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

Establishment of Protective Measure Technologies against Damages to 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 the following damages to overhead transmission facilities: the partial collapse of transmission towers resulting from overload of heavily accreted snow, the short circuiting of transmission lines caused by galloping*1, and the failure of electrical insulators, or flashover due to heavily accreted snow containing sea salt. After the occurrence of snow-related damage, CRIEPI began a ten-year research project from FY 2007 to 2016 on damage to overhead transmission facilities caused by severe snowstorms. This project is conducted in cooperation with electric power companies.

In the first phase (from FY 2007 to 2011) of this project, field observations were mainly conducted in order to elucidate the physical processes of snow-related damage and to examine current countermeasures. The second phase of the project commenced in FY 2012 to propose effective countermeasures against the snow-related damage using practical analysis and prediction methods. Applicability of the research results to distribution facilities is also investigated.

Main results

1 Continuous operation of field observation and consolidated data management systems

On the Kushiro Test Line constructed in FY2013, we obtained some samples of noticeable wet-snow accretion with strong wind, which clearly suggest conditions that the effect of the snow resistance ring, a representative anti-icing device, tends to appear and there is an impact from the heat generated by an electric current (Fig. 1). Furthermore, field observation data related to meteorological conditions of snow-related damage and the effect of countermeasures have been obtained in eight other sites in Japan. A data management system to store practical examples of snow-related damage and their meteorological conditions has been continuously operated, and 663 practical examples*2 have been newly added to the data base. This data is used in the elucidation of meteorological conditions of snow-related damage, examination of its prediction methods, and evaluation of effectiveness of measures against it.

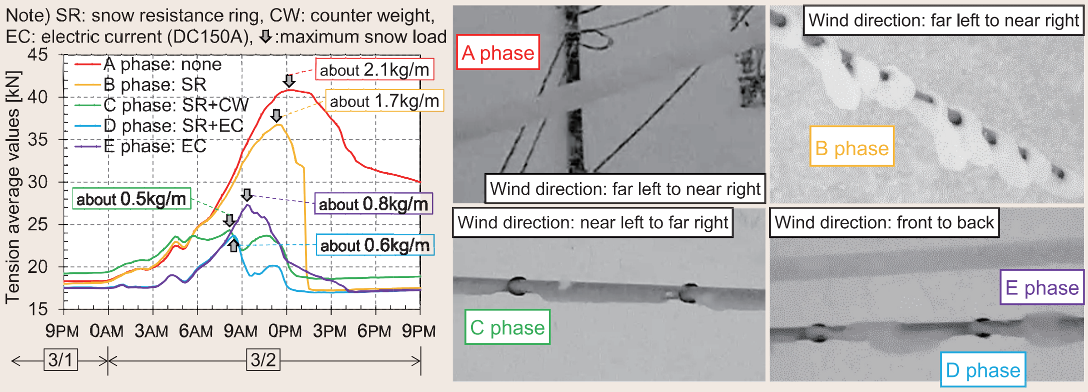
2 Elucidation of snow-related damage and development of its prediction methods

A simple snow accretion model, which we have developed for estimation of snow load on transmission towers, has been examined by using observation data at meteorological offices. New hazard maps, which can be used for evaluation of the possibility of galloping occurrence, have also been produced based on a numerical simulation weather prediction model and analysis of meteorological statistics (Fig. 2). These results can be utilized for establishment of effective and reasonable countermeasures for snow-related damage.

3 Development of a model for snow accretion to electric wires, and its melting and shedding

A snow accretion simulation code developed by CRIEPI, named SNOVAL (Ver.2), has been extended to improve its accuracy. A model of snow accretion to electric wires and its melting is newly incorporated in SNOVAL (Ver.2). This model enables us not only to calculate the liquid water content of the snow deposit by taking into account the melting process due to heat exchanges with the air, but also to give the density of snow deposit and snow accretion factor evaluated based on the liquid water content. Adhesive force between the snow deposit and electric wire is also estimated based on the liquid water content. Furthermore, SNOVAL (Ver.2) is improved to incorporate a snow shedding model, in which the time of snow shedding is evaluated based on the balance between the adhesive force and gravitational, aerodynamic forces exerted on the snow deposit, or on the balance of moments related to these forces (Fig. 3). The extended version, SNOVAL (Ver.3), is thus able to reproduce the process from the start of snow accretion until snow shedding. The findings obtained from the analysis with SNOVAL (Ver.3) are utilized to improve the accuracy in the simple method for the estimation of accreted snow mass described in 2 and to predict the snow deposit shape necessary for galloping analysis.

*1 Self-excited oscillation of conductors due to wind and accreted snow or ice. If the amplitude becomes large or the oscillation continues, the phenomenon causes short circuiting or facility failure through fatigue.
*2 Practical examples of short circuiting and damage to electric facility such as supports and conductors due to icing.



(a) Changes in conductor tension average values at 10-minute intervals

(b) 3/2 at 10AM, snow accretion 30-40M from towers (span length 300M)

Fig. 1: Examples of Snow Accretion Measurement on the Kushiro Test Line Single Conductor Lines (2015/3/1-2)

Conductor tension increased with snow accretion in all phases, but the increase due to snow accretion was limited in lines with snow resistance rings compared to those without the rings, and even greater snow volume was limited in its accretion in the C phase where counterweights were also used (left figure). Also, on lines with the snow resistance rings, the rings divide the snow, causing it to slide off (right image). Furthermore, the melting of the snow due to the heat generated from the electric current and the snow slide from the wire surface clearly shows the effects of this rings compared to the phase without electric current.

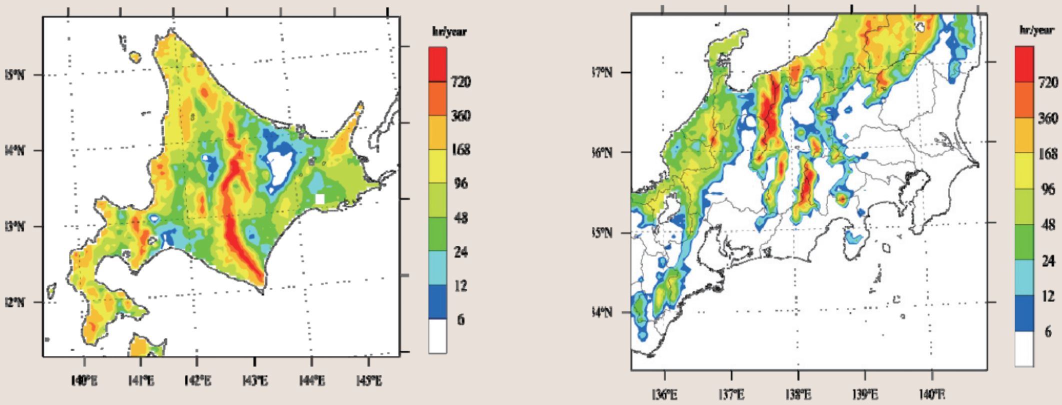
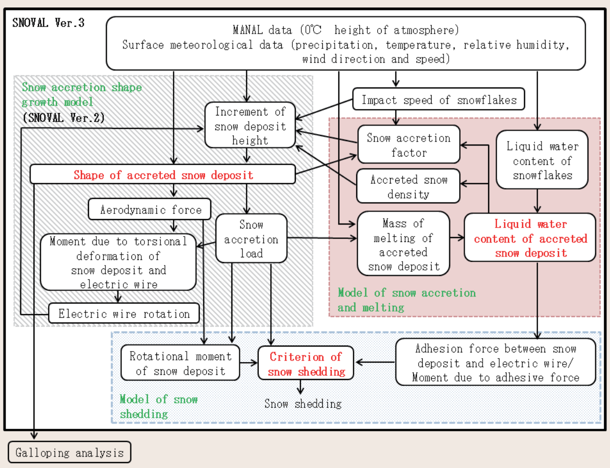
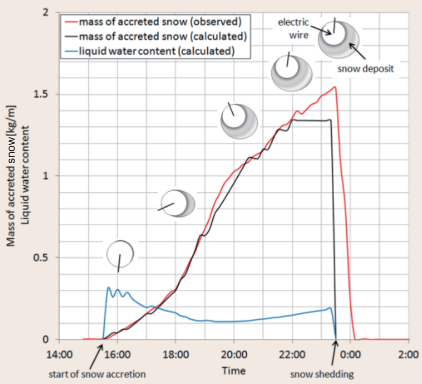


Fig. 2: Hazard maps for galloping occurrence

New hazard maps across Japan which show the frequency of weather conditions for galloping occurrence (frequency per year where snow accretion on transmission line occurs and the wind speed is beyond a certain threshold value) were made for each direction of transmission line by using the high-resolution long-term weather and climate database (CRIEPI-RCM-Era2), which was derived from a weather forecasting and analysis system (NuWFAS). The possibility of galloping occurrence in each area can be easily evaluated by using the maps, and can be used for extraction of locations where galloping tends to occur.





※The bold line on the section of snow deposit indicates electric wire rotation from the initial position of 6 o'clock.

Fig. 3: Framework of SNOVAL (Ver.3) and analytical results for a snow accretion event

SNOVAL (Ver.3) is an extended version based on SNOVAL (Ver.2: snow accretion shape growth model), and incorporates an input of meteorological data of surface and atmosphere, models for snow accretion, its melting and shedding, taking into account the melting process of snow deposit (left figure). All processes from the start of snow accretion and growth, until snow shedding are accurately reproduced with these models (right figure).