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THREE FACE ATTACHMENT RETROFIT AGAINST FATIGUE CRACKING AT 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. In this study, we investigate stress reduction effects of three face attachment retrofit through fatigue tests using a large girder specimen with web penetration details where cross beam lower flanges are connected to the lower surface of a slot by welding. As a result, there is very little difference between two and three face attachments about stress reduction effects, while they are more effective than one face attachment. The upper side attachment is more effective than the lower side attachment, while both side attachment is best. Two and three face both side attachments can reduce about 40% of stress concentration, while two and three face upper side attachments can reduce 50–60%.

Keywords: Fatigue test, Retrofit, Highway steel bridge, Cracks.

1 INTRODUCTION

Fatigue cracking in steel girder web penetration details is so dangerous that it can break steel girders (Fisher 1984). The 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).

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 verified the effect of retrofitting methods against fatigue cracking in web penetration details (Sakamoto *et al.* 2018). However, these methods cannot prevent fatigue crack initiation perfectly.

In this study, we investigate the stress reduction effect by three face attachment retrofit through fatigue 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.

2 EXPERIMENTAL PROCEDURE

2.1 Specimen

Figure 1 shows configurations and dimensions of the specimen and location of strain gauges. Dimensions of the specimen are increased from the previous one (Yoshida *et al.* 2014), so that three face attachments can be fixed to the space between the cross beam flange and the main beam flange. Figure 2 shows the details of three face attachment retrofit.

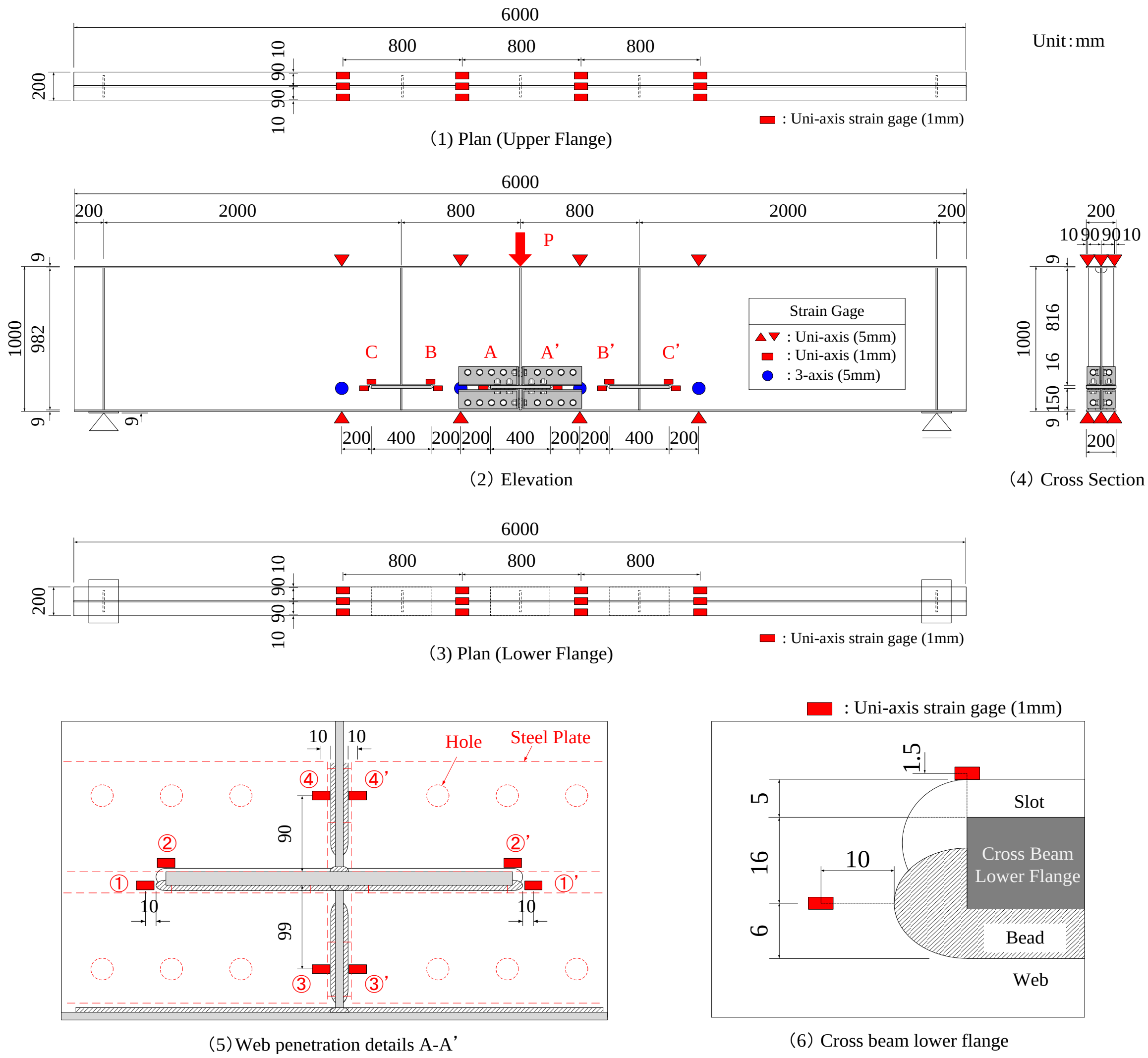


Figure 1. Configurations and dimensions of the specimen, and location of strain gauges.

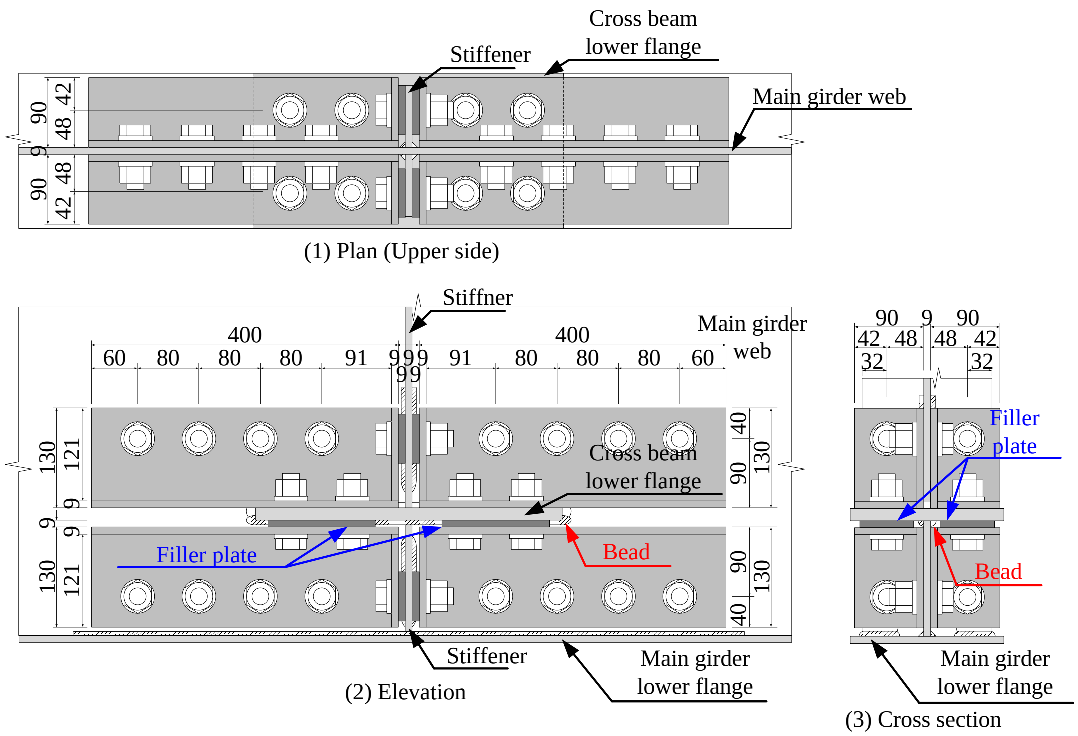


Figure 2. Three face attachment retrofit.

2.2 Preventive Measure

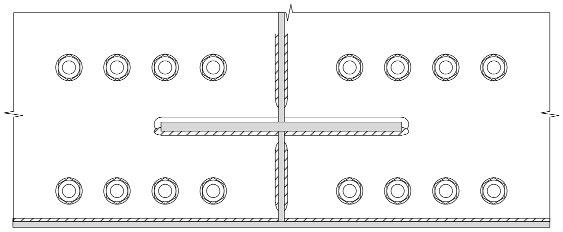
Figure 3 shows ten cases of the retrofitting methods. Case one is no retrofit, Cases from two to four are upper and lower side attachments, Cases from five to seven are upper side attachments, Cases from eight to ten are lower side attachments. While, Cases two, five and eight are three face attachments, Cases three, six and nine are two face attachments, and Cases four, seven and ten are one face attachments.

2.3 Static Loading Test Procedure

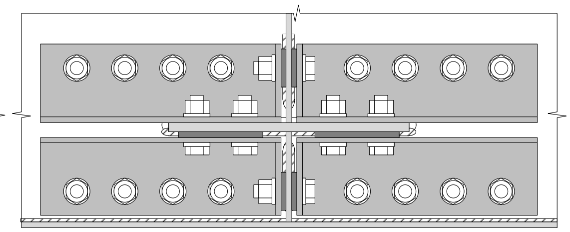
We conducted static loading tests in the three-point bending condition to grasp the stress distributions around web penetration details and to investigate the stress reduction effect. Figure 4 shows the loading conditions. The load range was set to 100kN so that the maximum tensile stress of about 40MPa could be generated in the bottom flange similarly as the previous study (Yoshida *et al.* 2014).

3 EXPERIMENTAL RESULTS

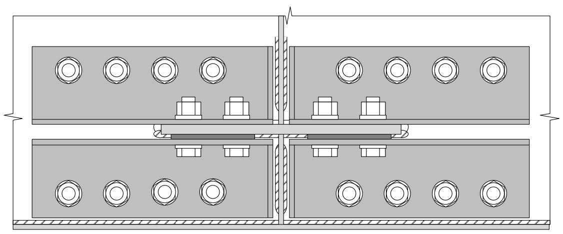
Figure 5 shows the stress change at all gages in the case of upper and lower attachment. At gages ① and ①’, stress decreases remarkably after attachments. Two and three face attachments are more effective than one face attachment, and there is very little difference between them.



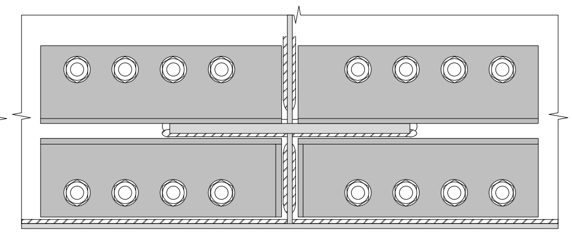
(1) No Retrofit



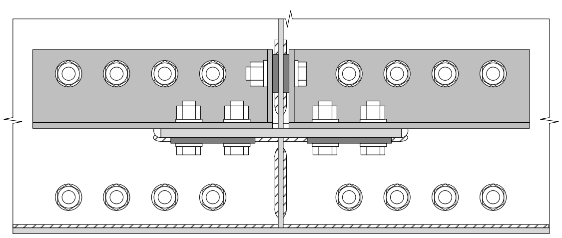
(2) Upper and lower side attachment
with 3 faces attachment



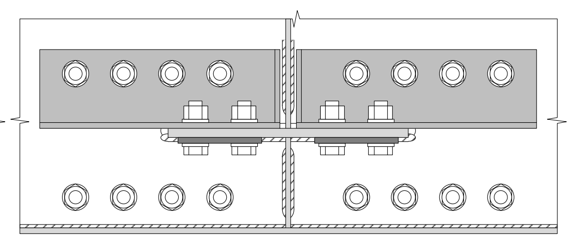
(3) Upper and lower side attachment
with 2 faces attachment



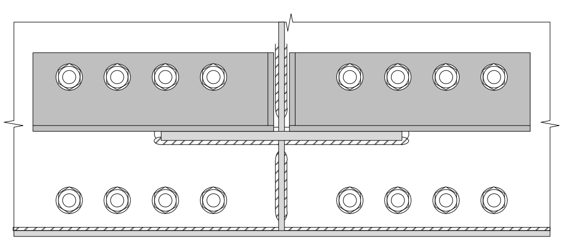
(4) Upper and lower side attachment
with 1 face attachment



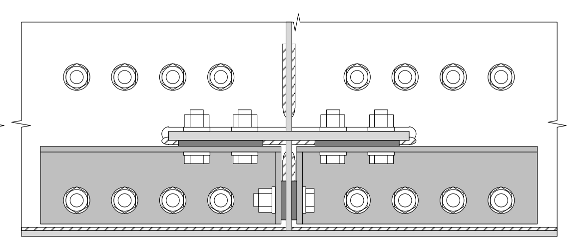
(5) Upper side attachment
with 3 faces attachment



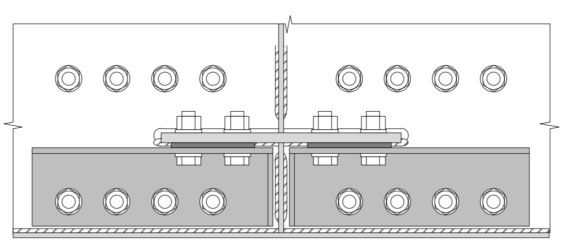
(6) Upper side attachment
with 2 faces attachment



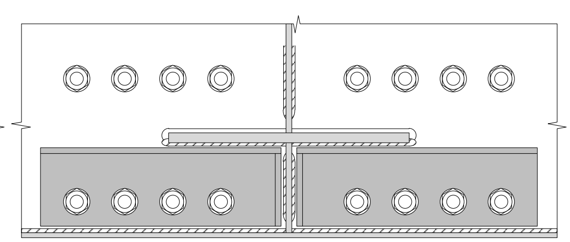
(7) Upper side attachment
with 1 face attachment



(8) Lower side attachment
with 3 faces attachment



(9) Lower side attachment
with 2 faces attachment



(10) Lower side attachment
with 1 face attachment

Figure 3. Ten cases of attachments.

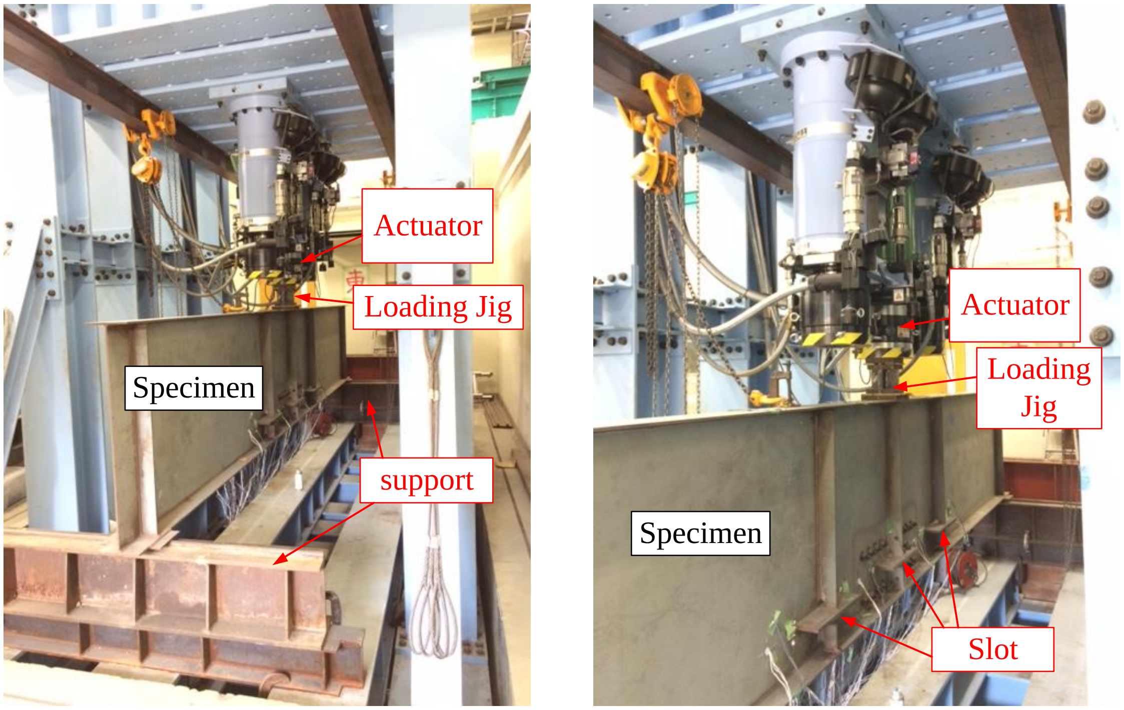


Figure 4. Loading conditions.

Figure 6 shows the stress change at all gages in the case of three face attachment. At gages ① and ①' where high tensile stress occurred before attachments, the upper side attachment is more effective than the lower side attachment, while both side attachment is best.

Figure 7 shows the stress change at gages ① and ①' in all cases of attachments. Two and three face both side attachments can reduce about 40% stress concentration, while two and three face upper side attachment can reduce 50–60%.

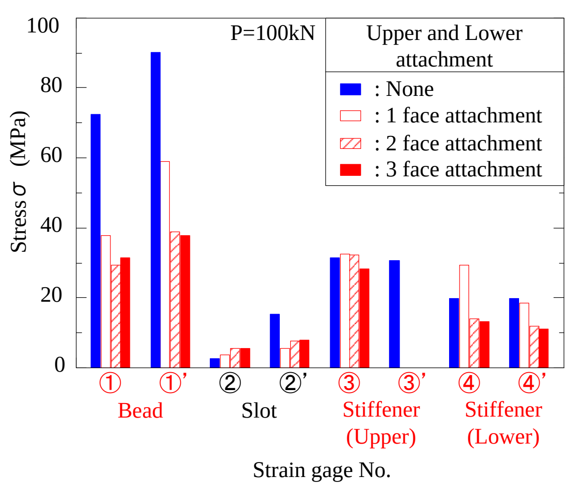


Figure 5. Stress change at all gages in the case of upper and lower attachment.

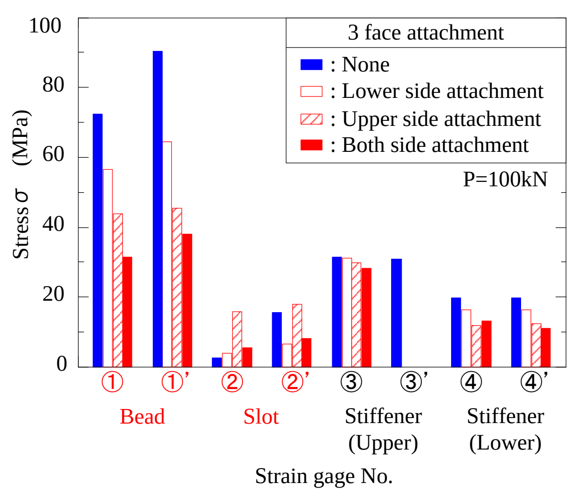


Figure 6. Stress change at all gages in the case of three face attachment.

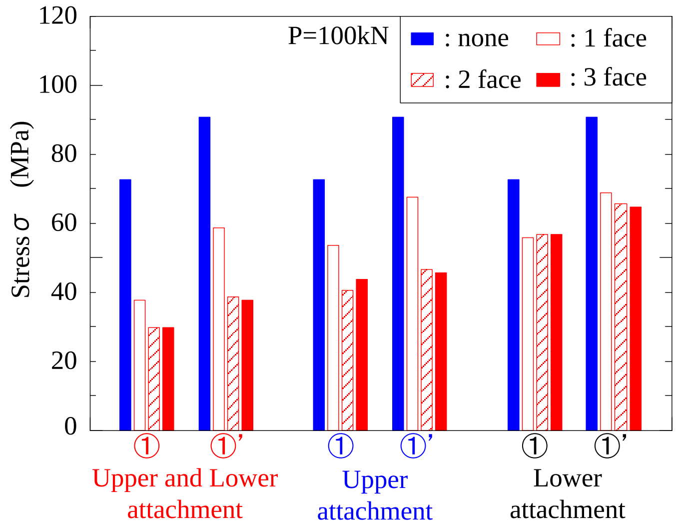


Figure 7. Stress change at gages ① and ①' in all cases of attachments.

4 SUMMARY

(1) Two and three face attachments are more effective than one face attachment about stress reduction effect, while there is very little difference between them.
(2) The upper side attachment is more effective than the lower side attachment, while both side attachment is best.
(3) Two and three face both side attachments can reduce about 40% of stress concentration, while two and three face upper side attachments can reduce 50–60%.

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