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AN INVESTIGATION OF CORROSION ENVIRONMENT OF A BRIDGE CONSTRUCTED IN MOUNTAINOUS AREA

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Corrosion occurred on steel bridges which were constructed in mountainous area. However, few studies have investigated the corrosive environment of steel bridge in mountainous area. In this research, Temperature, humidity, wind conditions and amount of airborne salt have been observed at bridge site. In order to comprehensively assess corrosive condition, exposure test was also performed. Observation and exposure test were conducted at the steel plate girder bridge with 60m length and three main girders. During observation period, anti-freezing agent (Na-Cl) is sprayed in winter. From the observation, time of wet on the bridge is longer than bridges those were constructed at coastal area. It was clearly observed that flying behavior of anti-freezing agent around superstructures is influenced by the prevailing wind. Furthermore, distribution of amount of adhesion salt at the surface of steel in the bridge section was also clarified. Rust thickness of exposure specimen was revealed that the influence of anti-freezing agent, and at lower flanges becomes larger than that of web. These results can be applied to corrosive environmental simulation of steel bridges.

Keywords: Corrosion, Weathering steel, Bridge, Exposure test, Anti-freezing agent.

1 INTRODUCTION

In Japan, from 1978 to 2014, weathering steel bridges has increased to about 20% of the total steel bridges (JBA 2015). If it is generating protective rust on the design plan in weathering steel bridges, it is possible to reduce the corrosion rate. In other words, if it is possible to reduce the corrosion rate by a protective rust, eliminates the need for corrosion protection by paint, it can be the reduction of life-cycle-cost (Yamaguchi *et al*. 2006). However, in some bridges that were constructed at coastal area, protective rust did not formed due to large amount of airborne salt and high humidity. Therefore, in the construction of the weathering steel bridge, it is important to determine the propriety of the corrosive environment in the installation point. Conventionally, it has been paying attention to airborne salt as one of determine the propriety, thus there are lot of researches about corrosive environment of steel bridges constructed in coastal area. But corrosion due to anti-freezing agent also occurred on steel bridges which constructed in mountainous area (Iwasaki *et al*. 2012, NILIM *et al*. 2014), and few studies have investigated the corrosive environment of steel bridge in mountainous area. This paper aims to clarify the corrosive environment of the mountainous area bridge. Temperature, humidity, wind conditions and amount of airborne salt have been observed at bridge site.

In order to comprehensively assess total corrosive condition, exposure test was also performed.

2 SITE OBSERVATION

On-site observation was conducted at Chigashira Bridge. Figure 1 shows location of the bridge and other steel bridges which constructed in coastal area compare with the bridge. Figure 2 and Figure 3 displays outline of the bridge and Table 1 indicates overview of the bridge. The bridge is located in Ato town, Yamaguchi city, Japan. The bridge length is 60 m, and it is a plate girder bridge with 3 main girders. In Fig 2, main girders of the bridge assumed G1, G2, and G3 from the south side, and strain girders of it assumed S1, S2 from the south side.

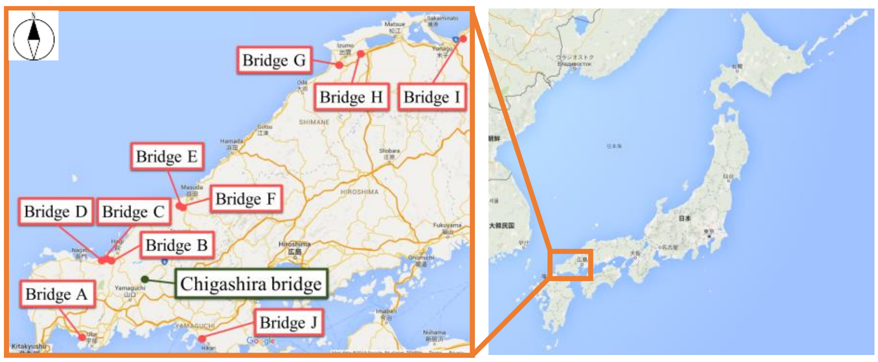


Figure 1. Location of bridges.

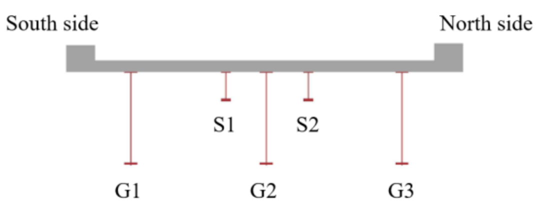


Figure 2. Cross section of Chigashira bridge.

Figure 3. Chigashira bridge.

Table 1. Overview of Chigashira bridge.

Location	Root 9, Ato town
Bridge length (m)	60
Offshore distance(km)	20
Direction of the bridge axis	Northwest-Southeast
Type	Plate girder bridge with 3 main girders

On the occasion of elucidation of the corrosion environment at the bridge, airborne salinity was measured by dry gauze method which installed in nine places. Adhering salinity was measured by steel sheet which installed in fifteen places. Wind direction and wind speed were measured by anemometer which installed in south end of the inspection passage. Temperature and humidity were measured by logger which installed in five places. Exposure test was performed by exposed specimens (10mm×10mm) which installed in the place same as a steel sheet (six pieces). Rust thickness was measured by film thickness meter. Average thickness of each specimen were computed by average of rust thickness of five points on the specimens. An observation at the bridge was started from September 29, 2015, and it is still ongoing.

3 RESULT OF OBSERVATION

3.1 Time of Wet and Wind Condition

In Chigashira bridge, ratio of time of wet was calculated from temperature and humidity, and Fig.4 shows compared with ratio of time of wet of steel bridges constructed in coastal place (past of the same period). The ratio of time of wet was found by dividing total of measurement time from total of time of wet. The time of wet defined as the temperature at 0℃ or more and a humidity of 80% or more of time by ISO.

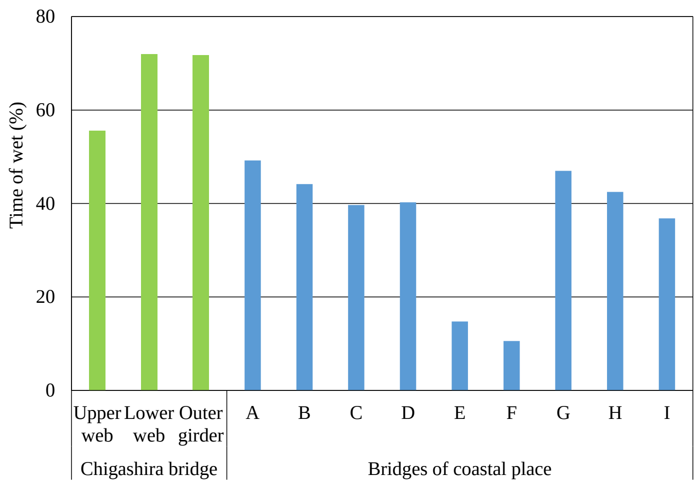
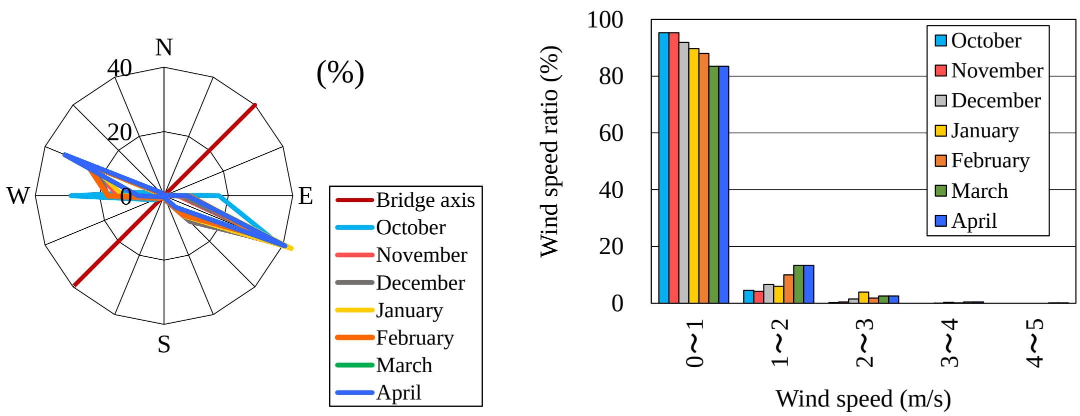


Figure 4. Comparison of time of wet.



(a) Wind rose (b) Wind speed ratio

Figure 5. Wind condition of Chigashira bridge area in different month.

From Fig.4, ratio of time of wet of all parts in Chigashira bridge were bigger than that of steel bridges constructed in coastal place. Figure 5 (a) shows wind rose, and Figure 5 (b) shows wind speed ratio. From Fig.5 (a), prevailing wind was from east southeast every month. It is bridge axial orthogonal direction. From Fig.5 (b), wind speed has become stronger every month, but wind ratio of 0~1 m/s indicates a more than 80% every month. From, wind conditions of around Chigashira bridge, it can be seen that gentle wind is mainly blowing bridge axial orthogonal direction.

3.2 Airborne Salinity

Figure 6 shows the installation position of dry gauze and the status of inflow wind. Fig.7 shows airborne salinity that measured from October, 2015 to March, 2016, and Fig.8 shows transitions of anti-freezing agent and airborne salinity of No.5. From Fig.7, airborne salinity of under the girder (No.1, 5 and 9) and part of inner girder (No2 and 6) increased from December, 2015 to January, 2015. This type of phenomenon is due to the anti-freezing agent. Because from Fig.8, airborne salinity has also increased with the increasing of anti-freezing agent. As a result, anti-freezing agent scattered to the girder. In addition, amount of airborne salt of No.2 and 6, the prevailing wind is affecting. Because prevailing wind blows from the G1 side, and flows into the girder as shown in Fig.6.

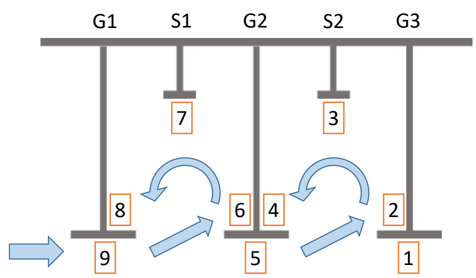


Figure 6. Installation position of dry gauze and the status of inflow wind.

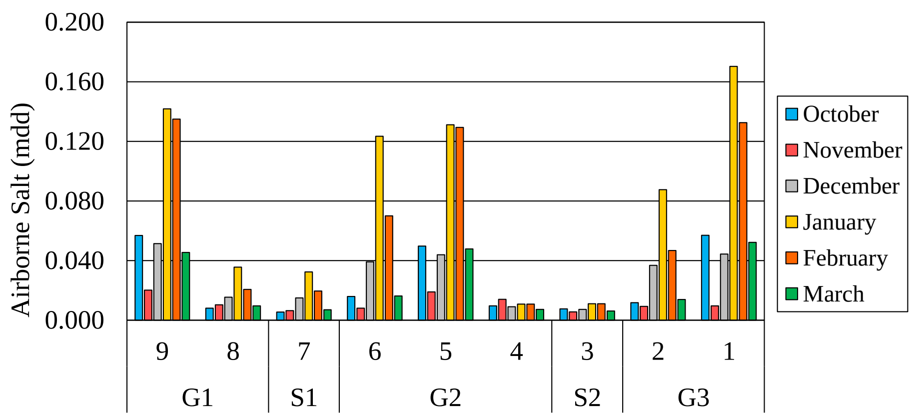


Figure 7. Airborne salinity in different month.

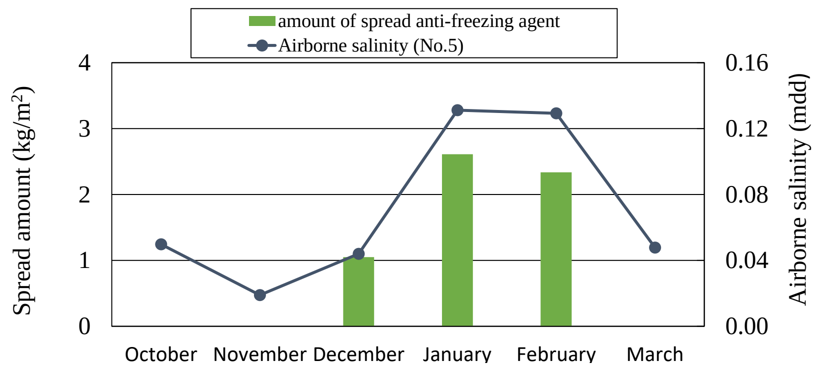


Figure 8. Transitions of anti-freezing agent and airborne salinity (No.5).

3.3 Exposure Test

Figure 9 shows installation position of exposed specimens. Figure 10 shows rust thickness of exposed specimens that measured from October, 2015 to April, 2016. From Fig.10, focusing on exposed specimens of inner girder (No.4, 5, 6, 7, 9, 10, 11 and 12).

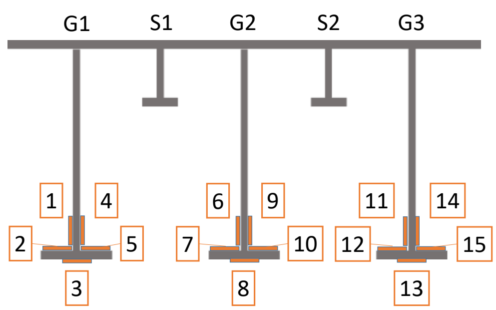


Figure 9. Installation position of exposed specimens.

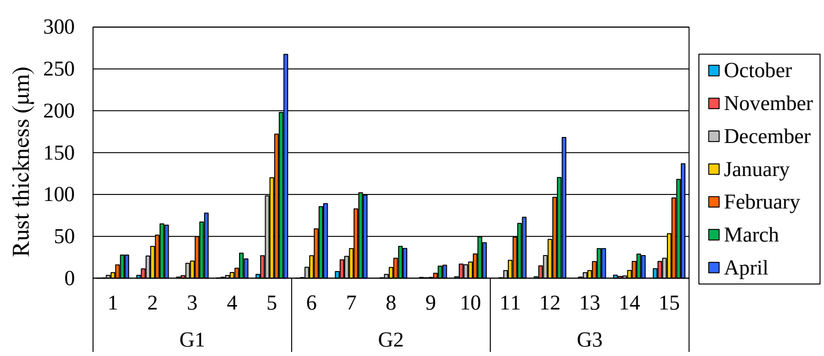


Figure 10. Rust thickness on exposed specimen.

In inner girder of G1G2, rust thickness of No.5 is shown maximum because rust liquid had been deposited in November. But in web, rust thickness of No.6 of susceptible to prevailing wind is more growth than rust thickness of No.4. And in inner girder of G2G3, rust thickness of 11 and 12 of susceptible to prevailing wind were more growth than rust thickness of No.9 and 10. From these, rust thickness of inner girder is affected by the anti-freezing agent that scattered by prevailing wind. Figure 11 shows the time course of rust thickness at Chigashira bridge and steel bridges constructed in coastal place in the L.flg lower surface. From Fig.11, rust thickness of Chigashira bridge was bigger than that of Bridge A to Bridge F. This is assumed to be related to the fact that there are more time of wet at Chigashira bridge compared with that of steel bridges constructed in coastal area, and anti-freezing agent scattered to the girder in Chigashira bridge.

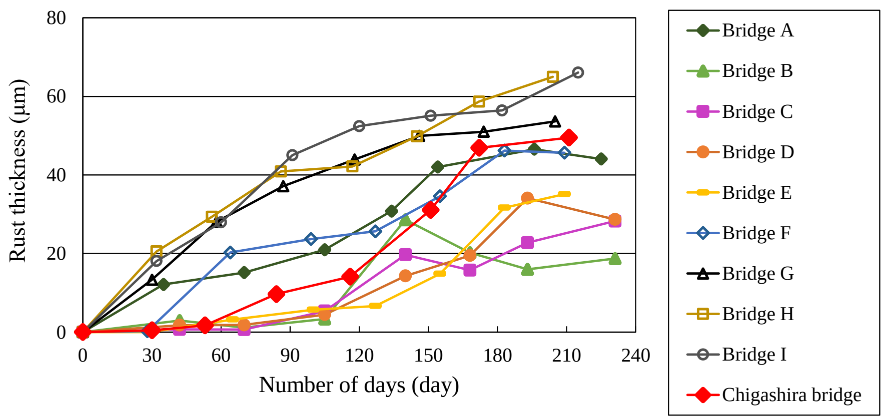


Figure 11. Comparison of rust thickness.

4 CONCLUSION

The corrosive environment investigated in Chigashira bridge, which is located in mountainous area, and ratio of time of wet and rust thickness, were compared with steel bridges constructed in coastal areas. From the fact that airborne salinity has also increased with the increasing of anti-freezing agent, anti-freezing agent was scattered to the girder. In addition, scattered of anti-freezing agent by prevailing wind is the main, prevailing wind affected airborne salinity of especially under the girder and part of inner girder. For rust thickness, prevailing wind affected rust thickness of especially part of inner girder. In comparison with steel bridges constructed in coastal place (Bridge A to Bridge I), rust thickness of Chigashira bridge was bigger than that of Bridge A to Bridge F. This is assumed to be related to the fact that the length of the time of wet and anti-freezing agent is affected to rust thickness. These results can be applied to corrosive environmental simulation of steel bridges.

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