Priority Subjects — **Establishment of Optimal Risk Management**

Establishment of Protective Measure Technologies against Damages of Overhead Transmission and Distribution Facilities Caused by Wind and Snow

Background and Objective

In December 2005, severe snowstorms on the coast of the Sea of Japan caused electric power outage due to damage of overhead transmission facilities. The details of the damage are; the partial collapse of transmission towers resulting from overload of heavy snow accretion, the short circuiting of transmission lines caused by galloping*, and the failure of electrical insulators, or flashover, due to the sea salt contained in the snow. After the power outage due to snow-related damage occurred, CRIEPI began a ten-year research project from FY 2007 to 2016 on damage to overhead transmission facilities caused by severe snowstorms.

In the first phase (from FY 2007 to 2011) of this project, we constructed field observation systems for snow accretions on transmission facilities, conductor oscillation and their related atmospheric conditions and a consolidated data base system for snow-related damage and meteorological information. These systems have been operated continuously. Physical processes of snow-related damage were studied and current measures against it were examined. In the second phase (from FY 2012 to 2016), we will propose effective countermeasures against snow-related damage using practical analysis and prediction methods.

Main results

1 Continuous operation of field observation and consolidated data management systems

Field observation systems in seven sites across Japan have been continuously operated, as well as the data management system to store practical examples of snow-related damage and their meteorological conditions. Also, user-friendliness of the data management system has been improved by enhancing the graphic user interface (Fig. 1). A summary report was published, describing the results obtained from research and analysis in the first phase of the project, aiming to elucidate the physical process of snow-related damage, to improve its prediction methods, and to examine current measures against it based on field observation data (N19).

Furthermore, we have designed full-scale test facilities to be constructed in the eastern Hokkaido area (in Kushiro city) in FY 2013, with the purpose of conducting field observations on snow-related damage to overhead transmission facilities and to examine the effect of measures against it.

2 Development of a simple snow accretion model based on properties of snow particle accretion

In-situ observations of snow accretion on transmission lines are used to develop a method for estimating accretion efficiency. This method takes properties of snow particle accretion into account, together with the effects of wind velocity and countermeasures. From analyzing data sampled by a rod of conductor (N12024), an empirical equation for the density of accreted snow is also suggested, in which the density depends on both wind velocity and temperature. A snow accretion model is proposed based on the above findings, assuming the cylindrical shape of accreted snow. The mass of snow accretion is calculated quite easily by inputting meteorological variables and the direction of the span. Results of application suggest our model works better than traditional models (Fig. 3).

3 Study of the fundamental mechanism of galloping using wind tunnel tests

The large-amplitude and low-frequency galloping of transmission lines was physically simulated in a wind tunnel by employing a unique support technique using a sector model of four-bundled conductors. The applicability of an aerodynamic force model for simulating the galloping of overhead transmission lines was evaluated based on the wind tunnel test results (N12021). The mechanism and effect of a loose spacer in suppressing galloping were clarified in the wind tunnel tests using a sector model of the four-bundled conductors with and without rotatable sub-conductors having specific rigidity (Fig. 4) (N12022).

* Self-excited oscillation of conductors due to wind and accreted snow or ice. If the amplitude becomes large or the oscillation continues, the phenomenon may cause short circuits or facility failures through fatigue.

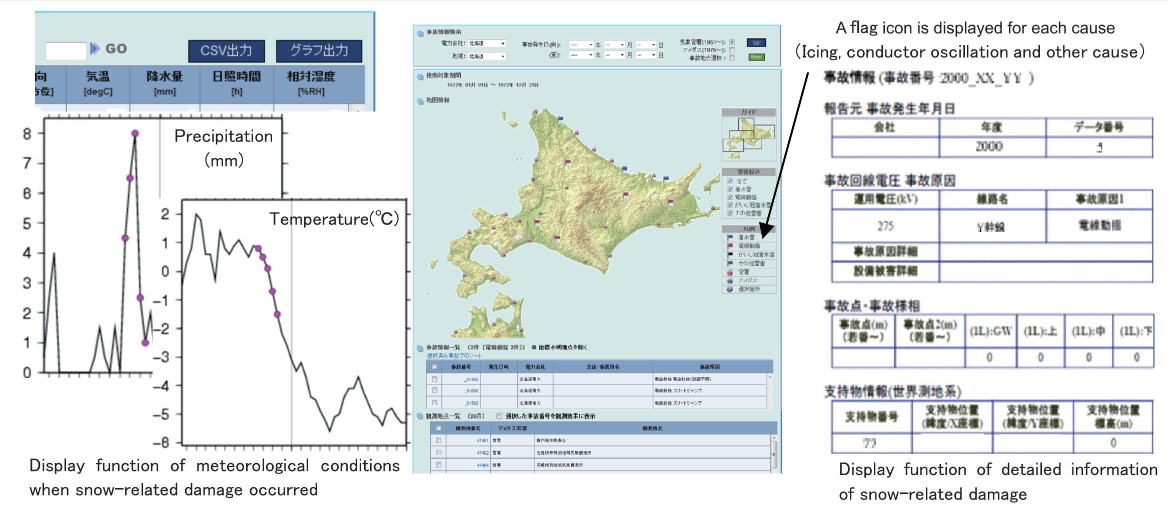

Fig. 1: Sample display windows of the improved database system for damage to overhead transmission facilities due to snow storms and its related meteorological information (Dummy data are displayed on the map.)

Data was not easy to search and analyze efficiently in the data management system before improvements were made. This is due to the fact that the data could be extracted only in text format. In order to improve user-friendliness, the GUI was reformed so that the database can be operated visually by adding a new function of displaying locations of facilities which have suffered snow-related damage and meteorological observation stations on geographical maps.

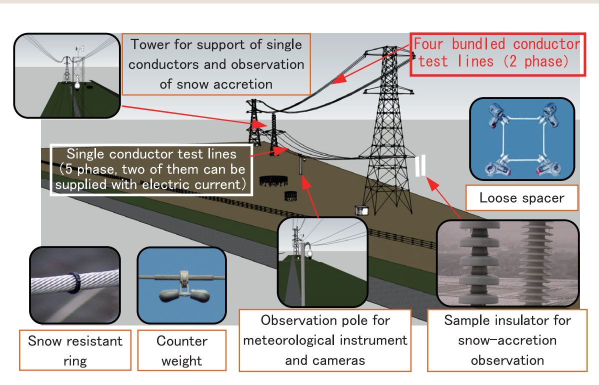

Fig. 2: Full-scale test facilities for snow-storm damage to overhead transmission lines

Field observation under actual conditions is essential for the study of snow-related damage to overhead transmission facilities and examination measures against it. A decision to construct full scale test lines was made by our institute, and a detailed plan for the test lines was designed, composed of 2 towers approx. 50m in height, a tower approx. 30m in height, 2 phases of four-bundled conductors approx. 400m in span length and 5 phases of single conductor approx. 250m in span length. Details of the field observation to be performed are as follows: measurement of fundamental meteorological conditions (wind, temperature, humidity etc.), conductor tension, and observation of snow accretion and conductor oscillation (displacement measurement by image analysis technology). A displacement sensor using GPS, video disdrometer and ultra high sensitive camera will also be used.

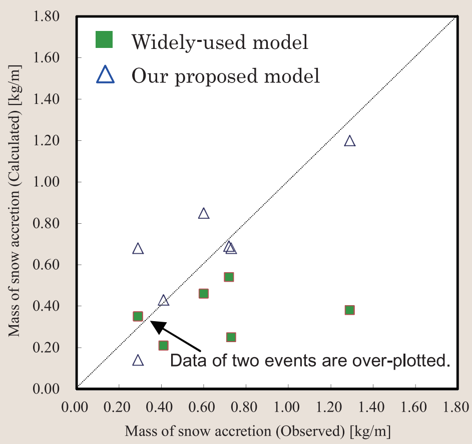

Fig. 3: Calculated and observed mass of snow accretion (applied to 7 events observed at C-line of Hokuriku Electric Power Co.)

Based on our discrimination chart for determination of the type of snow accretion, the accretion efficiency and the density of accreted snow are estimated both for wet and dry snow using meteorological data (temperature, wind velocity, and wind direction). This results in improving the quantitative accuracy and the feasibility of our model. Moreover, the combined use of our model with a meteorological model enables us to analyze and forecast the spatial distribution of snow accretion with fine resolutions.

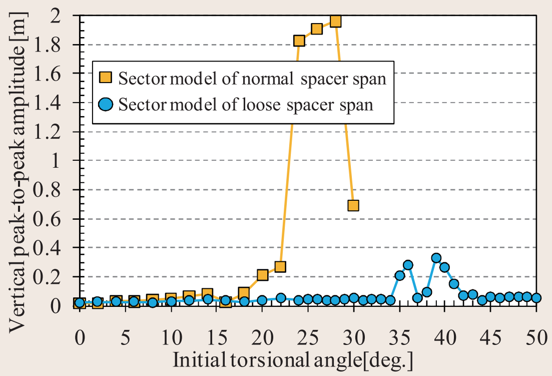

Fig. 4: Galloping suppression effect of loose spacer (results of wind tunnel test, characteristics of vertical peak-to-peak amplitude)

This figure shows an example of the test results obtained for different torsional angles of a sector model of four-bundled conductors with or without rotatable sub-conductors at the same wind speed. When two rotatable sub-conductors were set at the upwind side in the same manner as an actual span with loose spacers, the response amplitude was smaller than that in the case with four rigid sub-conductors as the normal spacer span. Furthermore, the initial torsional angle range where galloping occurred increased when the rotatable sub-conductors were installed.