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 on overhead transmission facilities as follows: the partial collapse of transmission towers resulting from overload of heavily accreted snow, the short circuit accidents of transmission lines caused by galloping*1, and the failure of electrical insulators, or flashover due to sea salt contained in the snow. This has given us a valuable precept that verification of the effectiveness of measures against snow-related damage and improvement of its analysis and prediction methods are important for stable electricity supply.

In this project, 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 operated, aiming to elucidate the physical process of the snow-related damage and to improve its prediction methods.

Main results

1. Continuous operation of field observation and consolidated data management systems

We installed extensive field observation systems to understand a variety of mechanisms (such as snow accretion, galloping, and flashover) causing damage to transmission facilities two years ago. Valuable data have been obtained from our continuous operation of the observation systems, and these data are stored with meteorological data in our established data management system. Based on the field observations, the effectiveness of countermeasures for snow-related damage is being evaluated, and a simple snow accretion model is also being improved. The galloping motion of four bundled conductors measured in the field observation has been numerically simulated well considering the variation in snow accretion on the conductors.

2. Establishment of a flashover voltage test method for snow-accreted insulators

Elucidation of flashover voltage for snow-accreted insulators is essential to verify the effectiveness of countermeasures for the failure of insulators caused by sea salt contained in the snow. Using an overseas test facility, we have established a flashover voltage test method for a 154 kV class full-scale insulator covered with wet and packed snow whose electric conductivity is adjusted to around 200 μS/cm and whose liquid water content is increased by spraying water (Fig. 1).

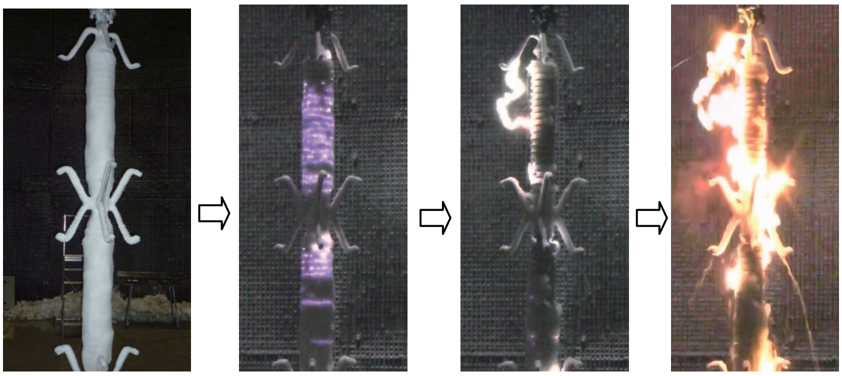
3. Development of an experimental technique for elucidation of galloping phenomenon

Wind tunnel tests with definite input conditions are effective to make clear the occurrence condition and response characteristics of conductor galloping, which are hard to derive only from field observations. We have introduced a wind tunnel customized for galloping tests in 2010 FY (Fig. 2), and have succeeded in physically simulating the galloping motion of actual overhead transmission lines at low frequency and with high amplitude in laboratory wind tunnel tests, by using the experimental technique for physical simulation tests of conductor oscillation developed in 2009 FY.

4. Development of estimation method for wide area distribution of airborne sea salt

Estimation of wide-area spatial distribution of cumulative airborne sea salt, which is one of the dominant corrosive environment factors, is needed to maintain overhead transmission lines efficiently. We have confirmed that NuWiCC-ST (a numerical simulation code for wind and transportation of airborne sea salt reflecting the topographic effects of local terrain developed by CRIEPI) can be effectively applied to estimation of cumulative airborne sea salt in the wide area over a radius of tens of kilometers [N10006]. We have also developed a new method for estimation of concentration of sea salt particles on the sea in a numerical simulation with NuWiCC-ST, considering both the wind speed and the distance of sea over which a given wind has blown [N10012] (Fig. 3). The simulation code is widely used for constructing distribution maps of airborne sea salt in electric utility companies.

*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 circuit or facility failure through fatigue.



(a) Long rod insulator covered with wet snow

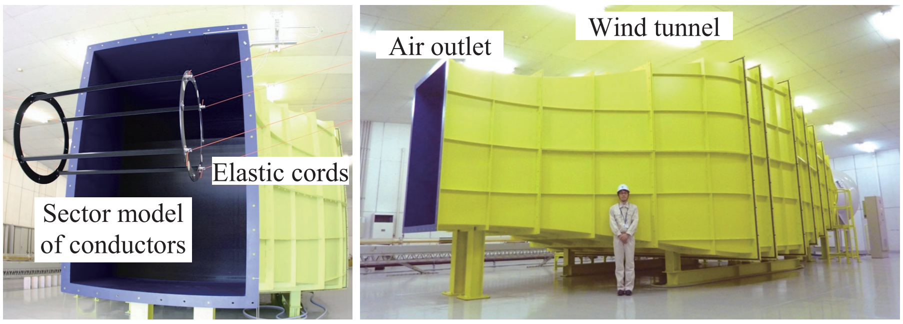
(b) Initial stage of applying voltage (Partial discharge)

(c) Just before flashover

(d) Flashover occurrence

(a) Artificial snow flakes whose electrical conductivity was adjusted to around 200 μS/cm were blown onto a long rod insulator, and filled the gaps between the sheds. The liquid water content of the accreted snow was increased by spraying water.
(b)-(d) A series of processes from partial discharge to flashover was well simulated by applying voltage to the insulator covered with cylindrical snow sleeve of high electrical conductivity

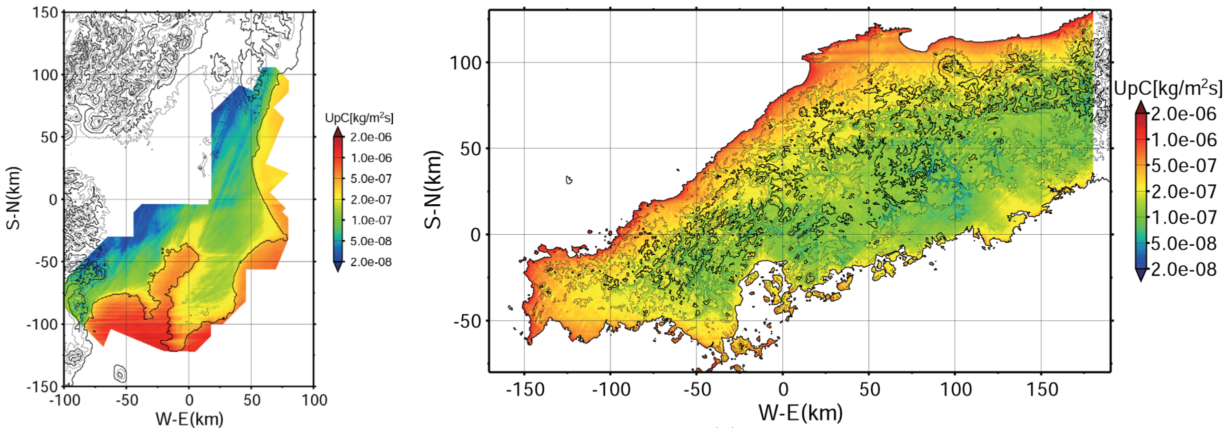
Fig. 1 Processes resulting in flashover in a snow-accreted insulator



<u>Spec. of wind tunnel</u>
Type:Blowdown and axial fan type
Outlet area: 2.5m height 1.6m width
Wind speed:3.0～16.5m/s
Turbulence intensity level: less than 0.5%

Fig. 2 Indoor experimental system of galloping simulation using sector model of conductor

By using a full-scale sector model of conductors and the elastic support technique developed in 2009 FY, the galloping motion of actual overhead transmission lines at low frequency and with large amplitude can be physically simulated exploiting a wide space in the downstream side of the contraction outlet of the wind tunnel.



(a) Kanto region

(b) Chugoku region

Fig. 3 Yearly mean distribution maps of airborne sea salt at 40 m above ground height

By using NuWiCC-ST, a numerical simulation code for wind and transportation of airborne sea salt developed by CRIEPI, yearly mean distribution maps of cumulated airborne sea salt in wide areas have been constructed. Comparison between sea salt concentration measured at several locations and that obtained from numerical simulations have shown the applicability of the method.