Priority Subjects — **Further Improvement of Facility Operations and Maintenance Technologies**

Development of Soundness Assessment Techniques for Aged Overhead Transmission Steel Towers

Background and Objective

The aging of overhead transmission steel towers constructed during Japan's high economic growth (almost two full decades beginning from 1954) has progressed rapidly, giving rise to a need for the standardization of their repairing and rebuilding, which must also be performed with efficiency. Meanwhile, in the 2011 Tohoku Earthquake, larger accelerations than these observed in the Southern Hyogo prefecture earthquake of 1995 were observed, therefore, it is also necessary to gain an understanding of the seismic performance of steel towers against high-level earthquake ground motion.

In order to contribute to the efficiency and rationalization of maintenance for aging overhead transmission steel towers, this project aims to develop comprehensive diagnostic methods for their soundness, including a remaining life assessment considering corrosion and fatigue, a more efficient corrosion inspection method and a foundation stability assessment. In addition, we aim to clarify the seismic margin of steel towers considering elastic-plastic behavior against high level earthquake ground motion.

Main results

1 Observation and mapping of corrosive environmental factors

For quantitative evaluation of corrosion factors in inland areas, devices for measuring corrosive environments were installed on an existing transmission tower (Narita-shi, Chiba-ken) and observations begun. Moreover, an annual averaged map of airborne sea salt (in the Kanto region) was made by trialing the super high resolution meteorological simulation database for 53 years (CRIEPI-RCM-Era2) created by the Numerical Weather Forecasting and Analysis System of CRIEPI (NuWFAS) and the simulation code of sea-salt transport (NuWiCC-ST). The predicted amount of annual averaged airborne sea salt using the NuWFAS data reproduced qualitative variation in the observed amount of deposited sea-salt (Fig. 1).

2 Evaluation of effects to inner corrosion of steel pipe for transmission towers: horizontal or diagonal arrangement to the ground

Steel pipes placed horizontally or diagonally to the ground to simulate horizontal and diagonal brace of an actual transmission tower, were exposed at Yokosuka coastal testing field. Several ACM (Atmospheric Corrosion Monitoring)*1 sensors were inserted into these steel pipes in the longitudinal direction to evaluate their internal corrosion rate. It appeared that the ACM sensors in the diagonally-arranged pipe showed a higher corrosion rate than that of the horizontally-arranged pipe (Fig. 2). The results acquired in this study will be utilized for the estimation of corrosion rate of each part and site of transmission tower and the identification of the parts and sites which need preferential maintenance inspection (Q13007).

3 Surveys and database construction for the current corrosion states of aging steel towers

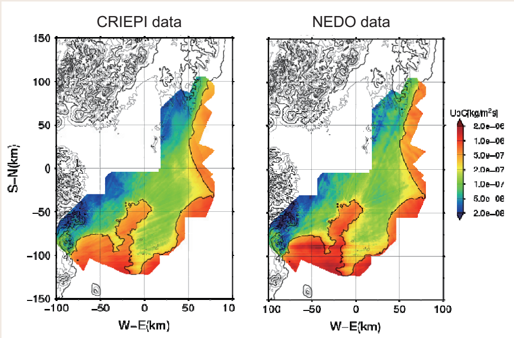
In order to identify the current deterioration states of aging steel towers mainly caused by corrosion, 41 steel towers installed in 25 transmission lines were surveyed from a coastal to mountainous area in Japan. The survey results showed typical corrosion states in that, corrosion in the coastal area was mainly caused by sea salt while that in the mountainous area was mainly caused by fog and dewfall. As a result, typical corroded environmental conditions for steel towers were specified. Based on the survey results, a database for ageing steel towers was constructed. The database includes not only the actual corrosion survey results, but also meteorological environment information and the basic design condition of steel towers, making it a useful tool for effective maintenance action.

4 Observations of pile foundation of steel tower and ground around foundation

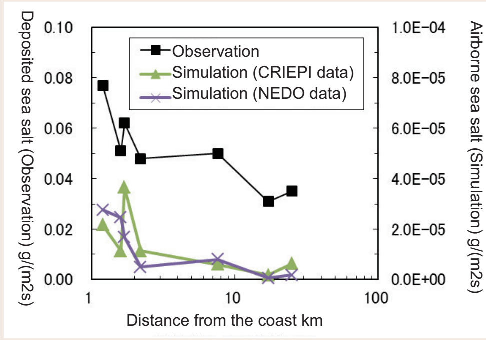
In order to clarify the earthquake behavior of steel tower pile foundation, a seismometer above the foundation and strain gauges of the pile top were installed in the full-scale test facilities for snow-storm damage to overhead transmission lines at Kushiro-shi, Hokkaido (Fig. 3). Time-dependent changes of the strain gauges in the construction phase of the tower were observed prior to the dynamic observation.

Measurement was carried out by setting up a developed borehole inclinometer with FBG optical fiber sensors*2 on a slope (Saikai-shi, Nagasaki-ken) where the mechanism of behavior was unclear. By setting up these sensors, we will acquire the basic data for the development of stability evaluation method for tower foundations.

*1 Sensor for measuring the corrosion rate of metal in a given environment.
*2 This inclinometer can measure subterranean displacement at a 20 cm pitch, which is more accurate than conventional measurement techniques.



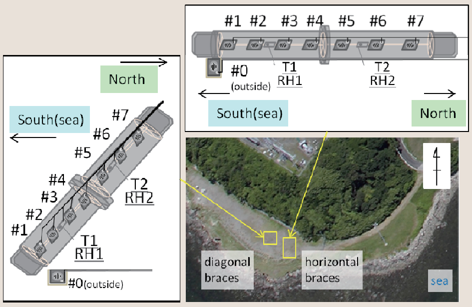
(a) Annual-averaged map of airborne sea salt (the Kanto region)



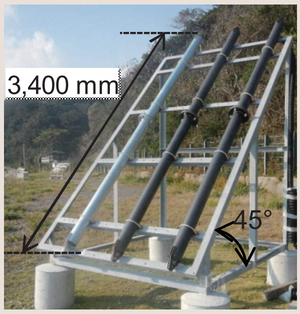
(b) Comparison with observation data (measured values using ACM sensors by TEPCO)

Fig. 1: Trial production of an annual-averaged map of airborne sea salt

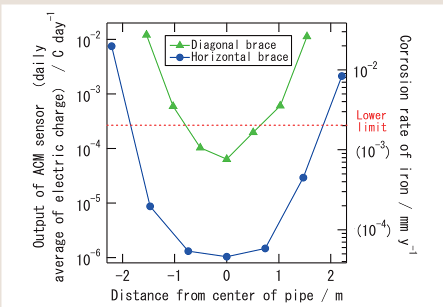
Airborne sea-salt maps were made based on occurrence frequencies of wind velocity at sea taken from the meteorological database for 53 years simulated by NuWFAS (CRIEPI data) and the existing database simulated by LAWEPS (NEDO data). In comparison with observed values of deposited sea salt and predicted values of airborne sea salt, the map using CRIEPI data was found to more precisely reproduce qualitative variation than the map using NEDO data.



(a) Schematic diagrams of ACM sensors arranged in horizontal and diagonal braces arranged at Yokosuka coastal testing field.



(b) Photo of diagonal braces arranged at a testing field.

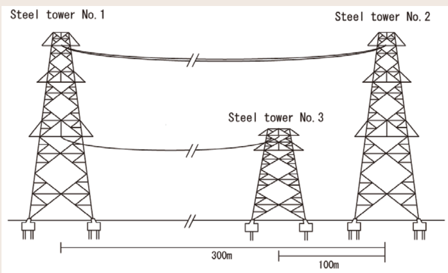


Lower limit in the figure shows the minimum effective value to calculate corrosion rate.

(c) Corrosion rate of inside horizontal and diagonal braces in June, 2013.

Fig. 2: Result of exposure test: horizontal and diagonal braces

Simulated horizontal and diagonal braces were arranged at a coastal testing field. Seven ACM sensors were arranged in both pipes at a regular interval in a longitudinal direction. An ACM sensor was also arranged outside the pipe. The sensors in the diagonal brace showed larger values than the ones in the horizontal brace. Particularly in the center, quite a significant difference in values for the diagonal and horizontal cases was observed. It is presumed that this difference depends on the inflow of corrosive substance into the steel pipes.



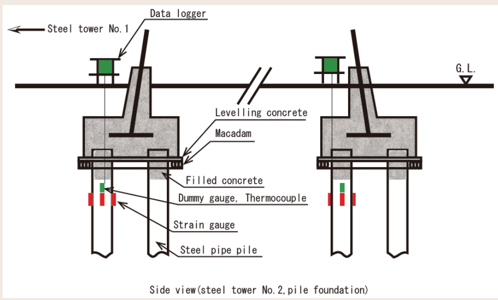


Fig. 3: Dynamic observation equipment of steel tower pile foundation

A seismometer above the foundation and strain gauges of the pile top were installed in the full-scale test facilities for snow-storm damage to overhead transmission lines at Kushiro-shi, Hokkaido (Installed in March 2014. Scheduled start of the dynamic observation is August 2014).