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Procedia Structural Integrity 19 (2019) 513–519

Structural Integrity
Procedia

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Fatigue Design 2019

Weld Bead Removal Retrofitting against Fatigue Cracking in Steel Girder Web Penetration

Chihiro Sakamoto[a], Masahiro Sakano[b], Hideyuki Konishi[c], Takashi Fujii[d]

[a] *Japan Consultant Association, Osaka, Japan*
[b] *Kansai University, Osaka, Japan*
[c] *Japan Bridge Association, Osaka, Japan*
[d] *Ministry of Land, Infrastructure and Transport, Himeji, Japan*

Abstract

Fatigue cracking in steel girder web penetration details is so dangerous that it can break steel girders completely. In 2006, one-meter-long crack was detected in Yamazoe Bridge. 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 previous studies, we investigated fatigue cracking behavior through fatigue tests using small girder specimens with web penetration details and effects of large 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. However these methods cannot prevent fatigue crack initiation perfectly.

In this study, we investigate effects of weld bead removal and small angle steel attachment retrofitting method against fatigue cracking in web penetration details through fatigue tests using a large girder specimen.

As a result, it has been verified that weld bead removal and small angle steel attachment method can prevent fatigue crack initiation perfectly in the web penetration details with a slot.

Peer-review under responsibility of the Fatigue Design 2019 Organizers.

Keywords: weld bead removal; retrofitting method; fatigue test; web penetration

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1. Introduction

Fatigue cracking in steel girder web penetration details is so dangerous that it can break steel girders completely [1]. In 2006, one-meter-long crack was detected in Yamazoe Bridge [2]. 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.

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10.1016/j.prostr.2019.12.055

In previous studies, we investigated fatigue cracking behavior through fatigue tests using small girder specimens with web penetration details [3] [4] and effects of large 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 [5] [6]. However these methods cannot prevent fatigue crack initiation perfectly.

In this study, we investigate effects of weld bead removal and small angle steel attachment retrofitting method against fatigue cracking in web penetration details through fatigue tests using a large girder specimen.

2. Experimental procedures

2.1. Specimen

Fig.1 shows configurations and dimensions of the specimen, and locations of strain gages to measure nominal stresses. Fig.2 shows a web penetration detail and locations of strain gages to measure local stresses. The specimen has three test parts. In test part A, full length of weld bead was removed. In test part B, one quarter length of weld bead was removed. In test part C, half length of weld bead was removed. In all test parts small angle steels were attached to main girder web and cross beam bottom flanges. Fig.3 shows conditions of removed weld bead (test part B).

Gage Nos.1 and 2 were pasted to measure local stresses around the edge of cross beam bottom flange. Gage Nos.3-5 were pasted to measure local stresses along the transverse welds of vertical stiffeners. Gage Nos.6-9 were pasted to measure local stresses at the tip of the weld bead during weld bead removal procedures.

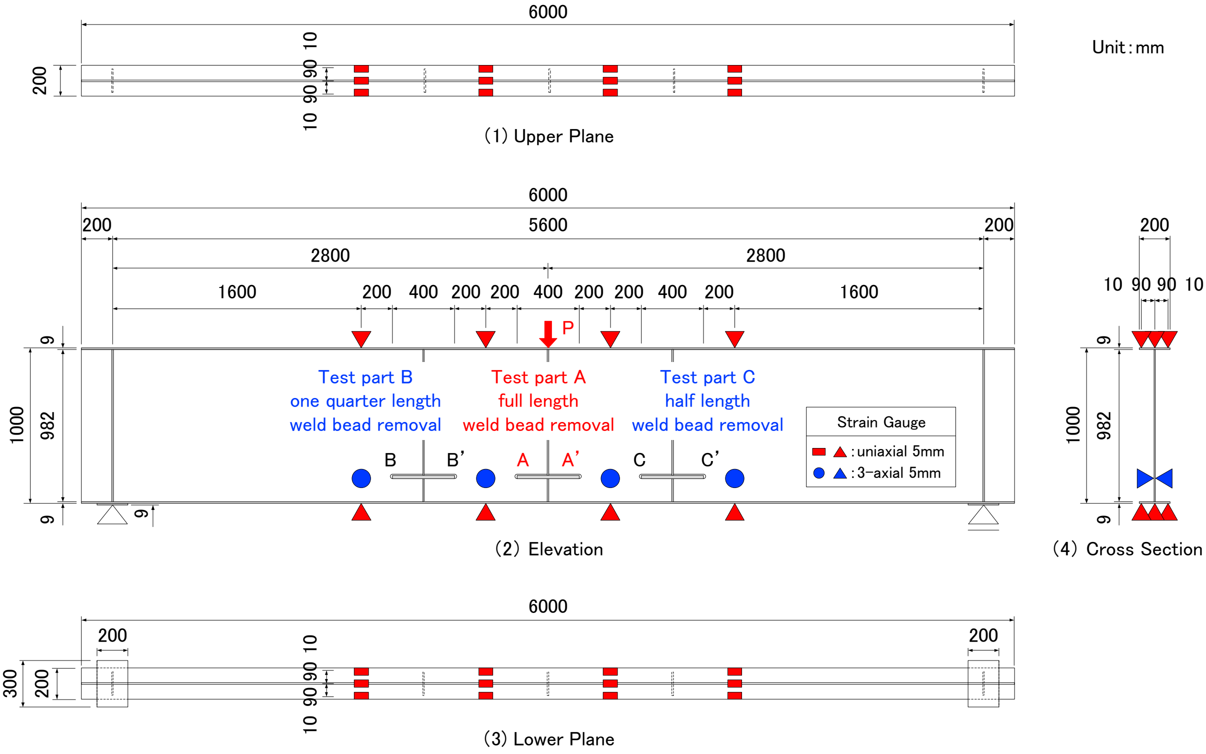
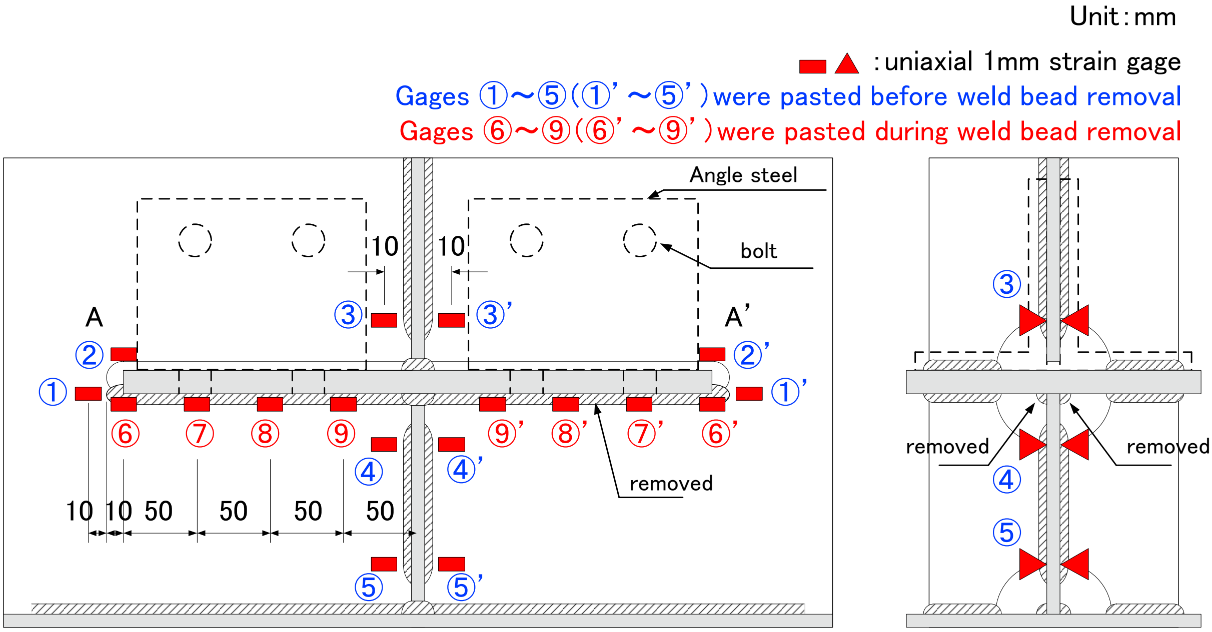


Fig. 1. configurations and dimensions of the specimen, and locations of strain gages.



(1) Elevation (2) Cross Section

Fig.2 web penetration detail, and locations of strain gages.

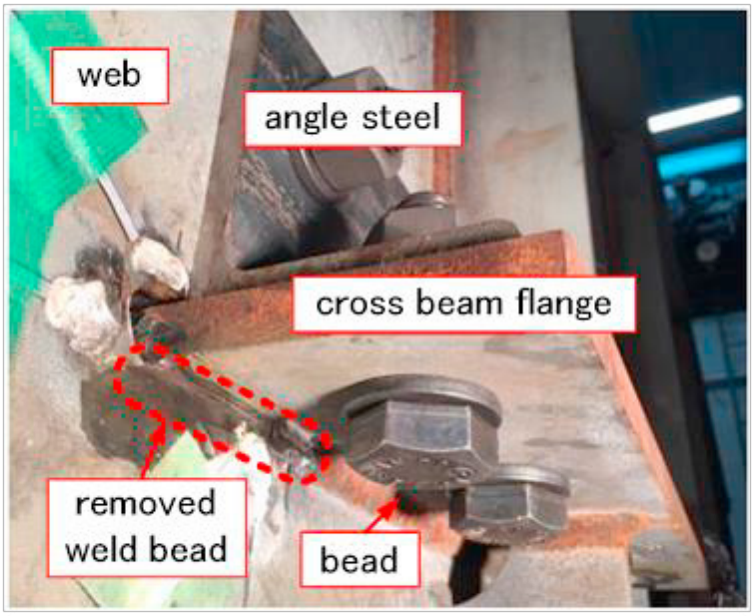


Fig.3 conditions of removed weld bead (test part B).

2.2. Static and fatigue loading test procedures

Fig.4 shows loading conditions. Static and fatigue loading tests were conducted in the 3-point bending condition. The load range in static loading tests was set to 100kN so that the maximum tensile stress of about 40MPa.

The load range jn fatigue tests 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. The loading frequency was 3Hz. Magnetic Particle Test (MT) was applied to detect fatigue cracks. When fatigue cracks were detected, they were removed by grinding and the tip of removed weld bead was shaped up. Then fatigue tests were continued.

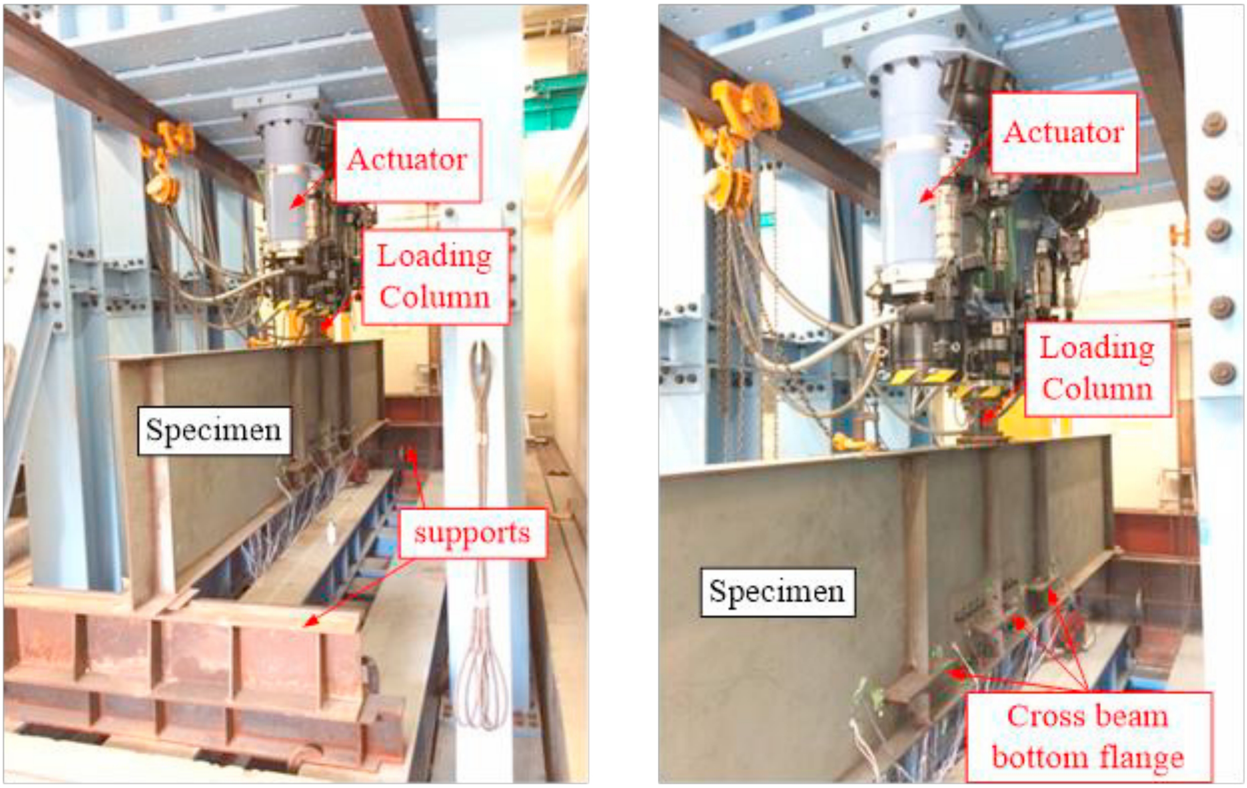


Fig.4 loading conditions.

3. Experimental results

3.1. Static loading test results

Fig.5 shows relationship between local stresses and bead removal length. After 10mm weld bead removal, stress at gage No.1 was reduced from 90MPa to 50MPa.Whereas, stress of 150MPa was measured at gage No.6'. After 60mm (one quarter of weld bead length) weld bead removal, stress at gage No.6' was decreased to 75MPa (just half of the stress before bead removal). Stresses at gage Nos.3-5 were smaller than 40MPa, there was very little influence by the length of weld bead removal.There is little change in stress distributions when the length of weld bead removal over 60mm (one quarter of weld bead length).

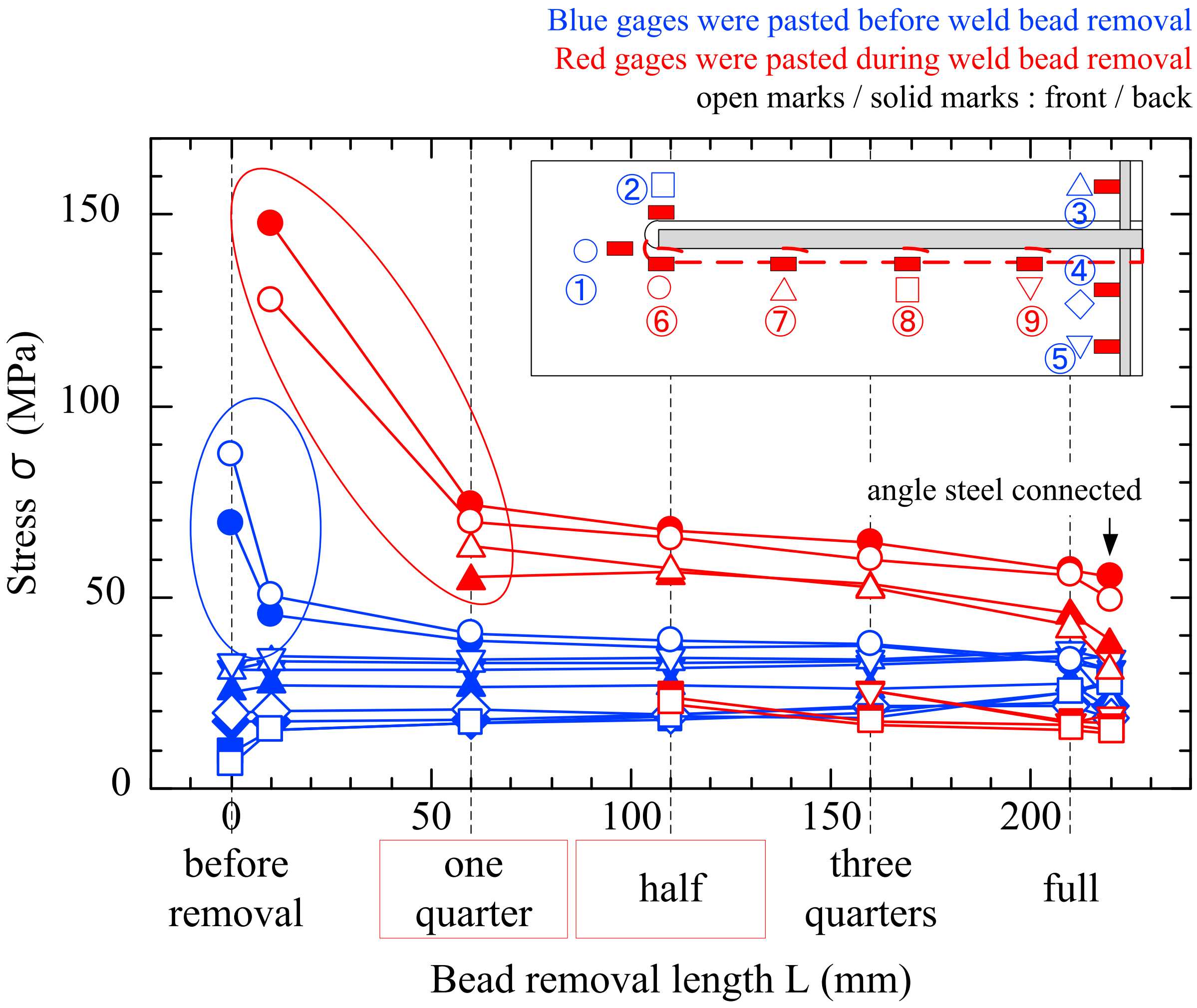


Fig.5 relationship between local stresses and bead removal length.

3.2. Fatigue test results

Fig.6 shows fatigue life of the specimen. Nd is the fatigue life when a fatigue crack is detected. Nw is the fatigue life when the crack is propagated into web. N_{30} is the fatigue life when the crack length reaches 30mm. In test part A (full length weld bead removal), no fatigue cracks were detected after 7.0Mcycles fatigue loading. In test Part C (half length of weld bead removal), a fatigue crack with the length of 3mm was detected after 1.0Mcycles fatigue loading. In test Part B' (one quarter length of weld bead removal), a fatigue crack with the length of 2mm was detected after 1.9Mcycles fatigue loading as shown in Fig.7. However, these cracks were not propagated until 3.0Mcycles fatigue loading. This is because that the stress was so small near the tip of removed weld bead as shown in Fig.5.

After shaping up the tip of removed weld bead, no fatigue cracks were detected after 4.0Mcycles fatigue loading as shown in Fig.8.

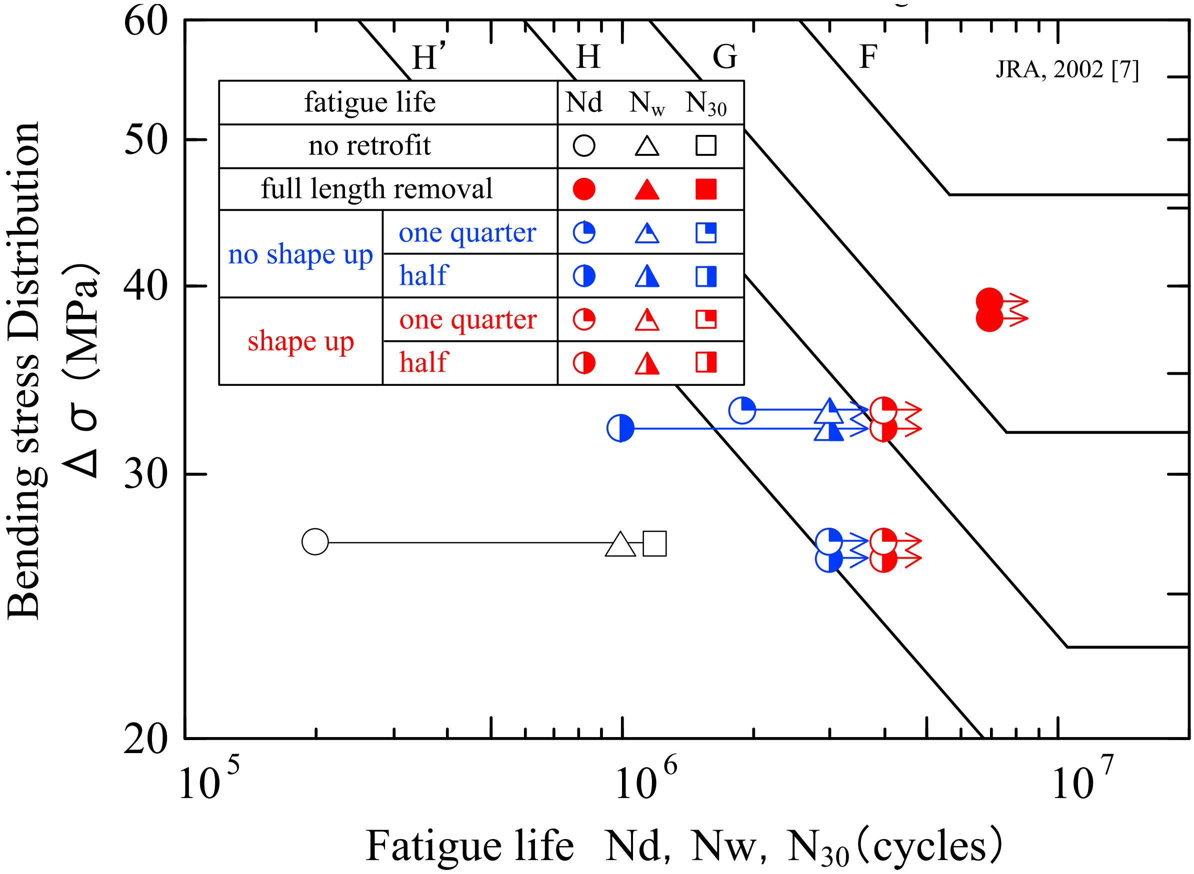


Fig.6 fatigue life of specimen.

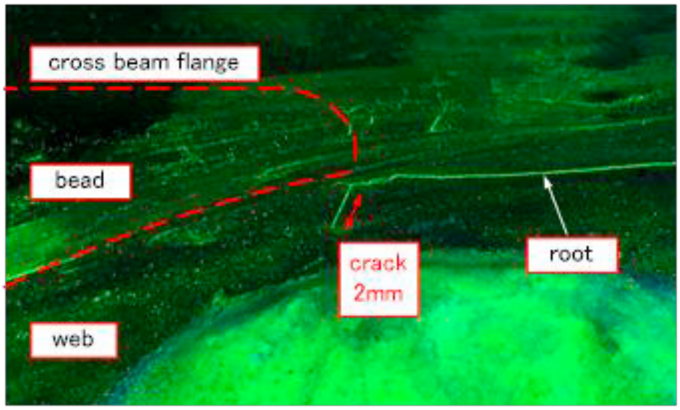


Fig.7 detected fatigue crack (N=1.9Mcycles, test part B')

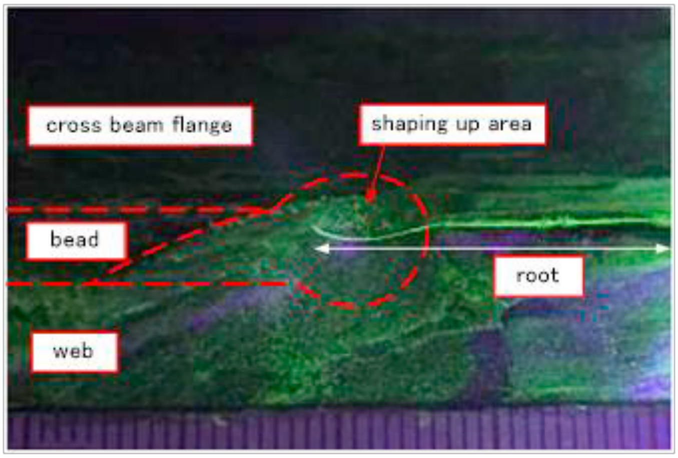


Fig.8 shaping up conditions at the tip of removed weld bead (N=4.0Mcycles, test part B')

4. Summary

- It has been verified that weld bead removal and small angle steel attachment method can prevent fatigue crack initiation perfectly in the web penetration details with a slot.

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