Interdependence between Structural Engineering and Construction Management
Edited by Ozevin, D., Ataei, H., Modares, M., Gurgun, A., Yazdani, S., and Singh, A.

ISBN: 978-0-9960437-6-2

RETROFITTING METHODS AGAINST FATIGUE CRACKING IN STEEL GIRDER WEB PENETRATION

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Fatigue cracking in steel girder web penetration details is so dangerous that it can break steel girders. Since a number of highway bridges have such web penetration details in Japan, it is of urgent importance to grasp these fatigue strength properties and develop effective retrofitting methods. In a previous report, we investigated the stress distributions around web penetration details, and fatigue cracking behavior, using steel girder specimens with web penetration details. In this study, we investigate effects of retrofitting methods against fatigue cracking in web penetration details through fatigue tests using large girder specimens with web penetration details in which cross beam lower flanges are connected to lower surface of a slot by welding. Principal results obtained through this study are as follows: (1) Weld toe grinding can extend fatigue life more than 5 times, (2) Two-face attachment can extend fatigue life more than 10 times, and (3) Two-face attachment with weld toe grinding can extend fatigue life more than 25 times.

Keywords: Fatigue test, Weld toe grinding method, Two face attachment method.

1 INTRODUCTION

Fatigue cracking in steel girder web penetration details is so dangerous that it can break steel girders (Fisher 1984). A one-meter-long crack was detected in Yamazoe Bridge in 2006 (Nara National Highway Office 2006). Since a number of highway bridges have such web penetration details in Japan, it is of urgent importance to grasp these fatigue strength properties. However, few fatigue tests have been reported on steel girder web penetration details (Sakano *et al.* 1995 and Hanshin Expressway Co. Ltd. 2012).

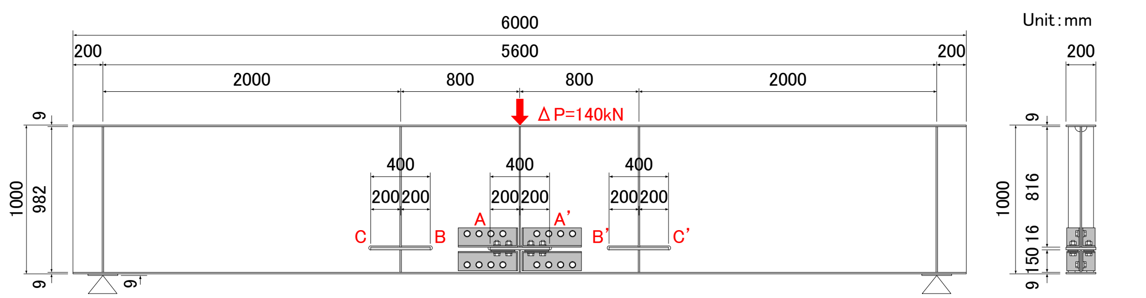
In previous studies, we investigated stress distributions around web penetration details and fatigue cracking behavior through fatigue tests using girder specimens with web penetration details (Yoshida *et al.* 2014 and Sakamoto *et al.* 2018a). Then we investigated the stress reduction effect by three face attachment retrofit through static loading tests using a large girder specimen with web penetration details where cross beam lower flanges are connected to lower surface of a slot by welding (Sakamoto *et al.* 2018b).

In this study, we investigate effects of two face attachment retrofitting methods against fatigue cracking in web penetration details through fatigue tests using a large girder specimen with web penetration details in which cross beam lower flanges are connected to lower surface of a slot by welding.

2 EXPERIMENTAL PROCEDURE

2.1 Specimen

Figure 1 shows configurations and dimensions of the specimen. Dimensions of the specimen were increased from the previous one (Yoshida *et al.* 2014 and Sakamoto *et al.* 2018a), so that two face attachments can be fixed in the space between the cross beam flange and the main beam flange. The specimen had 3 web penetration details, and 6 test parts. Test parts A, B, and C were as weld, and A', B', and C' were weld toe ground. Two face attachments were applied to test parts A and A'.

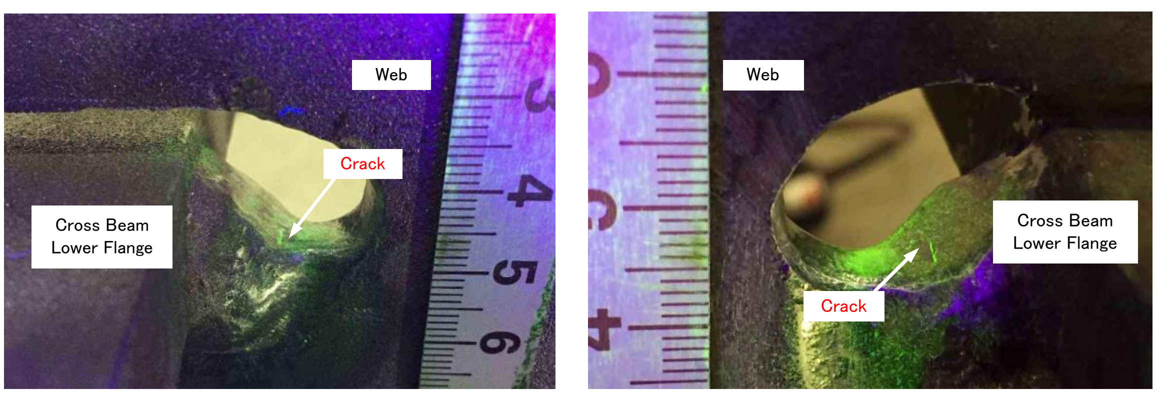


(1) Elevation (2) Cross Section

Figure 1. Configurations and dimensions of the specimen.

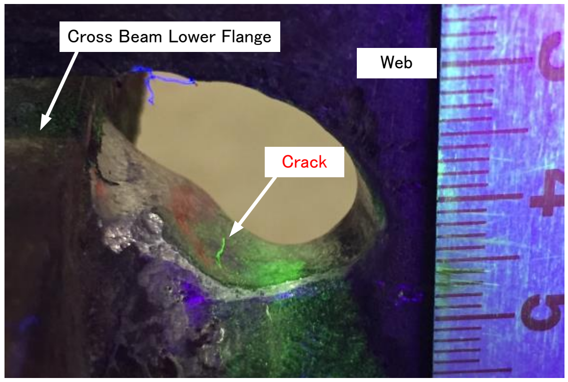
2.2 Weld Toe Grinding Method

Weld toes were ground to depth of 0.1 – 1.2mm and radius of 5.1 – 6.7mm, using a bar grinder in test parts A', B', and C'. After weld toe grinding, weld cracks were detected in the weld in all test parts as shown Figure 2.



(1) Test Part A' (2) Test Part B'

Figure 2. Ground weld toe.



(3) Test Part C'

Figure 2. Ground weld toe (contd).

2.3 Two Face Attachment Method

From the previous study (Sakamoto *et al.* 2018b), the upper and lower side attachments were most effective on stress reduction, and there was very little difference in stress reduction effects between two and three face attachments. Therefore, we adopted the upper and lower side two face attachments.

2.4 Fatigue Test Procedures

Figure 3 shows the loading conditions. We conducted fatigue tests in the 3-point bending conditions similarly as static loading test (Sakamoto *et al.* 2018b). The load range was set to 140kN (Pmin=260kN, Pmax=400kN) so that the maximum tensile stress of about 170MPa could be generated in the bottom flange (JIS SM490Y steel), considering the dead load stress. Magnetic Particle Test (MT) was applied to detect fatigue cracks at weld toe along cross beam lower flange edges. When fatigue cracks were propagated, a stop hole (SH) was drilled and a high tension bolt (HTB) was tightened. Then fatigue tests were continued.

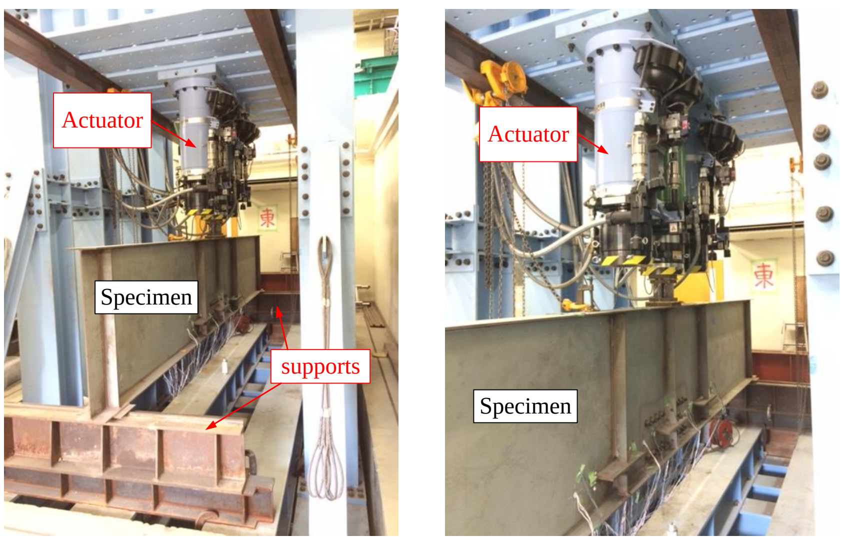


Figure 3. Loading conditions.

3 EXPERIMENTAL RESULT

Figure 4 shows principal stresses distributions. Considering directions of principal stresses, there may be low possibility of fatigue cracking in test parts B and B'.

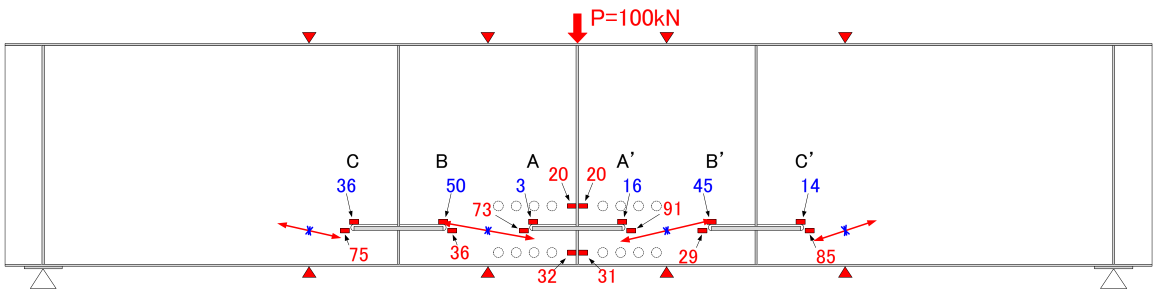


Figure 4. Principal stresses distributions.

Figure 5 shows locations of fatigue cracks. In the test part C (as weld), fatigue crack was detected after 0.2Mcycles loading. In the test part C' (weld toe grinding), fatigue crack was detected after 1.0Mcycles loading. After 1.4Mcycles loading, these crack length were reached to 30mm, SH was drilled and HTB was tightened. In the test part A (as weld with attachments) a fatigue crack was detected after 2.0Mcycles loading. In the test part A' (weld toe grinding with attachments), no fatigue cracks were detected after 3.0Mcycles loading with upper and lower side two face attachments and further after 3.0Mcycles loading with lower side attachments.

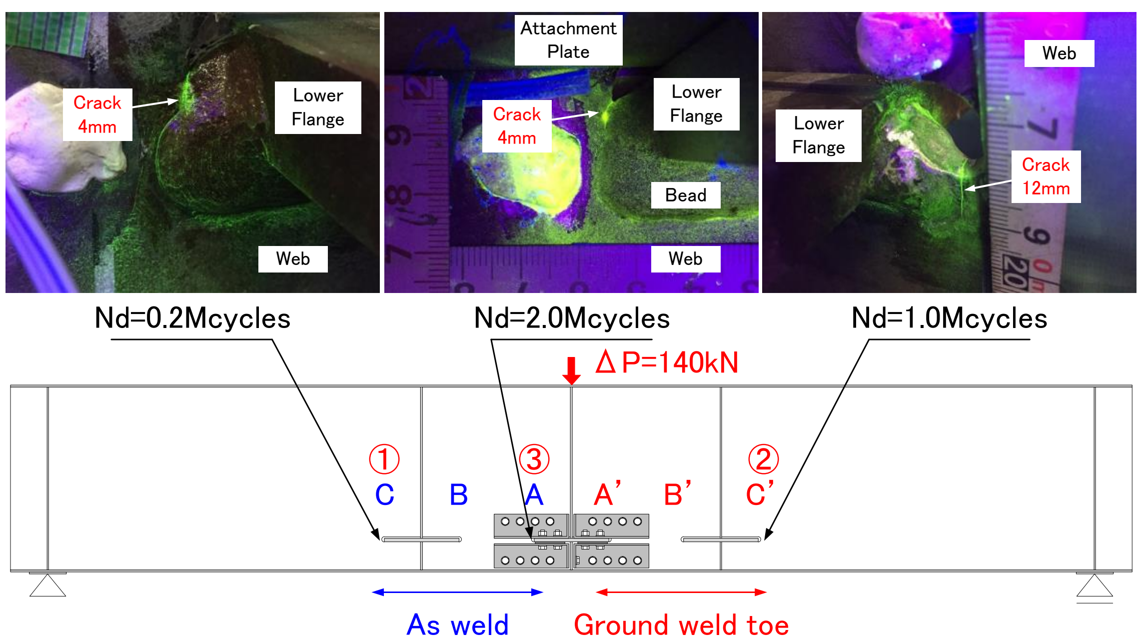


Figure 5. Locations of fatigue cracks.

Figure 6 shows stress range vs. fatigue life relationship. Comparing test parts C (as weld) and C' (weld toe grinding), weld toe grinding can extend fatigue life more than 5 times. Comparing test parts A (as weld with attachments) and C, two face attachment can extend fatigue life more than 10 times. Comparing test parts A' (weld toe grinding with attachments) and C, two face attachment with weld toe grinding can extend fatigue life more than 25 times.

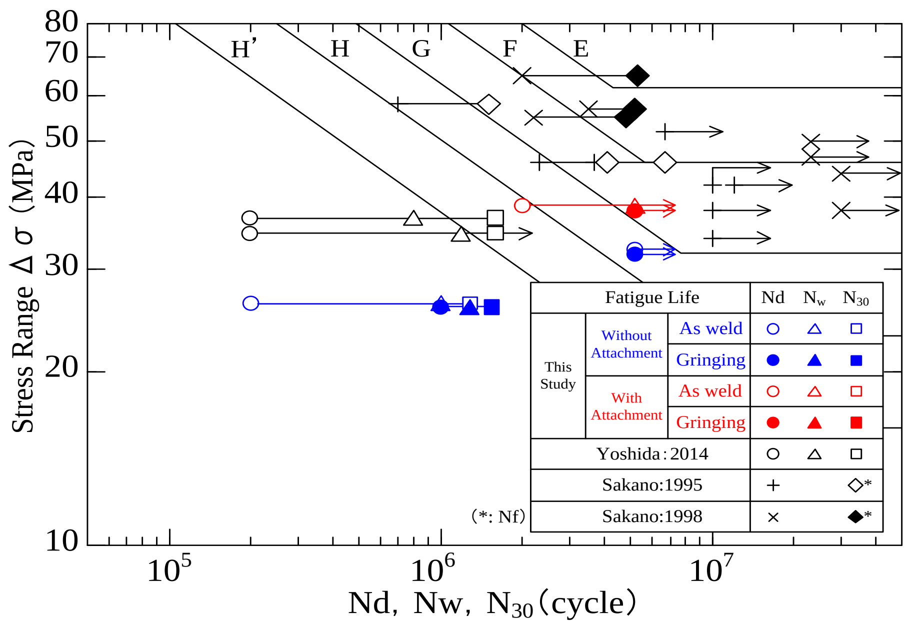


Figure 6. Stress range vs. fatigue life relationship.

4 CONCLUSIONS

The principal results obtained through this study are as follows;

(1) Weld toe grinding can extend fatigue life more than 5 times.
(2) Two face attachment can extend fatigue life more than 10 times.
(3) Two face attachment with weld toe grinding can extend fatigue life more than 25 times.

Future work is required on more effective and smart retrofitting measures.

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