Project Research — **Establishment of Optimal Risk Management**

Evaluation of Damage to Overhead Transmission Facilities Caused by Wind, Snow, and Salt

Background and Objective

In December 2005, severe snowstorms on the coast of the Sea of Japan caused damage to overhead transmission facilities as follows: the partial collapse of transmission towers resulting from an overload of heavily accreted snow, short-circuit accidents involving transmission lines caused by galloping,* and the failure of electrical insulators, or flashover due to sea salt contained in the snow. In the winter season in 2011, there were also heavy snowfalls. These phenomena have given us a valuable precept such that the verification of the effectiveness of measures against snow-related damage and the improvement of its analysis and prediction methods are important for stable electricity supply.

In this project, the field observation of snow accretions on transmission facilities, conductor oscillation, and their related atmospheric conditions has been continued, and a consolidated database system of snow-related damage and meteorological information has also been devised, aiming to elucidate the physical process of snow-related damage and to improve its prediction methods.

Main results

1 Continuous Operation of Field Observations and Consolidated Data Management Systems

In order to understand the mechanisms of snow-related damage to overhead transmission facilities, the field observation in seven sites in Japan and the operation of a data management system to store practical examples of snow-related damage and their meteorological conditions were continued. The field observation system of snow accretion consisting of simple devices using a short dummy conductor supported by fine-stranded wire ropes (N11030) was also enhanced. A simple method for judging accretion type classification as well as sets of equations for discrimination between rain, dry snow, and wet snow (N11059) were proposed through an investigation into the features of snow accretion using observed datasets. The use of the concept of classification can improve the accuracy of a snow accretion model. The field observation data of the galloping of four-bundled conductors were also analyzed in a time period when snow accretion was observed. The results show that the galloping can occur only in the limited range of wind speed, which can be reasonably explained by the increase in the static angle of attack with the wind speed (N11032).

2 Flashover Voltage Property of Snow-accreted Insulators and the Verification of the Efficiency of Measures against Snow Damage

Field observations for snow accretion properties of various types of insulators under natural conditions were continuously performed in the Niigata Kaetsu area of Japan (H11014), and 154 kV-class full-scale artificial flashover voltage tests of snow accreted insulators were also carried out (H11018). The test results showed that packed and wet snow could easily bridge the gaps between the sheds of long rod insulators rather than cap & pin insulators and that the flashover voltages of cap & pin insulators were sufficiently higher than those of long rod insulators. It was confirmed that the substitution of cap & pin insulators for long rod insulators seemed to be reasonable as measures against the snow damage (Fig. 3).

3 Development of a Prediction Method for Sea Salt Concentrations in the Air and the Precipitation

The accretion of sea salt-rich snow on electrical insulators causes a reduction in their insulation resistance. For understanding the sea salt transportation processes and such meteorological conditions, prediction methods for sea salt concentrations in the air and the precipitation are needed. By improving Re-SPRAY (the Regional Sea Salt Physical Process Analytical Model), which could consider the phenomena in the emission, deposition, and transportation processes (Fig. 4 [a]), the sea salt concentrations in the air and the precipitation can be estimated. The coupling system of Re-SPRAY and the NuWFAS (Numerical Weather Forecasting and Analysis System) could predict the spatial and temporal profiles of sea salt concentrations under time-variable meteorological conditions. From the results of Re-SPRAY applied to a heavy snowfall event over the Sea of Japan in the winter of 2010, it was confirmed that the performance of Re-SPRAY was favorable (Fig. 4 [b]) (N11011).

*Self-excited oscillation of conductors due to wind and accreted snow or ice; if the amplitude becomes large or if the oscillation continues, the phenomenon may cause a short circuit or facility failure through fatigue.

Other reports: (H11019), (N11004), (N11012), (N11019) and (V11036)

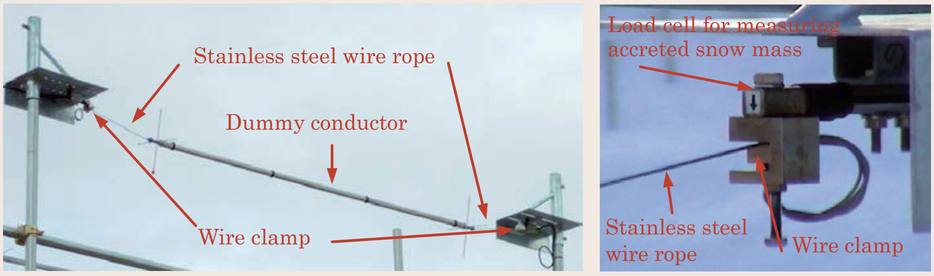
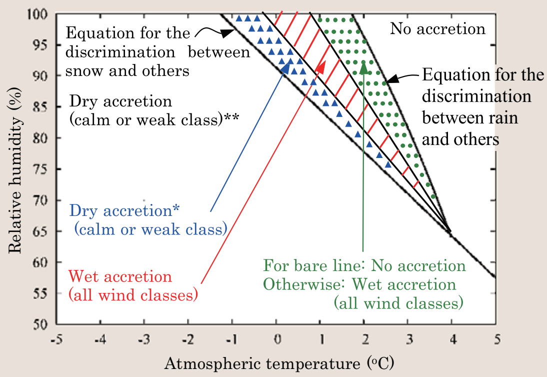


Fig. 1: Simple device for observing snow accretion using a short dummy conductor supported by fine-stranded wire ropes (photo on the left: general view; photo on the right: close-up view of the wire clamp part)

A cylindrical snow sleeve accompanied with the conductor rotation, which is equal to that at the middle of an actual overhead wire of a few hundreds of meters, forms on the dummy conductor when the device is subjected to natural snowfall. The supporting mechanics of the dummy conductor are very simple and are easy to produce and maintain when used for field observation.



* Wet snow accretion may be possible, but field data of wet accretion for this category have not been obtained .

** Strength of wind velocity is classified as follows: calm (< 1 m/s), weak (1 -3 m/s), medium (3 -8 m/s), and strong (> 8 m/s). Wetness of accretion is judged from wetness of precipitation particle.

Fig. 2: Schematic concept of accretion-type classification (example for the eastern Hokkaido area)

This chart uses a set of equations for the discrimination of precipitation type classification. A precipitation type is classified by temperature and relative humidity at each site, and the type of snow accretion can be identified from precipitation type and wind velocity. As the accretion coefficient and density are possible to be estimated according to the accretion type, an improved version of snow accretion model using the chart could be widely used for various climatic areas.

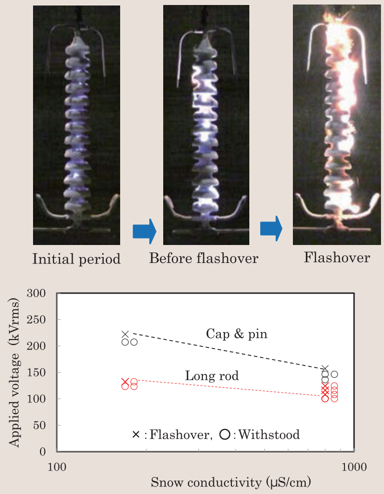


Fig. 3: Results of flashover voltage tests of snow-accreted insulators

The top photos show the discharge activity of snow-accreted cap & pin insulators during voltage tests. A number of air gaps formed in the snow as a result of melting. Thereafter, a long arc grew along the surface and finally developed into a complete flashover.

The bottom shows the relation between snow conductivity and flashover voltage. It can be seem that cap & pin insulators show sufficient higher flashover voltage than long rod insulators.

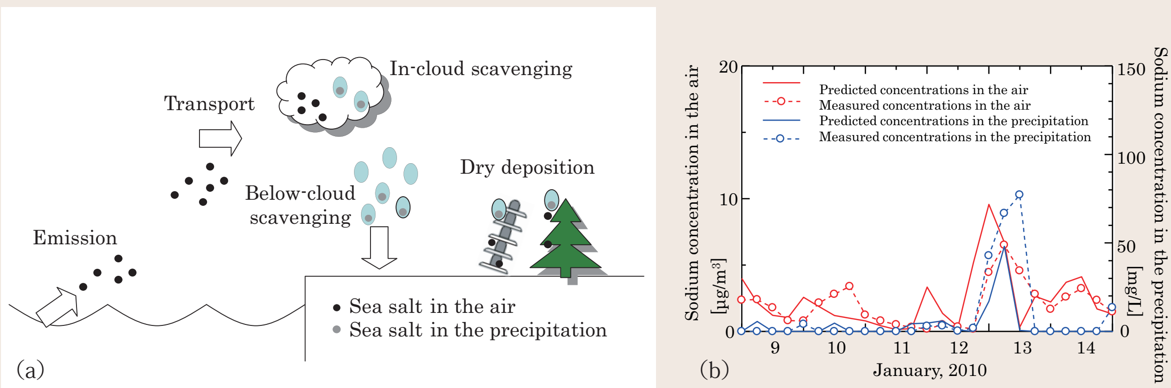


Fig. 4: Conceptual diagram of Re-SPRAY and the numerical result

(a) Conceptual diagram of Re-SPRAY; (b) Comparison of the predicted sodium concentrations in the air and the precipitation with the measured ones; the characteristic behavior of the sodium concentration in the air and the precipitation observed on January 13 can be predicted by Re-SPRAY.