Local Strain Estimation of Under-Matched Welded Joints made of 800MPa Class Steel

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Summary

It is clear that a hybrid steel girder is one of the effective usages of high performance steel for steel bridges, but adoptions of hybrid steel girders might result in under-matched joints and significant on fatigue strength of under-matched welded joints made of over 700MPa class steel is not clear yet. This paper presents fatigue test results of under-matching welded joints made of 800MPa class steels. Test results indicate that the fatigue strength in higher stress range region is less than that made of mild strength steels, and showed that the cause of reduction of fatigue strength is that under-matching welded joints caused strain concentration at around weld roots. This paper also presents applicability of local strain estimation method using the test results, and a unique curve was obtained from a relationship between local strain and the test results.

Keywords: under-matched welded joints; fatigue test; high strength steel; local strain estimation.

1. Introduction

For steel bridges, an application of high performance steels has globally been investigated It is clear that a hybrid steel girder is one of the effective usages of high performance steels for steel bridges. The hybrid steel girder could be thinner flange plates and therefore reduce weight of steel bridges, especially if over 700MPa class steel is used. However, hybrid steel girders might result in material mismatching at welded joints between mild and high strength steel. Under-matching welded joints might be accepted if welded joints are categorised as non-load carrying joints. Previous studies showed that fatigue strength of under-matched welded joints made of SM570 class steels is the same as that made of mild strength steels. However, fatigue strength of under-matched welded joints made of over 700MPa class steels is not clear. Consequently, there are still uncertainties about the fatigue strength and local strain estimation of welded joints made of over 700MPa class steel. Moreover, previous studies in terms of under-matched welded joints in low cycle fatigue region showed that strain concentration at fatigue failure initiation in low cycle fatigue region is higher than that in high-cycle fatigue region. Therefore, under higher stress range cyclic load condition, which is one of the expected usages for hybrid steel girders, fatigue failure initiation might unexpectedly be in low-cycle fatigue region even when base metal is elastic region.

This paper presents fatigue test results of under-matching welded joints made of 800MPa class steels, which may determine effects of under-matched welded joints. This paper also presents local strain estimation results using a method based on the effective notch strain concept proposed by SAIPRASERTKIT et al. [1], which might be able to capture strain concentration at these fatigue failure initiation.

2. Fatigue Test

Specimens are made of WEL-TEN780E (JIS G 3128 SHY685) steel with 22mm plate thickness, which is 800MPa class steel. Three weld materials were used, which were even-match weld

material L-80 (JIS Z3211 E7816-N5CM3U) and two under-matching welded materials. 50% under-match weld material G-200 (JIS Z3211 E4319U) and 40% under-match weld material L-55 (JIS Z3211 E4916). Even though even-match weld material was used, welded joints of specimens became 10% under-match welded joints unexpectedly, because actual yield strength of WEL-TEN780E is larger than that of L-80.

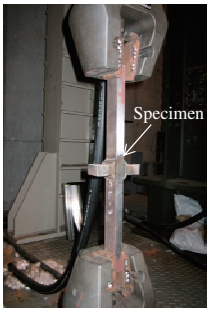

Fig. 1: Test Set-up

Test set-up is shown in Fig. 1. Fatigue tests were carried out under higher stress ranges, which were both 349MPa and 442MPa on design weld throat section area.

Fig. 2 shows results of fatigue tests, which are the relationship between stress range and number of cycles when specimens was failed. It can be observed from Fig. 2 that fatigue strength of 40% under-matching is about two-class less than that of 10% under-matching, and fatigue strength of 50% under-matching is about four-class less than that of 10% under-matching. Therefore, fatigue strength would be significantly affected by matching of weld material.

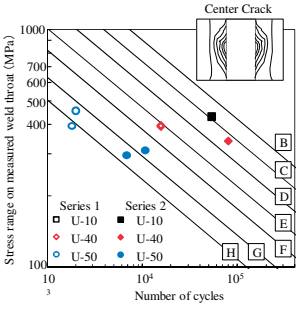

Fig. 2: Test Results

3. Local Strain Estimation

SAIPRASERTKIT et al. [1] investigated fatigue strength of load-carrying cruciform joints with material mismatching in low and high cycle fatigue regions, and they proposed a equations to estimate local strain at the weld root based on effective notch concept. Although applicability of the above equations was validated using fatigue test results, and it can evaluate the fatigue strength from low to high cycle fatigue regions [1], the under-matching welded joints made of over 700MPa class steel do not be included in the test results. Therefore, it is necessary to verify applicability of the method whether fatigue test results can represent a unique curve.

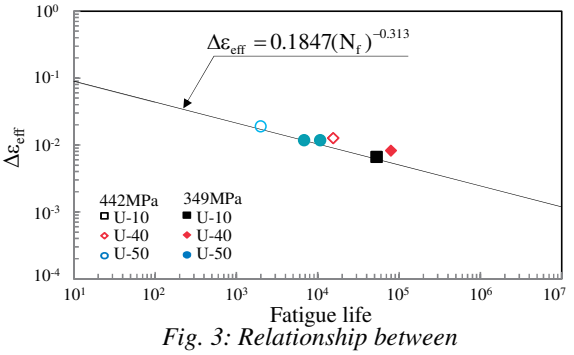

Fig. 3: Relationship between Local Strain Range and Fatigue Life

Fig. 3 shows the relationship between obtained local strain ranges by using local strain estimation method [1] and the fatigue test results as mentioned above. It is seen that plotted data were distributed with a curve that obtained from the previous study [1]. Therefore, the method proposed by the previous study can be used to evaluate effect of under-matching welded joints made of 800MPa class steel under higher stress range region. Consequently, based on Equation (1), it can be said that local strain may be increased with increase strength mismatching between welded joint and base plate.

4. Conclusions

Test results indicate that application of under-matching weld materials tends to reduce the fatigue strength of the welded joints and the cause of the reduction was strain concentration at weld roots of under-matching welded joints. In addition, it can be conclude that the local strain estimation method can be used to evaluate effect of under-matching welded joints made of 800MPa class steel.

References

[1] SAIPRASERTKIT K., HANJI T., and MIKI C., "Local Strain Estimation Method for Low- and High-Cycle Fatigue Strength Evaluation", *International Journal of Fatigue*, Vol. 40, 2012, pp. 1-6.