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LOCAL CORROSION ENVIRONMENT AROUND CROSS SECTION OF A PLATE GIRDER BRIDGE

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Corrosion is one of important factor for securing the safety of steel bridges. In general cases, the corrosive environment of the steel bridge is evaluated as a site environment. However, even in one bridge, the corrosive environment greatly varies from part to part. This research aims to clarify the difference of corrosion environment for each part of plate-girder-bridge which has three main girders. At this bridge, anti-freezing agent is sprayed in winter. On-site measurements were performed on five points on each girder, which are both sides of web, both sides of upper/lower part of bottom flange. These measurements points include two points where water leakage is scattered. Temperature, humidity, amount of airborne salt and amount of adhering salt have been measured. In order to comprehensively assess corrosive condition, exposure tests were also performed. Observations were carried out for one year. From measurement results, it became clear that temperature and humidity were not uniform at all observation points. These differed at the inside and outside of girder and upper part and lower part of web. Amount of airborne salt to each girder is strongly influenced by anti-freezing agent. On the upper surface of the lower flange of each girder, there are places where corrosion markedly progresses due to deposits and water leakage.

Keywords: Airborne salt, Anti-freezing agent, Exposure test, Weathering steel.

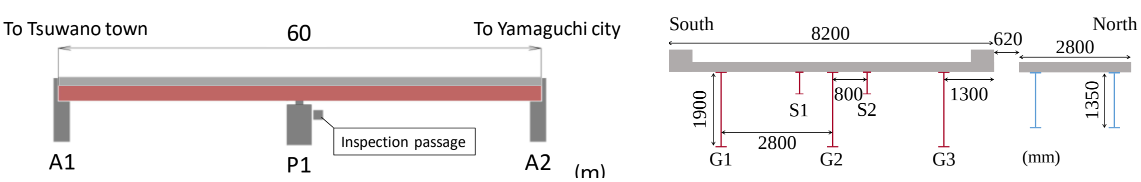
1 INTRODUCTION

Condensation, leakage, and airborne salt are well known main factors that contribute to corrosion on steel bridges. Leakage is the most common cause of corrosion, followed by airborne salt and condensation (Natori *et al*. 2001). Although corrosion of steel bridges mainly occurs at the ends of girders than at the center of the span, location of occurrence is not necessarily determined (Tai *et al*. 2015). Furthermore, the wind direction, wind speed, temperature, and humidity will vary greatly not only at the construction site of the bridge but also at the location in the bridge. Particularly in multi girder bridges, there are many unknown parts such as scattering of airborne salt to the girder, position of occurrence sites of dew condensation. This paper aims to clarify the difference of corrosion environment for each part of plate-girder-bridge which has three main girders.

2 SITE OBSERVATION

On-site observation has been conducting at Chigashira Bridge. Figure 1 shows location of the bridge. Figure 2 shows the dimensions of the bridge and set positions of measuring instruments. The bridge is in Ato town, Yamaguchi city, Japan. The bridge is a plate girder bridge (3 main girders) with length of 60m. On-site measurements have been conducted at side view on P1 as shown Figure 2(a). In Figure 2(b), main girders of the bridge assumed G1, G2, and G3 from south side, and stringers assumed S1 and S2. The pedestrian bridge is adjacent to G3 side. On the occasion of elucidation of the corrosion environment at the bridge, air temperature and humidity were measured by air temperature and humidity logger which set in five places as shown Figure 3(a). Temperature of girders were also measured at two points on G2, lower part of web (B1) and upper part of web (B2). Amount of airborne salt was measured by dry gauze method which set in nine places as shown Figure 3(b). Amount of adhering salt on steel sheet which set in fifteen places were observed as shown Figure 3(c). Exposure test was also performed by exposed specimens (10mm × 10mm × 2mm) which set in the place same as steel sheets as shown Figure 3(c). The film thickness meter measured the rust thickness of exposed specimens. Average thickness of each specimen was computed by average of rust thickness of five points on each specimen. An observation at the bridge was started from September 29, 2015, and it is still ongoing. All observation data was measured once a month.

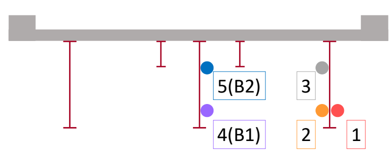
Figure 1. Location of Chigashira Bridge.



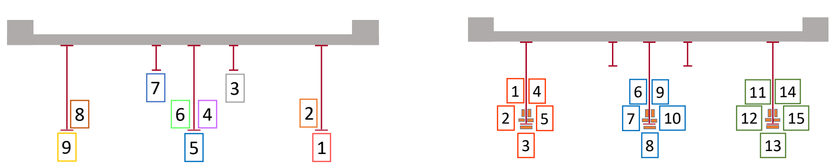
(a) Side view.

(b) Cross section

Figure 2. Outline of Chigashira Bridge.



(a) Air temperature and humidity logger.
(Girder temperature logger)



(b) Dry gauze

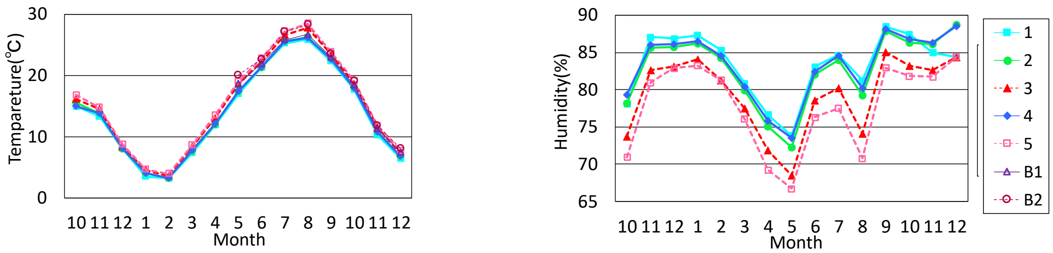
(c) Exposed specimen and steel sheet.

Figure 3. Set positions of measuring instruments.

3 RESULT OF OBSERVATION

3.1 Temperature and Humidity

Figure 4 shows changes of air temperature, humidity and girder temperature from October 2015 to December 2016 (Girder temperature logger started measurement from May 2016). From Figure 4(a), temperature at upper part of web (No.3 and 5, and B2) is higher than lower part of web (No. 1, 2, and 4, and B1), and there is a maximum difference between temperature of No. 5 with No. 1 that reached 2.6℃ in August 2016. From Figure 4(b), humidity at the lower part of web is higher than the upper part of web, and there was a maximum difference between humidity of No. 5 with No. 1 are reached 10.4% in August 2016. In August 2016, daily changes of the maximum/minimum temperature and humidity are shown in Figure 5. From Figure 5(a), maximum temperature other than outer girder (No. 1) are almost same. However, in Figure 5(c), minimum temperature at the upper part of web is higher than lower part. Regarding humidity, from Figure 5(b), maximum humidity at lower part of web is higher than upper part, and from Figure 5(d), minimum humidity was almost same in all sites. Temperature and humidity are not evenly distributed within the cross section, mainly since minimum temperature and maximum humidity are not evenly distributed neither.



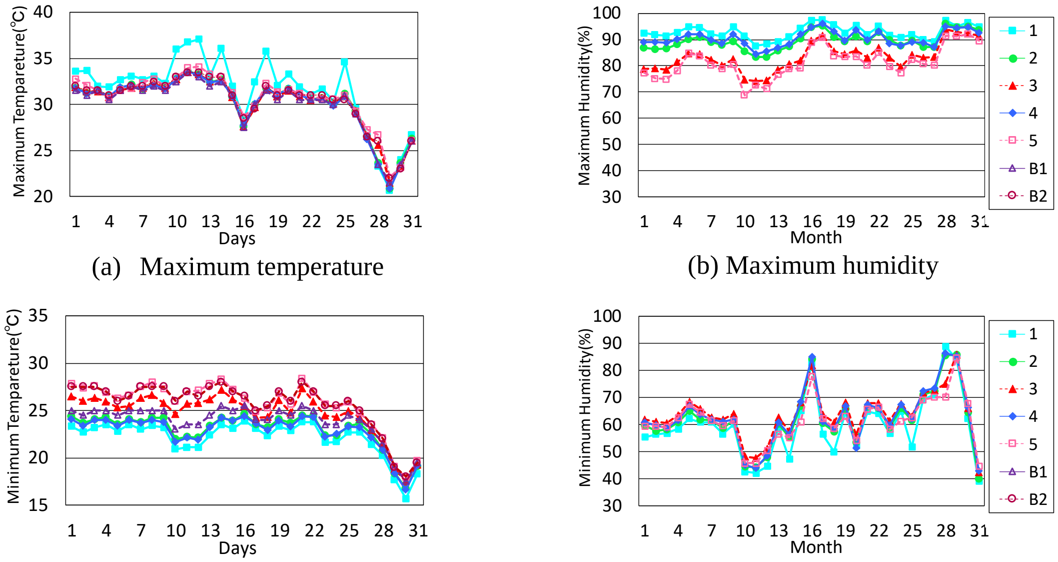
(a) Temperature (b) Humidity

Figure 4. Changes of temperature and humidity by month.

Figure 6 shows the time changes in temperature and humidity in August 23. The time zone painted with yellow indicates the time from sunrise to sunset. From Figure 6, when the sun was not appearing, temperature at the upper part of web (No.3,5 and B2) is higher than the lower part (No. 1, 2, 4, and B1), and humidity at lower part of web is higher than the upper part because the floor plate absorbs in solar heat during the day. On the other hand, during daytime, there is hardly any difference in temperature and humidity between the measurements sites. From the above, temperature and humidity were differed when sun was not appearing on the upper and lower part of web, and upper part of web was affected by solar heat which floor plate suffered.

3.2 Airborne Salt

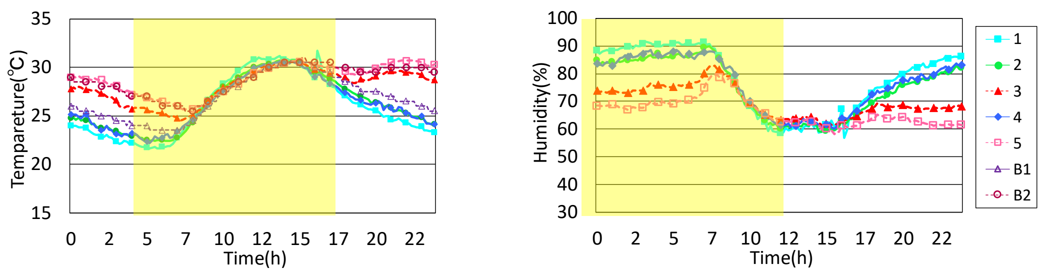
Figure 7 shows amount of airborne salt and transitions of amount of spread anti-freezing agent. The amount of airborne salt of under girders (No. 1, 5 and 9) and part of inner girders (No. 2 and 6) are increased when anti-freezing agents were sprayed on the road. Namely, anti-freezing agent sprayed on the road was scattered to the girder.



(a) Maximum temperature (b) Maximum humidity

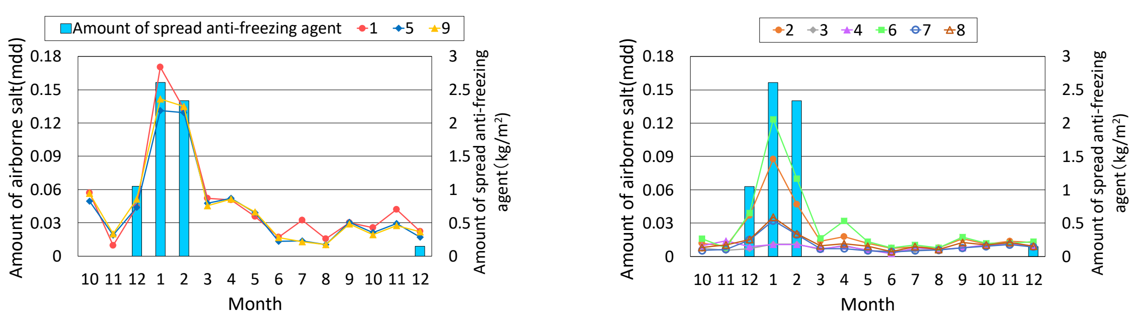
(c) Minimum temperature (d) Minimum humidity

Figure 5. Changes of maximum/minimum temperature and humidity in August.



(a) Temperature. (b) Humidity.

Figure 6. Changes of temperature and humidity in August 23.



(a) Outer girder. (b) Inner girder.

Figure 7. Airborne salinity in different month.

In Figure 7(b), amount of airborne salt has been increased at the inner girders (No. 2, and 6) during anti-freezing agent were scattering. At Chigashira Bridge, winds in the direction of perpendicular to the bridge axis are blowing, and the wind from G3 side is dominant. Figure 8 shows an image of wind currents from G1 side blows into girders. Wind from G1 side enters between girders and is anticipated to flow counterclockwise. At this time, it could be expected that due to No. 6 and No. 2 are faced directly to intruding wind, amount of airborne salt will increase. On the other hand, scattering of anti-freezing agent due to wind from G3 side will be prevented by a pedestrian bridge.

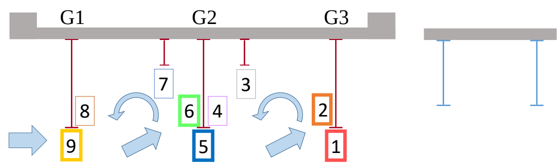


Figure 8. Image of wind currents from G1 side blows into girders.

3.3 Exposure Test

Figure 9 shows corrosion weight loss of one year after from start of exposure. Displayed result is average value of two pieces which set at each point. From measurement results, corrosion weight loss of No. 15 is the largest and then No. 12, 7, and 5 are relatively large. On No. 15, there were sediments considered to have been detached from floor plate. No. 12 and 7 are sites where amount of airborne salt protruded in inner girder due to scattering of anti-freezing agent, and water leakage got splashed to No. 12 because drainpipe of the vicinity of No. 12 has cracked the tip. Therefore, corrosion weight loss of No. 12 larger than No. 7. Even in No. 5, drain pipe is set vicinity of it, and water leakage from the upper part of drainpipe was observed. All of the above parts are located on the upper surface of bottom flange, and it seems that corrosion weight loss has increased since moisture and corrosion promoting substances tend to accumulate structurally. The sites where corrosion weight loss exceeds 0.02μm at the part other than upper surface of bottom flange are No.3 on lower surface of bottom flange and No. 6 on web. In No. 3, it is assumed water leakage falls on No. 5 and was trickled to No. 3. As in No. 7, No. 6 is considered to be influence of scattering of anti-freezing agent. From the above, it was revealed that the influence on rust thickness was dominant by water leakage or sediments at the lower surface of bottom flange and scattering of anti-freezing agent at the web. In addition, anti-freezing agent was sprayed at Chigashira Bridge during winter, therefore there is a possibility that anti-freezing agent is dissolved in water leakage (NILIM 2014).

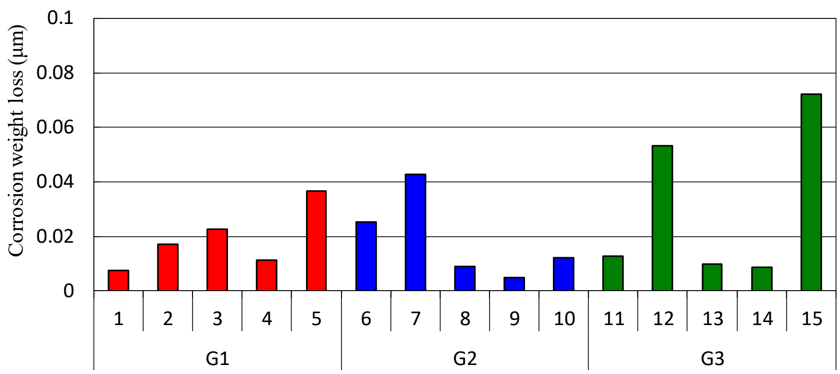


Figure 9. Corrosion weight loss on exposed specimen.

4 CONCLUSION

The corrosive environment was investigated in Chigashira Bridge which is located in mountainous area. From measurement results, temperature and humidity environment around the girders became clarify, and the difference was observed at lowest temperature and highest humidity in each site. In addition, as a result of the time changes of temperature and humidity, it was found that temperature and humidity differed in the time period when sun was not appearing on the upper and lower part of web. However, temperature and humidity distribution during the day was uniform in each site. Then, results of comparing amount of airborne salt and amount of spread anti-freezing agent, it was found that anti-freezing agent scattered to the girder, and there are sites where corrosion weight loss has increased due to scattering of anti-freezing agent. Then, anti-freezing agent was sprayed at Chigashira Bridge during winter, therefore it is possible that the anti-freezing agent is dissolved in water leakage. These results can be applied to a corrosive environmental simulation of steel bridges.

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