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Autor: Maeda, Y. / Ishiwata, M. / Kawai, Y.

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Additional Tests for "Type 2 Crack" in Hybrid Girders

Essais complémentaires pour les fissures de "type 2" dans les poutres hybrides

Zusätzliche Versuche bezüglich der Risse von "Typ 2" in hybriden Trägern

Y. MAEDA
Professor of Civil Engineering
Osaka University
Suita, Osaka, Japan

M. ISHIWATA
Senior Engineer
Kawasaki Steel Co., Ltd.
Tokyo, Japan

Y. KAWAI
Research Engineer
Kawasaki Steel Co., Ltd
Chiba, Japan

1. Introduction

At the Preliminary Report of the 10th Congress of IABSE[1], we pointed out that the fatigue failure of thin-walled hybrid girders is generally due to "Type 2 Cracks" initiated at transverse stiffener-to-web fillet weldments. Further, a good correlation between the large-sized girder test results and the small-sized model test results using a steel plate with a transverse fillet welded attachment, was demonstrated. The girder tests, however, were not sufficient in numbers to warrant the fatigue strength, and the model tests did not exactly simulate the structural behavior of the girders because of the difference of strain states.

We are now presenting the results of additional fatigue tests, which have been carried out on axially loaded transverse non-load-carrying fillet welded specimens under strain control to examine the fatigue strength of "Type 2 Cracks" in hybrid girders.

2. Tests

Transverse non-load-carrying fillet welded specimens, as shown in Fig. 1, intended for simulating the boxing parts of the transverse stiffener-to-web fillet welds in hybrid girders, are axially loaded under strain control by fixing the out-put of strain gauges on the specimens to the maximum strain of 1700×10^{-6}, which corresponds to the design working strain of 80 kg/mm^2 high strength steel in a tension flange of girders.

The specimens consist of JIS-SS41 steel with a specified tensile strength of 41 kg/mm^2, and are divided into two series, namely, the ones of which at weld toe are as-welded and the others are lightly ground at the toe to examine the effect of finishing. Such a test simulates the structural behavior proper

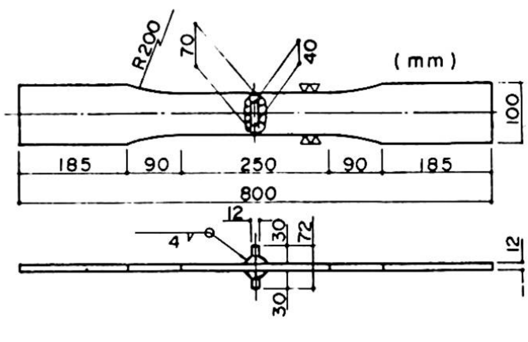

Fig.1 Details of As-Welded Specimen

to hybrid girders that a web reaches a kind of strain-controlled state after yielding due to the contribution of elastic frame action of flanges to the restraining of plastic flow of the web.

3. Results

The test results are graphically shown on the S-N diagram in Fig.2, in terms of equivalent stress range due to the strain range versus number of cycles to failure, neglecting the effect of stress ratios. The fatigue strength at 2×10^6 cycles of the as-welded specimens and of the lightly-ground specimens can be estimated at 9.5 kg/mm^2 and 10.5 kg/mm^2 as the mean value of stress ranges, respectively. The effect of finishing on the fatigue strength is not so remarkable at the present tests. This may be attributed to the fact that the grind operation was not fully performed and consequently some fine notches were not removed.

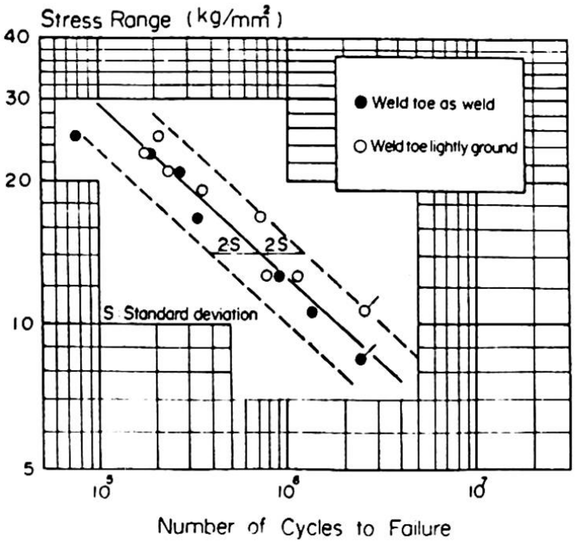

Fig.2 Fatigue Test Results

4. Discussions

(1) To study the influence of load controlling method on fatigue lives, comparison of the present test results with previous fatigue data on model specimens with the same configuration as the present ones, which were given by reanalysis of Gurney et al[2] about numerous tests, is shown in Fig.3.

It can be seen that the present test results, unexpectedly, agree well with the reanalyzed S-N curve by Gurney et al, which took into account the effect of residual stress on fatigue. It may be recognized that such a good agreement was obtained, because the correction of S-N curves was done on the assumption that residual stresses resulting from welding would generally be as high as the yield stress of the parent material as expected in a large as-welded structure, and such an assumption can be applied to the present tests,

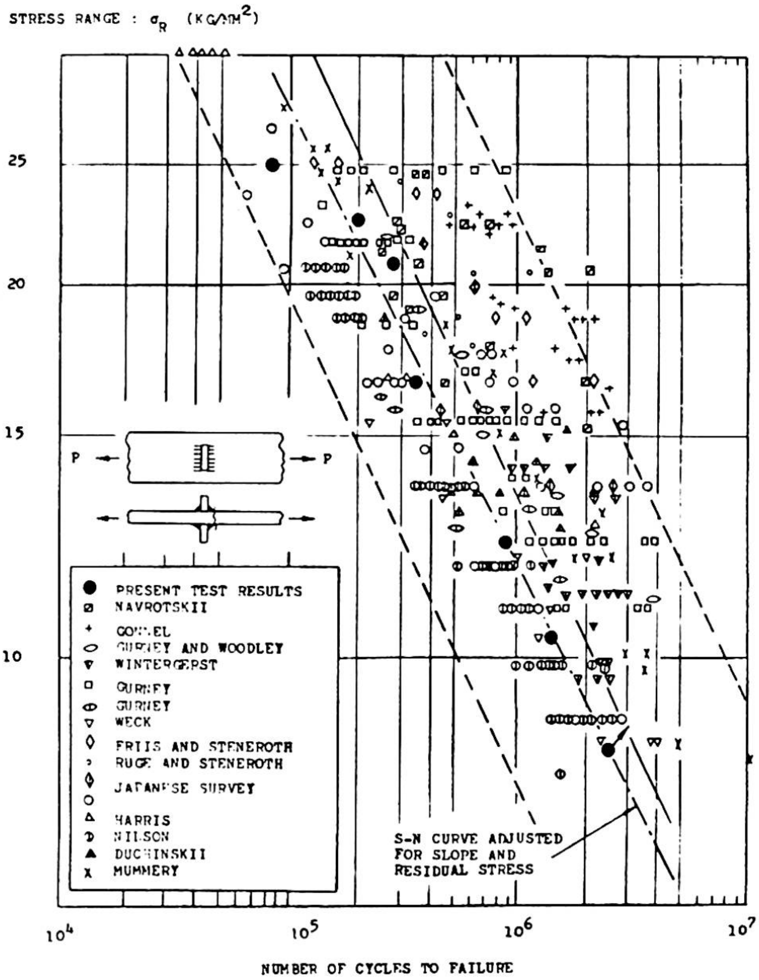

Fig.3 S-N Curves for Transverse Non-Load-Carrying Fillet Welded Joints

in which the specimens could yield at the maximum loading controlled by the strains.

(2) To study on the effect of steel grades on the fatigue strength, another comparison of the present test results for as-welded specimens with other steels[3], is made as shown in Fig. 4. Here, JIS-SM58 and WES-HT80 are high-strength steels with a specified tensile strength of 58 kg/mm^2 and 80 kg/mm^2, respectively. The latter specimens are provided with the same configuration as the present test specimens, but their loading was controlled by loads from zero to tension.

Since any significant difference among those data cannot be observed, it will be concluded that, at such a welded joint with a large notch effect, the fatigue strength in terms of stress ranges are almost identical one another regardless of steel grades, stress ratios and load-controlling methods.

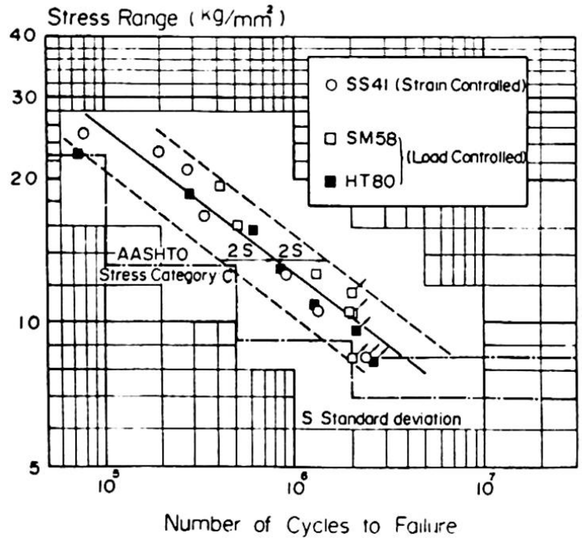

Fig.4 Fatigue Strength of Transverse Non-Load-Carrying Fillet Welded Joints for SS41, SM58 and HT80

(3) Finally, the relation between girder fatigue tests[1),4)] and some model fatigue tests is shown in Fig.5 . The model test results consist of the present test results and the previous ones in Japan [5),6)] on steel plates with transverse fillet welded attachments without boxing. The figure reveals that the present test results under relatively severe loading conditions, can be compared well with the lower 95 % confidence limit line of all the quoted test results except the present test results, and this implies that the present test results give conservative fatigue strengths due to "Type 2 Cracks" in hybrid girders.

It can be also noticed that the allowable fatigue stresses for "Stress Category C" specified at AASHTO Interim Specifications[7)], 1974, are reasonable for "Type 2 Cracks" in hybrid girders as seen in Fig. 4.

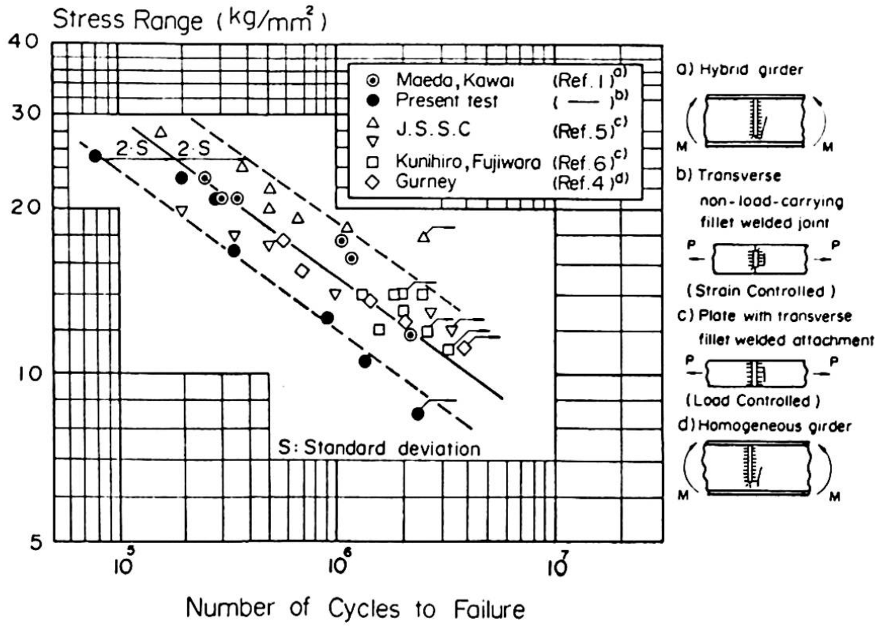

Fig.5 Comparison of Fatigue Strength for Type 2 Cracks in Girder Tests with Model Specimen Tests

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SUMMARY

To supplement the paper presented by the same authors at the Preliminary Report on "Structural Behaviour of Hybrid Girders in Bending and Application to Actual Bridges", additional tests on "Type 2 Cracks" are reported with the results and the discussions. It will be concluded that the fatigue strengths for Type 2 cracking are almost identical one another regardless of steel grades, stress ratios and load-control methods.

RESUME

Pour compléter la contribution présentée par les mêmes auteurs dans le Rapport Préliminaire, "Comportement à la flexion de poutres à âme pleine hybrides. Application aux ponts actuels", des essais complémentaires ont été réalisés pour étudier les fissures de "type 2". Résultats et discussions sont présentés. Il est possible de conclure que les résistances à la fatigue correspondant aux fissures de "type 2" sont pratiquement les mêmes, et indépendantes du type d'acier et de la contrainte moyenne.

ZUSAMMENFASSUNG

Um den von den gleichen Autoren im Vorbericht erschienenen Beitrag zu ergänzen ("Biegeverhalten von hybriden Vollwandträgern. Anwendung im Brückenbau"), wurden zusätzliche Versuche zur Untersuchung von "Typ 2" Rissen durchgeführt. Ergebnisse und Diskussion werden dargestellt. Die Schlussfolgerung lautet, dass die den Rissen "Typ 2" entsprechenden Ermüdungsfestigkeiten praktisch gleich sind, unabhängig von der Stahlfestigkeit und von der mittleren Spannung.