Recreation of Root Cracks in Transverse Welds Between Sole Plate and Bottom Flange

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Abstract
Both of toe cracks and root cracks are developed in fillet welds between sole plate and bottom flange of steel girders. Since root cracks were initiated inside fillet welds, those discovery were difficult. When root cracks appear on the weld bead surface, they can be long inside. These cracks are so dangerous that can penetrate weld bead and finally break out bottom flange. This is why, their early detection is required. The main cause of these cracks is compressive stress by lack of rotation of bearing. The purpose of the study is to reproduce root cracks in transverse welds between sole plate and bottom flange of steel girders using small specimens with a gap between sole plate and bottom flange. Static loading test were conducted to grasp the stress distributions and decide loading position. Fatigue tests were conducted on two specimens. The first specimen was loaded near the center of the sole plate. Its loading position was decided from result of static loading test. The second one was loaded on the edge of sole plate to produce situation which is deterioration of movability of bearing. As a result, root cracks can be recreated on the bead of the fillet welds between sole plate and bottom flange of steel girders by loading on edge of sole plate. In the future, we can try to detect root cracks by some non destructive testing.

Keywords: Root crack, fillet weld, fatigue test

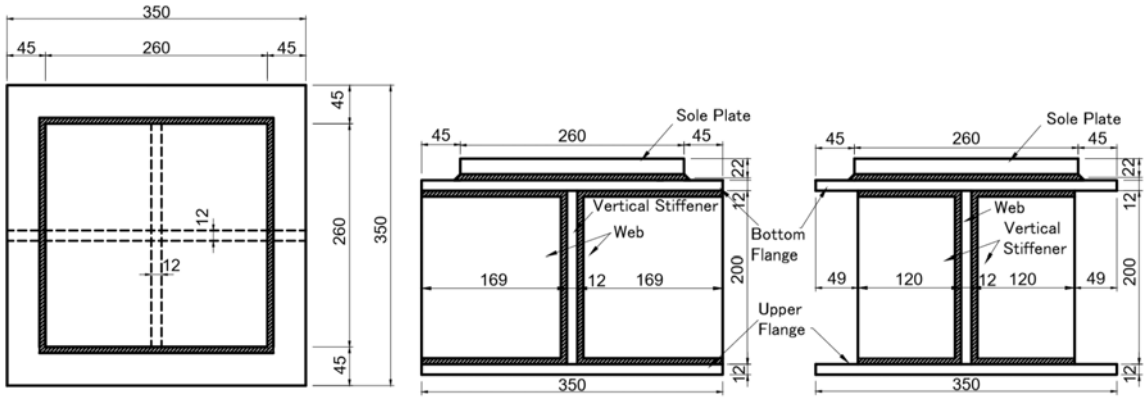
1. Introduction

Both of toe cracks and root cracks are developed in fillet welds between sole plate and bottom flange of steel girders. Since root cracks were initiated inside fillet welds, those discovery were difficult. When root cracks appear on the weld bead surface, they can be long inside. These cracks are so dangerous that can penetrate weld bead and finally break out bottom flange. This is why, their early detection is required. The main cause of these cracks is compressive stress by lack of rotation of bearing. The purpose of the study is to reproduce root cracks in transverse welds between sole plate and bottom flange of steel girders using small specimens with a gap between sole plate and bottom flange.

2. Experimental Procedures

2.1. Specimen
Fig.1 shows configuration and dimensions of the specimens. The specimens were turned upside down. The specimens are smaller than those used in previous study (Okuyama and Sakano, 2017). The specimens are made of SM400A and welded with 3mm gap between sole plate and bottom flange. Two specimens were prepared.

2.2. Location of strain gages
Fig.2 shows the location of strain gages and loading positions. Uniaxial 5mm long strain gages were pasted on the bead surface to monitor initiation and propagation of crack. Uniaxial 3mm long strain gages were pasted on the web surface 5mm below the weld toe.



(1)Plan (2)Elevation (3)Cross section

Fig1. Configurations and Dimensions of Specimens

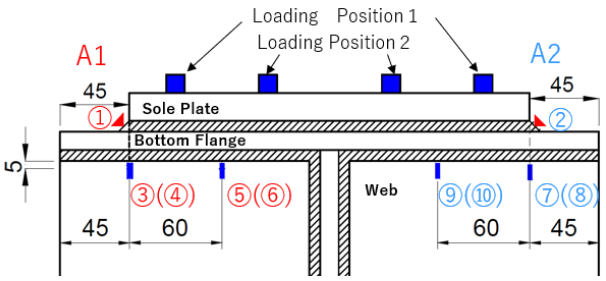


Fig.2 Location of Strain Gages and Loading Positions

2.3. Fatigue Test Procedures

The specimen was loaded using steel bars (12mm square, 50mm long). Loading position of the first specimen were decided based on static load test result.

3. Experimental Results

3.1. Static loading test results

Fig.3 shows the relationship between strain change and distance from fillet weld. Strain of gages No.1 and 2 increased drastically from 0mm to 20mm, increased gently from 20mm to 90mm, and hardly change after 90mm. The longer distance between loading position and edge of sole plate, the less than strain of gages No.3, 4, 7 and 8. Fatigue tests were conducted at loading position1 and loading position2. When loading position1, strain of gages No.1 and 2 was large and strain of gages No.3, 4, 7 and 8 is large. When loading position2, strain of gages No.3, 4, 7 and 8 is decrease but strain of gage No.1 and 2 turned maximum.

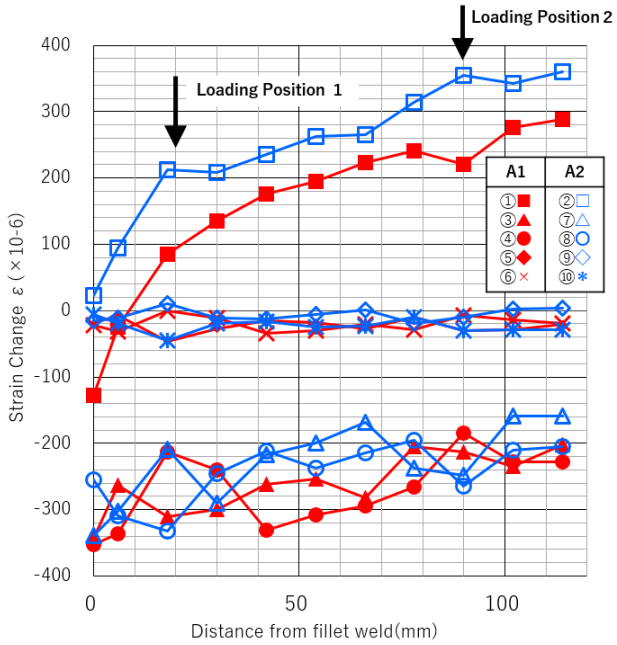


Fig.3 Relationship between Strain Change and Loading Position

3.2. Fatigue test results

Fig.4 shows the relationship between strain change and the number of loading cycles. There is almost no change from N=0 to N=1Mcycles when loading position1 and ΔP =100kN. Then, strain changes very little after N=2Mcycles, when loading position2 and ΔP =100kN.

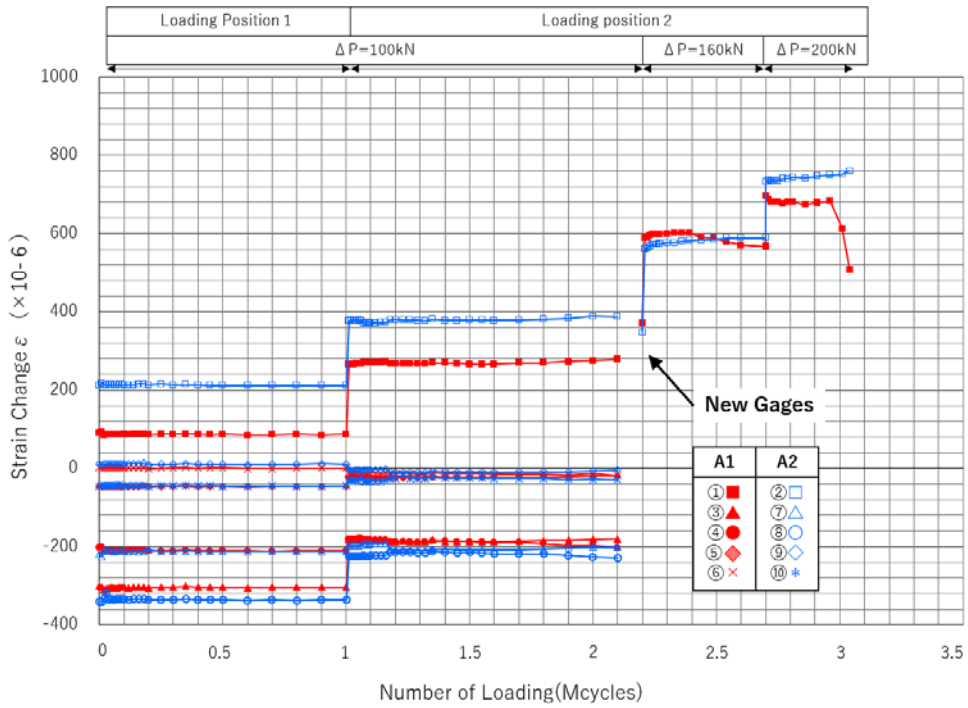


Fig.4 Relationship between Strain Change and the Number of Loading Cycles

Then, strain changes after N=2.5Mcycles when loading position2 and ΔP=160kN. Finally, strain of gage No.1 changes drastically after N=3Mcycles loading when loading position2 and ΔP=200kN. Photo.1 and 2 shows detected crack. The crack appeared bead surface is estimated that it initiated root and penetrated bead surface.

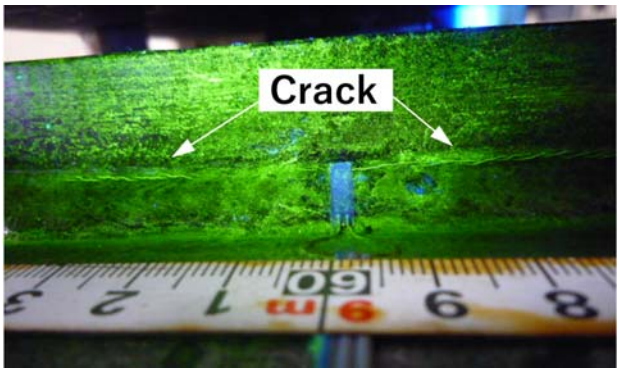


Photo.1 Detected Fatigue Cracks (A1, N=3.04Mcycles)

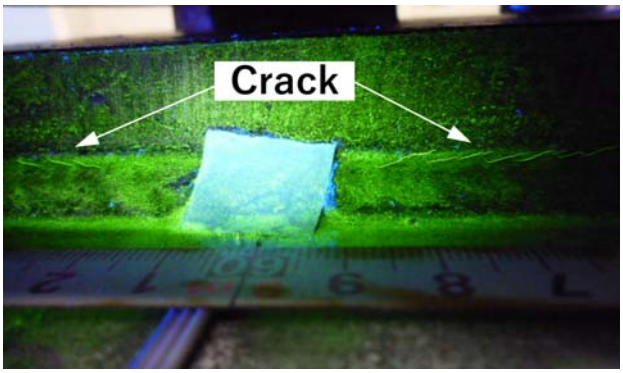


Photo.2 Detected Fatigue Crack (A2, N=3.04Mcycles)

4. Summary

As a result, root cracks can be recreated on the bead of the fillet welds between sole plate and bottom flange of steel girders using smaller specimens. In the future, we will try to detect root cracks by some non destructive tests.

5. References

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Okuyama, R., Sakano, M. (2017), "Recreation of fatigue cracks at the upper end of vertical stiffeners and in transverse welds between sole plate and bottom flange" 15th Symposium Strength Design and Safety Evaluation of Machine and Structures, pp. 9-12, The Society of Materials Science, Japan (in Japanese)