CREVICE CORROSION STATE OF GUSSET PLATE CONNECTIONS ON STEEL TRUSS BRIDGE

Tokyo Metropolitan University Student member Nguyen Xuan Tung, Member ○Kuniei Nogami, Yusuke Kishi
Waseda University Member Teruhiko Yoda, Hideyuki Kasano
Public Works Research Institute Member Jun Murakoshi, Tadao Enomoto, Daiki Tashiro

1. INTRODUCTION

In several corrosion researches recently, especially related to corrosion shapes, most of them were about the corrosion shape on the inner or outer surfaces but the crevice corrosion between the attached surfaces still remain unknown. In this study, the detailed crevice corrosion shape of the gusset plate connections and the attached plates that were made from the two connections (P25d and P72u as shown in Photo 1) of the steel truss bridge were measured by using the laser measurement equipment, and the actual crevice corrosion state of the above specimens were evaluated on the basis of the corrosion depth distribution of these surfaces. Based on the detailed results of corrosion measurement, the crevice corrosion and the corrosion characteristics of the gusset plate connection were clarified.

(a) P25d *(b) P72u*

Photo 1: Gusset plate connections

2. CORROSION MEASUREMENT METHOD

In order to measure the corrosion shape of the surfaces on the specimen, the specimen was set vertically parallel using the grabbed tool device. The laser measurement equipment was set up as shown in Photo 2. The laser measurement equipment is composed of ①surface roughness measuring device, ②grab tool device, ③A-D converter and ④measurement - control equipment. Table 1 shows the specifications of equipment. Measurement interval of the laser measurement equipment of the specimen was selected as 1mm in order to understand its mechanical performance. The based-plane was set by hands at the visually healthy place and must be sure that corrosion has not occurred on the specimen surface.

Photo 2: Laser measurement equipment

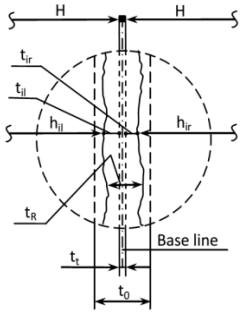


Figure 1: Corrosion depth calculation

3. CORROSION DEPTH CALCULATION METHOD

The corrosion depth is calculated from the following calculation method as shown in Figure 1:
On the left side (inner surface): $t_{il} = H_l - h_{il}$
On the right side (outer surface): $t_{ir} = H_r - h_{ir}$
where:
t_{il}, t_{ir}: corrosion depths on the left side and on the right side, respectively
H_l, H_r: distances from the laser meter to the based-surface on the left side and on the right side, respectively
h_{il}, h_{ir}: Distances from the laser meter to the measured point on the specimen surface on the left side and on the right side, respectively.

Then the remaining thickness is calculated as follow:

$$t_R = t_0 - t_{il} - t_{ir}$$

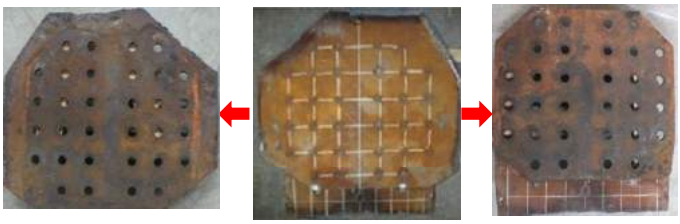
where:
t_{il}, t_{ir}: Corrosion depths on the left side (inner surface) and on the right side (outer surface), respectively
t_R: Remaining thickness of the specimen
t_0: Initial thickness of the specimen

4. CREVICE CORROSION STATE

4.1. P25d connection specimens

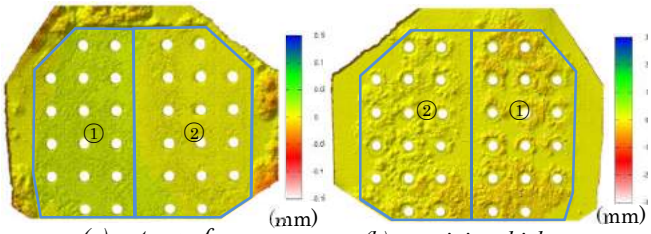
Corrosion depth distribution of the gusset plate specimen

The conditions and corrosion state of the inner and outer surfaces of the gusset plate specimen were shown in Photo 3 and Figure 2, respectively. As can be seen from Figure 2, the corrosion of the inner surface, contact surface, occurred only on the edges of the specimen, the average corrosion depth is approximately 0 mm due the rust existed on the whole surface, and the maximum corrosion depth is 0.252mm. While in the other area the corrosion has hardly seen due to the contact of the gusset plate and the flange plate, however, there was a rust layer (region ①) with the



Gusset plate *Tensile diagonal*

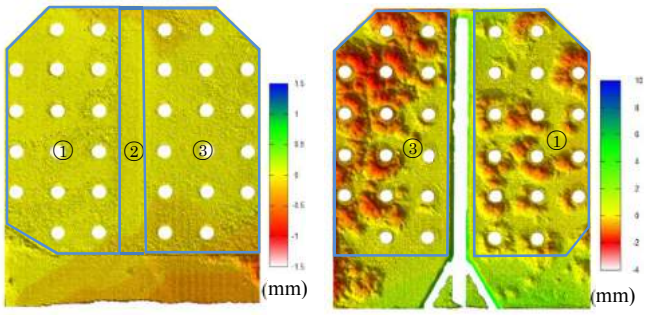
Photo 3: P25d connection



(a) outer surface *(b) remaining thickness*

Figure 2: Corrosion depth distribution of the inner surface

Keywords: Crevice corrosion, Steel truss bridge, Gusset plate connection
Address : 1-1 Minami-Osawa, Hachioji, Tokyo, Japan, 192-0372



(a) outer surface *(b) remaining thickness*

Figure 3: Corrosion depth distribution of the inner surface

average thickness is 0.011mm. The corrosion of the outer surface of the gusset plate occurs around the rivet holes in the shape of dough-nut. The average corrosion depth is 0.14mm and the maximum corrosion depth is 2.7mm.

Figure 3 shows the corrosion depth distribution of the inner and outer surface of the diagonal member specimen. The outer surface was attached opposite with the inner surface of the gusset plate specimen, so that the corrosion is hardly seen on this surface except the bottom area where the face was directly exposed to the environment. There was a existed rust layer on region ① and the average corrosion depth is 0.006mm and the maximum corrosion depth is 1.456 mm. For the contact surface, the average corrosion depth is 0.044 mm and the maximum corrosion depth is 1.456 mm equivalent to 0.44% of thickness loss. In region ② and ③, the rust and corrossion also can be seen clearly. Corrosion occurred at the top and bottom but more severely on the right corner due to the existing sediment. For the inner surface, the corrosion occurred severely on the whole surface especially around the rivet holes. The average corrosion depth is 0.25mm and the maximum corrosion depth is 4.01mm.

4.2. P72u connection specimens

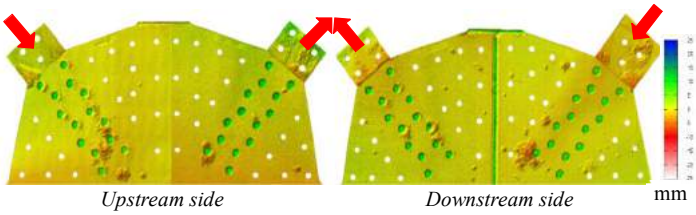
In view of the loading capacity requirements in the past, plates were attached to the P72u gusset plates using high strength bolts in 2002 as the reinforcement. In order to measure the contact surface of these plates, they were removed by releasing the bolts. The conditions of the attached plates and the gusset plates after cleaning process were shown in Photo 4. As can be seen on this Photo, after 10 years of the reinforcement, the corrosion did not occur on the contact surfaces.

(a) Gusset plate *(b)Attached plate*

Photo 4: P72u connection specimens

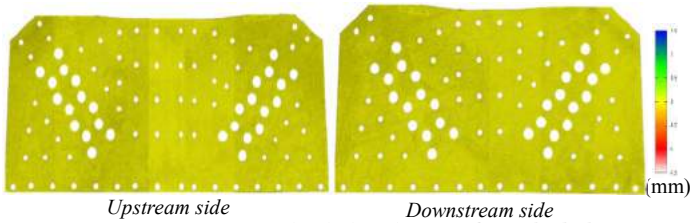
Gusset plate connection

The corrosion depth distribution of P72u gusset plates is shown in Figure 4. On the upstream side, the corrosion on the gusset plate occurred locally and mostly concentrated on the compression diagonal side of gusset plate. The corrosion also occurred around the rivet head in the half-doughnut-shape. As can be seen clearly in Figure 4, the



Upstream side *Downstream side*

Figure 4: Corrosion depth distribution of P72u gusset plates



Upstream side *Downstream side*

Figure 5: Corrosion depth distribution of attached plates

upper part of gusset plate on the upstream side was shifted about 2mm due to the loading test.

The corrosion depth distribution of the outer surface in the downstream side is also shown in Figure 4. Similar to the upstream side, the corrosion on the downstream side gusset plate occurred locally and occurred in the half-doughnut-shape around the rivet heads. On the diagonal members, corrosion occurred on the whole of the flange of diagonal members, the contacted regions, and more severely on the tensile member.

The attached plates

The corrosion depth distribution of the attached plates was shown in Figure 5. As can be seen clearly on this figure the crevice corrosion did not occurr on the whole surface of these attached plates.

5. CONCLUSION

From the detailed corrosion measurement results of the specimens, the summaries are given as follows:

1) With respect to the P25d connection specimens, the rust layer existed on the whole surface especially on the contact surface of the gusset plate specimens. The average thickness of this rust layer on the contact surface of the gusset plate is 0.011mm while that on the contact surface of the flange of the tensile diagonal member is 0.044mm.

2) With respect to the P72u connection, the corrosion occurred locally in both upstream and downstream sides of the gusset plates. On the downstream side, the corrosion occurred on the all flanges of diagonal members. Around several rivet heads the corrosion occurred in the half-doughnut-shape. On the upstream side, the upper part of gusset plate on the upstream side was shifted about 2mm due to the loading test resulting in the corrosion of the lower part seems occur severely. On the attached plates, the crevice corrosion did not occur on the whole surface of these attached plates.

REFERENCE:

1.K.Nogami, N.Yamamoto, T.Yamasawa, T.Yoda, H.Kasano, J.Murakoshi, N.Toyama, K. Arimura, M.Sawada: Measurement of corroded gusset plate connections in steel truss bridge and characteristics of corrosion state, *Journal of Structural Engineering, Japan , 58A, pp.679-691*, (2012), (in Japanese)

2. X.T.Nguyen, K. Nogami, S.Takahashi, M.Kurihara, T. Yoda, H. Kasano, J. Murakoshi, N.Toyama, T.Enomoto: Evaluation for crevice corrosion state of gusset plate on steel truss bridge, *Proceedings of 12nd Japan – Korea Joint Symposium on Steel Bridges, Okinawa – Japan*, 2013.8