model and its boundary conditions. Two-dimensional analyses under the plane strain assumption were performed. The effective notch with a radius of 1.0mm was adopted at the weld root tip, as shown in Fig. 7. The base metal, the deposit metal (DM) and the heat affected zone (HAZ) were modeled individually. In case of base metal, the yield strength, Young's modulus and Poisson's ratio are 429N/mm^2, 2.0×10^{5}N/mm^2 and 0.3, respectively. The DM and HAZ are assumed to have 20% higher yielding strength than the base metal.

5. FATIGUE ASSESSMENTS BY EFFECTIVE NOTCH STRAIN

The effective notch strain ranges were calculated along the effective notch and their maximum value was used for arranging the results. Fig. 8 shows the relationship between the effective notch strain range and the fatigue life, in which the effective notch strain based fatigue strength curve for load-carrying cruciform welded joints[2)] is also shown with a solid curve.

Regardless of the size of the weld root face, all test results distribute in the same region when arranging with the effective notch strain. Furthermore, the results locate around the curve for load-carrying cruciform joints, meaning that a unique relationship can be obtained regardless of the weld root size and joint configurations. Therefore, it is concluded that the low cycle fatigue strength of corner welded joints can be evaluated by using the effective notch strain range with the unique fatigue strength curve.

6. CONCLUSIONS

This study investigated the fatigue strength evaluation method for the corner welded joint in low cycle fatigue region. The results revealed that the effective notch strain is applicable to evaluate the low cycle fatigue strength of the corner welded joints.

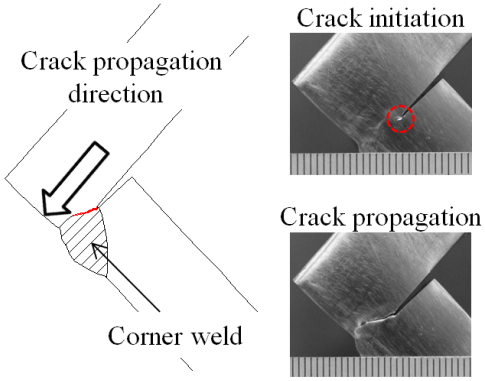

Fig. 5 Crack behavior (C8-12 specimen)

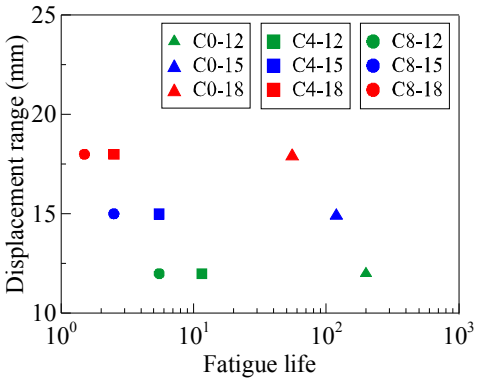

Fig. 6 Test results

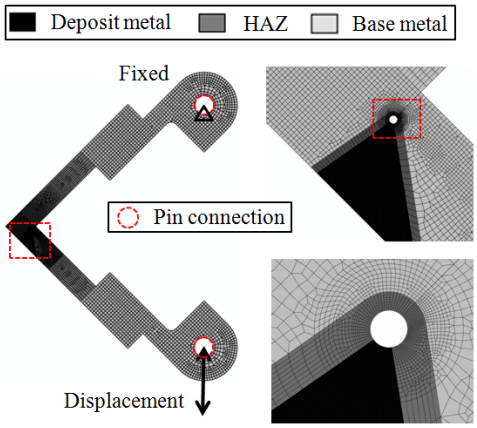

Fig. 7 Analysis model (C4 series specimen)

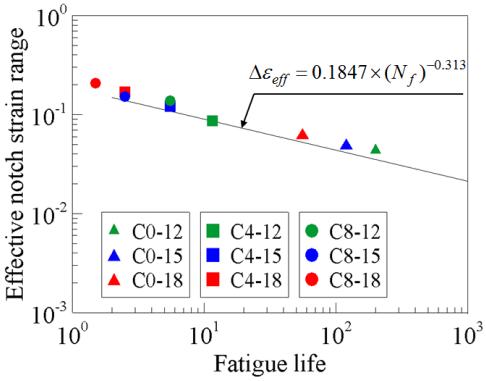

Fig. 8 Low cycle fatigue assessment by effective notch strain

ACKNOWLEDGMENT The authors gratefully acknowledge the support from the Grant-in-Aid for Young Scientists (B) (22760339), and would like to express their sincere gratitude to NIPPON SHARYO, Ltd.

REFERENCE 1) Park et al. (2013), *Proc.of JSSC*, 21, pp.802-808. 2) Saiprasertkit et al. (2012), *Int J Fatigue*, 40, pp.120-128