RETIMOOFITTING METHODS AGAINST FATIGUE CRACKING IN STEEL GIRDER WEB PENETRATION

CHIHIRO SAKAMOTO1, MASAHIRO SAKANO1, HIDEYUKI KONISHI2, and TAKASHI FUJII3

1Dept of Civil and Environmental Engineering, Kansai University, Osaka, Japan
2Japan Bridge Association, Osaka, Japan
3Ministry of Land, Infrastructure and Transport, Himeji, Japan

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’.

![Figure 1. Configurations and dimensions of the specimen.](image1)

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.

![Figure 2. Ground weld toe.](image2)
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.
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 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 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.

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.

References

Sakamoto, C., Sakano, M., Konishi, H., and Fujii, T., “Retrofit against Fatigue Cracking at Web Penetration Details with a Slot in Steel Girder,” 9th International Symposium on Steel Bridges, No.3.4, Prague, 2018a.
Sakamoto, C., Sakano, M., Konishi, H., and Fujii, T., “Three Face Attachment Retrofit against Fatigue Cracking at Steel Girder Web Penetration,” The Fourth Australasia and South-East Asia Structural Engineering and Construction Conference, No.11.6, Brisbane, Australia, 2018b.