INVESTIGATION OF DEW CONDENSATION ENVIRONMENT OF A BRIDGE IN MOUNTAINOUS AREA

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1. INTRODUCTION

Corrosion is one of the most important factor of degradation of steel infrastructures which affects their long term performance and durability. Thus, it is important to accurately evaluate corrosion environment of steel bridge for an appropriate corrosion prevention and maintenance management. This research aims to evaluate the corrosive environment of a steel bridge constructed in mountainous area on-site by field measurement. Hence, Evaluation of dew condensation as a results of air temperature and relative humidity which is one of the fundamental corrosion factor of steel bridge was carried out at Toyokuni bridge. The outcome of present investigation revealed that the dew can easily occur in mountainous area and confirmed the corrosion environment.

2. EVALUATION OF DEW CONDENSATION

In this study, the dew- point temperature (T_{DEW}) is obtained as a following:

i. Atmospheric temperature and relative humidity were obtained on-site by field measurement.
ii. The dew point-temperature is calculated from air temperature and relative humidity at saturated vapor pressure by using Sonntag's equation either from equation (1) or (2). Here y= ln (÷611.213).

In case of $y \geq 0$;

$$T_{Dew} = 13.715 \times y + 8.4262 \times (10^{-1}) y^2 + 1.9048 \times (10^{-2}) \times y^3 + 7.8158 \times (10^{-3}) \times y^4 \quad (1)$$

In case of $y < 0$;

$$T_{Dew} = 13.7204 \times y + 7.36631 (10^{-1}) y^2 + 3.32136 \times (10^{-2}) \times y^3 + 7.78591 \times (10^{-4}) \times y^4 \quad (2)$$

iii. Dew condensation can be evaluated by subtraction of girder temperature from dew point-temperature (Δt=TDEW-T). The dew occur whenever Δt is greater than zero.

3. OVERVIEW OF SITE OBSERVATION

On-site observation has been conducted at Toyokuni bridge. Fig. 1 shows the bridge overview, Fig. 2 shows the bridge cross section and set position of measuring instruments. This bridge is located in Aichi prefecture, Japan. This is steel girder bridge with length of 180 m.

4. FIELD MEASUREMENT

4.1 *Comparison of measured temperature and humidity using meteorological observatories*

In this study, the air temperature and relative humidity was obtained at Toyokuni bridge. The measurement was conducted for month of December 2018. Fig. 3 shows the simultaneously comparison results of bridge temperature with Nagoya and Shinshiro meteorological observatories (MO). As indicated by the graph, the Toyokuni temperature was lower compare to both (MO) in the entire month. Fig. 4 shows the comparison results of Toyokuni humidity using only Nagoya (MO) because the Shinshiro doesn't record humidity, the value of humidity is higher at the targeted bridge as compare to meteorological observatory and it is reached to more than 96% during the month. However, the light blue line of the graph shows the rainy days in the graph.

4.2 *Evaluation of dew condensation at Toyokuni bridge*

Fig. 5 demonstrates the evaluation of dew condensation based on air temperature in the bridge. The difference between temperature and dew point- temperature became small and continuously increased the tendency of dew condensation. From filed measurement result, we clearly see the dew occurred around the bridge and that environment caused corrosion of bridge.

The result obtained by the atmospheric corrosion monitoring (ACM) sensor is presented in Fig. 6. Additionally, this graph clearly shows the dew condensation, as a result of the current corrosion value being within the range of 0.01-0.1. This range is a remarkably accurate statement of the dew condensation. Moreover, the corrosion current amount at AMC2 is higher compare to ACM1, it means the higher corrosion will occur at flange as compare to web. Hence, the evaluation result obtained by the ACM sensor during the on-site field measurement also confirms the dew condensation. Furthermore, Fig. 7 shows the comparison of the girder temperature of web at point (A) and flange at point (b) with dew-point temperature. As indicated by the graph that although the girder temperature is higher compare to dew point –temperature, but the dew occurred in the bridge because the corrosion current at AMC2 shows dew. This might be due to high value of humidity and low value temperature as shown in Fig. 3 & Fig. 4.

Keywords: Steel bridge, dew condensation environment, maintenance management.
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Figure 1: Toyokuni bridge overview.

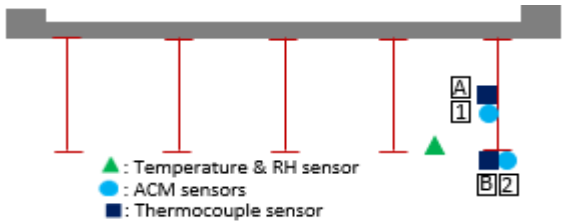

Figure 2: Set position of measuring instruments.

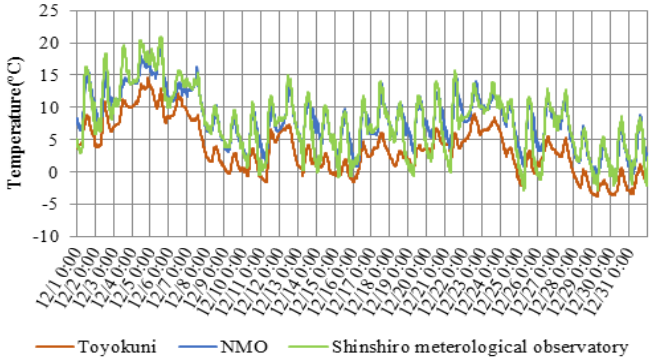

Figure 3: Comparison of Toyokuni bridge temperature using Nagoya & Shinshiro metrological observatories.

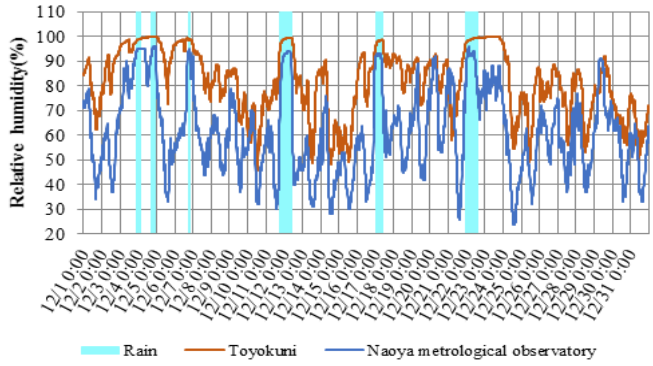

Figure 4: Comparison of relative humidity of Toyokuni bridge using NMO for December 2018.

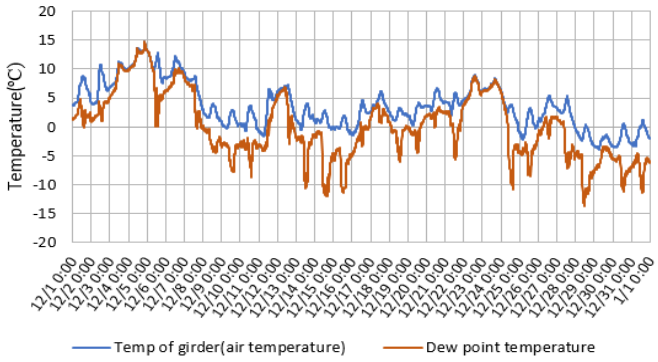

Figure 5: Comparison of temperature and dew- point temperature for December 2018.

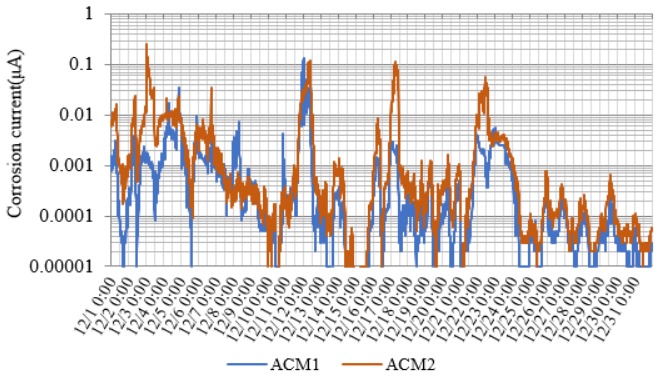

Figure 6: Evaluation of dew condensation by ACM sensor.

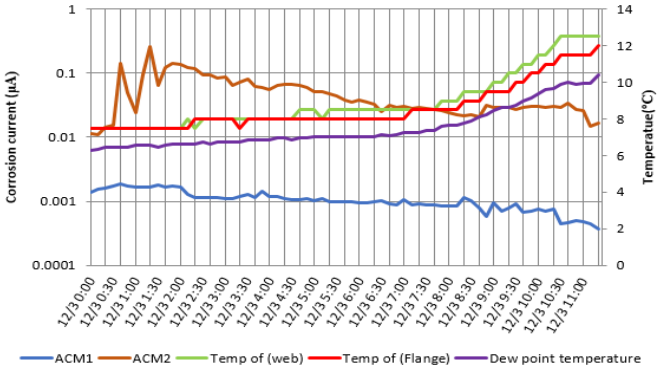

Figure 7: Corrosion current by ACM sensor and dew- dew point temperature at Toyokuni bridge.

5. CONCLUSIONS

Corrosion of steel bridge due to aging being increased in Japan, and it is necessary to accurately evaluate the corrosion environment of steel bridges for corrosion prevention. Hence, in this study an investigation of dew condensation environment of Toyokuni bridge which is located in mountainous area was carried out using field measurement. The following summary can be made:

- The present investigation revealed, that dew condensation occurred in Toyokuni bridge, the higher corrosion will occur at flange of girder compare to web.
- The previous investigation of dew condensation in flat area shows that dew can occur when the girder temperature either equals or falls below the air-temperature. While in such, mountainous area the dew can occur even the girder temperature is a little higher compare to air temperature.
- In mountainous area, the dew condensation may occur even girder temperature and dew point –temperature are close to each other's or even if the difference between girder and dew point-temperature is 1°C-3°C.
- The evaluation result of dew condensation which was carried out you using WRF in the last couple of years, was confirmed by this filed measurement. The present investigation also confirmed dew as well as WRF.