A Measurement on the Crack Opening Displacement at the Fillet Welded Joint subjected to Out-of-Plane Bending Moment

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1. Introduction

Most fatigue cracks usually occur at the welded joint, thus lowering the fatigue strength and the fatigue life of a welded structure. Therefore, it is necessary to determine the fatigue strength and the residual life of the welded joint with fatigue cracks through proper fatigue assessment. Linear Elastic Fracture Mechanics (LEFM) is well established for the fatigue evaluation of the welded joint, especially, at which fatigue cracks are present. In LEFM, the Stress Intensity Factor (SIF) is regarded as one of significant factors to lead the fatigue crack propagation. The SIF can also be expressed as the function of the Crack Opening Displacement (COD). With this respect, this study focuses on measuring straightly the value of COD at the cracked welded joint, thus examining the quantitative correlation between the values of COD and crack geometries giving effect on fatigue crack propagation.

2. Methodology

Fig.1 shows the clip gage to measure the COD at the cracked welded joint in a structural member. Two knife-edged tips are attached to each leg of clip gage to fix tightly its legs into two notches on steel plate. Fig.2 shows the installment of clip gage on the fillet welded joint of the specimen modeling a vertical stiffener subjected to out-of-plane bending moment. First, a part of weld bead is ground after the fatigue crack elongated enough to the required length for measurement. Second, two notches are made transversely in the middle of cracked-line, thus the clip gage being placed on. After that, the rubber band and the magnet settled the clip gage because they avoid the clip gage's legs being dislocated from the notches by rotation deflection. To reduce the error caused by the clip gage twist, a saddle piece is put on its head and a wire is used. In addition, a load cell and a dial gage are placed to measure the load, P, and the displacement, δ, for monitoring the change of the specimen's stiffness, K, along with crack propagation progress. Finally, a jack-up device is utilized for generating some static loads on the specimen.

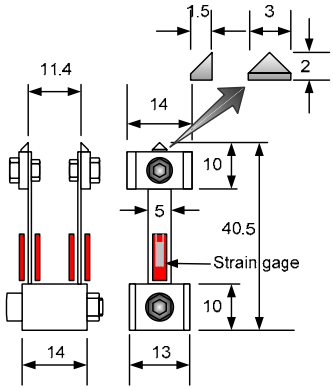

Fig.1 Spec. of clip gage

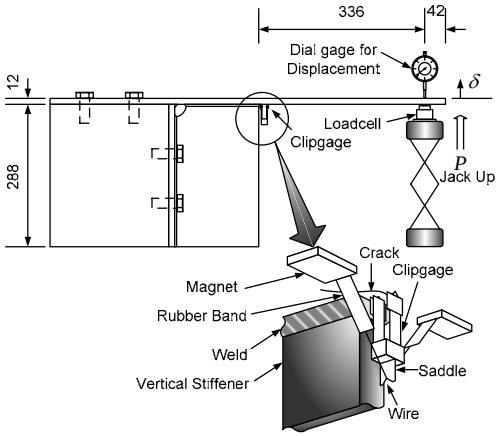

Fig.2 COD measurement

3. Fatigue test and Crack propagation

In this study, a new fatigue test machine was used for demonstrating the out-of-plane flexural behavior of structure details; steel deck plate and vertical stiffener as shown in Fig.3. The centrifugal force produced by the adjustment of two wings of the vibrator inside turns into the bending moment to induce some fatigue cracks at the welded joint. Fig.4 shows the crack propagation progress on the fractured section. At the early phase, the crack initiated at the weld toe and then propagated along with the edge line of weld bead. Subsequently, it branched toward both sides and enlarged combining with the other several small cracks. After that, it elongated straightly to both sides and propagated curvedly to the thickness direction at the same time. In this overall regard, the growth phase is to

break it down into Ntoe, Nb, N10 (2b 40mm), N20 (2b 60mm), N30 (2b 80mm) and Nf, which can be organized by the crack propagation progress that has those crack lengths. The Ntoe stands for the crack initiation at the weld toe and Nb for the branched crack and Nf is penetration.

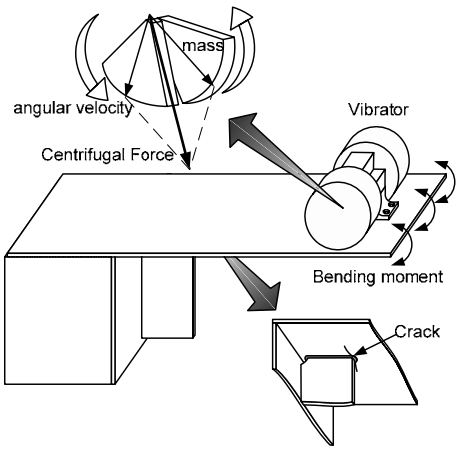

Fig.3 Fatigue test machine

4. Results

Fig.6 gives the quantitative correlation between the values of COD and the mean stress as the result of the measurement on the as-welded joint. The mean stress was calculated from the data recorded in the strain gages, G1 and G3, as shown in Fig.5. As can be seen, the COD values were quite linear. The crack growth rate tended to increase until N20, because the COD values of N20 were quite as large as compared to those of N10. After N20, the crack penetrated with less propagation. Fig.7 shows that the COD has steadily increased corresponding to crack length (2b) when the mean stress has 20 and 40MPa respectively in several specimens.

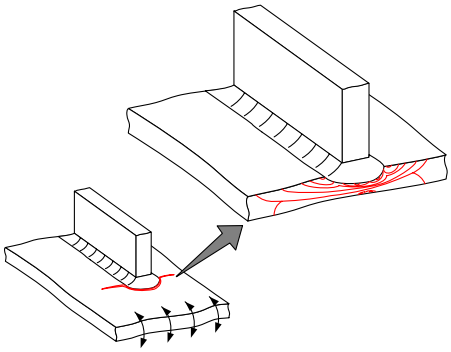

Fig.4 Crack propagation

5. Conclusion

In summary, the clip gage allowed us to measure the COD at the cracked welded joint under bending moment. As a result, the COD values were obtained from the measurement on laboratory-size specimens when the crack length increased. Therefore, a further study should be directed at determining how to improve the way of measurement for the practical use in a real bridge and to develop the analytical model for the fillet welded joint subjected to out-of-plane bending moment.

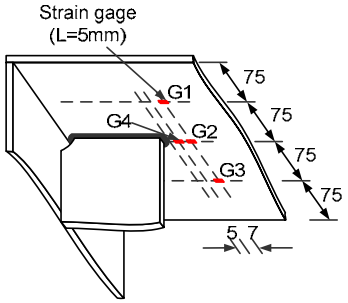

Fig.5 Strain gage location

6. References

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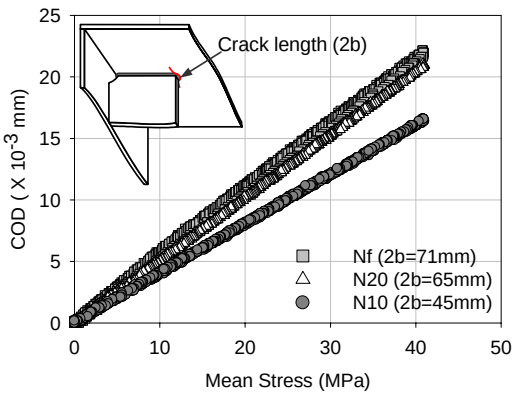

Fig.6 Stress and COD in the as-welded

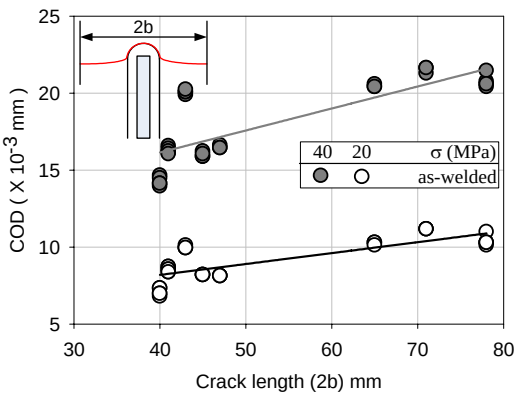

Fig.7 Crack length and COD