Effect of Snow Accretion Resistance Measures on Overhead Transmission Lines

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***Abstract*— When snow accretes and grows on overhead transmission lines, line tension increases due to the increased snow and wind loads. Substantial snow accretion, although it is a very rare event, can cause damage such as line and tower breakdown. Tohoku Electric Power experienced wide-area damage to facilities due to snow accretion on a transmission line in 1980. Presently, the company uses countermeasures including the snow-resistant (SR) ring and the counterweight (twist prevention damper).**

However, there is little field observation data on the effect of snow accretion resistance for these countermeasures on actual lines although there is quite a bit of experimental data using an artificial snow facility. Improving the database on the snow accretion effects in a natural environment is required.

Under this background, the company installed a full-scale test line in 1981 in its service area and has continued to observe the effects every winter since then. This report describes the results of the data analysis on the quantity of accreted snow with different snow accretion resistance measures.

I. Introduction

SNOW accretion on overhead transmission lines often causes significant damage to the lines. Once large-scale snow damage occurs to them, although it is a very rare event, it takes a lot of time to restore. Snow accretion on overhead transmission lines increases the load on them not only by the increased weight of the accreted snow but also by the increased wind load due to the increased surface area against wind. In addition snow may accrete unevenly between adjacent spans, with unbalanced loads from span to span, which leads to increased loads on the supports. When snow has significantly accreted, it may cause breakdown to lines and/or support members.

The service area of Tohoku Electric Power is located in the northeastern part of the Honshu Island of Japan, where there is a heavy snowfall in winter on the Sea of Japan side, and there may be a large quantity of wet snow on the Pacific Ocean side when a low-pressure area passes there. Thus, it is a heavy-snow area. Snow accretion, therefore, on overhead transmission lines is one of the important issues to be taken care of in design and maintenance.

Tohoku Electric Power experienced large-scale snow damage to its facilities in 1980. When a low-pressure area that had developed to almost the scale of a typhoon passed over the seas east of the Tohoku area, Sendai and surrounding areas were hit by snow with strong winds. The low-pressure area moved slowly, so that the snow with strong winds lingered. As a result, a large quantity of wet snow accreted on overhead transmission lines, which led to breaks of many lines and damage to power transmission towers, with power outage to about 600 thousand households.

Many cases of large-scale snow damage in Japan have been caused by wet-snow accretion on transmission lines in a temperature range 0ºC-2ºC. The above-mentioned snow damage was also caused by wet-snow accretion on power lines.

There are two types of snow accretion, depending on air temperature and wind velocity, in Japan. They are low density snow accretion (or dry snow) which grows under the condition of wind velocity below 5 m/s and temperature from -2ºC to +2ºC, and high density snow accretion (or wet snow) which grows under the condition of wind velocity up to 20 m/s and the temperature from 0°C to +1.5°C[1].

To prevent or reduce the wet snow accreting on power lines, the snow-resistant (SR) ring and the in-span counterweight (NBD) have been used.

Snow accreted on an overhead transmission line develops into cylindrical-sleeve snow on a wire in two different ways: One is that snow accretion slides down along strands of a wire, developing into cylindrical-sleeve snow. The other is that snow does not slide, but the wire is twisted, and the accretion develops into cylindrical-sleeve snow[2].

The SR ring stops snow from sliding along strands of a wire and lets it drop off the wire to prevent snow accretion from developing on it.

The NBD acts as a counterweight to increase the torsional rigidity of a wire when it is installed, and can prevent snow accretion from developing into cylindrical-sleeve snow.

There is not much data on the effects of those snow-resistance measures that have been produced from field observation on a full scale, while there is a lot of experimental data produced with an artificial snow facility. Data on the effects of such countermeasures in the actual environment should be improved.

Various countermeasures to prevent snow accretion on transmission lines have been developed, and used by electric power companies in Japan. The effects of almost all such products were verified with an artificial snow facility; on the other hand, sufficient data on the effects has not been produced with full-scale equipment in the actual environment. In addition, no plausible theories on the conditions of snow accretion on a transmission line, or the correlation between snow accretion and meteorological factors, have been established.

With the snow damage in 1980 as a turning point, Tohoku Electric Power constructed a test line in December 1981, and has since continuously observed snow accretion on the test line to develop and study for practical application of snow-resistant wires, and for snow accretion prediction.

Significant snow accretion on overhead transmission lines rarely occurs, which resulted in a long run observation of snow accretion that has continued for the past 25 years. This report presents the result of data analysis on the snow accretion with various snow accretion resistance measures taken.

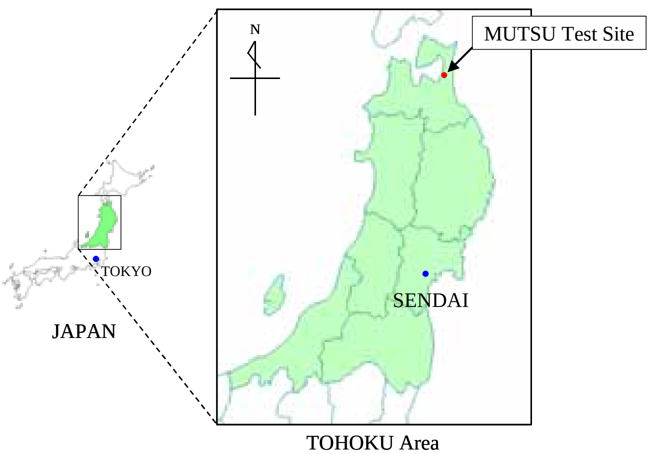

Fig. 1. Location of test site

II. Outline of the Test Line

The Mutsu test line was constructed in 1981 to verify the effects of snow-resistance measures and to study snow accretion on wires[3]. This site is located at the bottom of the Shimokita Peninsula, which lies in the northeast part of the Tohoku area, and runs on a hill area (at an elevation of 80 m) between the Pacific Ocean to the east and Mutsu Bay to the west. This area has experienced damage due to heavy snow accretion. It is expected that there is accretion of wet snow on wires in this area in winter. The location of the test site is shown in Fig. 1.

The test facility is comprised of 4 towers with 2 spans, as shown in a plan view in Fig. 2. The line runs in an east-west direction in one span and in a north-south direction in the other. It allows observing snow accretion in two directions at the same place at one time, which is rare in Japan. Each span allows for a maximum of 10 wires to be strung. None of the conductors are energized.

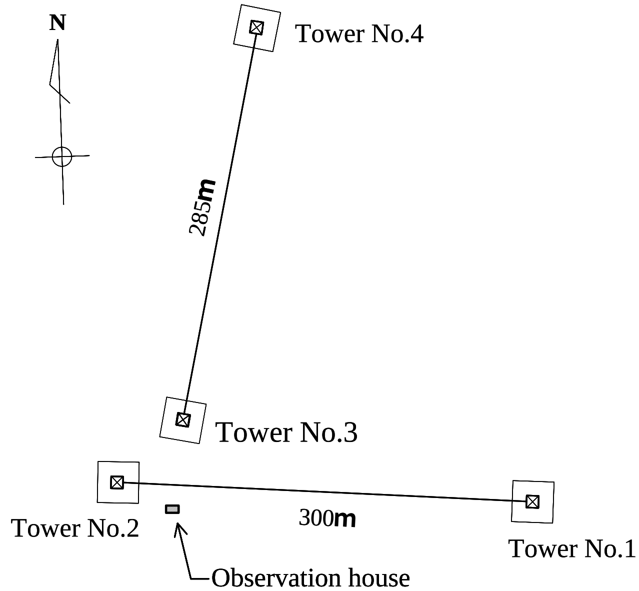

Fig. 2. Tower layout and line direction

The observation items are presented in Table 1. They include the tension of each wire, in addition to meteorological observation items. The tension of a wire is used to estimate the snow mass accreted on the wire. The snow mass is calculated using the temperature of the wire and wind velocity on the assumption that snow mass is the same through all the spans with an even shape of cylindrical-sleeve snow.

Fig. 3. Picture of tower (Tower No.2)

Table 1. Measurement Items

	Items	Notes
Weather	Wind velocity	Record maximum wind velocity and average wind velocity
	Wind direction	16 directions
	Air temperature	
	Humidity	
	Precipitation rate	
	Solar insolation	
	Atmospheric pressure	
Cable Tension	Each stringing position < (1)-(10) >	Estimate the snow mass

Fig. 4 is a block diagram of the observation system. Signals from each sensor go through a converter to be input to a computer as a recording device. The observed value is recorded every 30 minutes, and sent to the office in Sendai via a telephone network, as well as stored on site. Thus, the condition of the observation site can be known at a remote office.

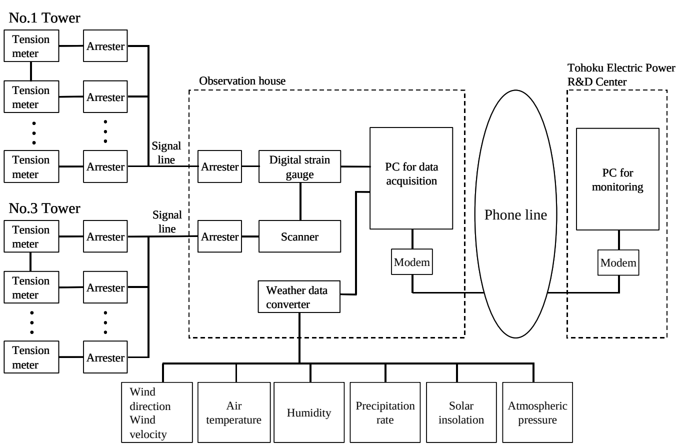

Fig. 4. Block diagram of observation system

Table 2 shows the types of the current wires tested. Fig. 5 shows the positions of the wires installed. Basically, two types of wires with the same outer diameter (ACSR 160 mm^2 and SBACSR 210 mm^2 in Fig. 6) are installed with various snow-resistance measures to compare between them. The countermeasures currently installed are the SR ring (Fig. 7), in-span counterweights called NBD (Fig. 8), and combinations of them, which are standard snow-resistance measures in the company. In addition, the snow-resistance effects of phase-to-phase spacers are also observed.

Table 2. Cables tested

Cables tested and countermeasures		Stringing section	
Wire	Countermeasures	No.1-2	No.3-4
ACSR160	− (No-countermeasures)	(7)	(7)
ACSR160	SR Ring	(8)	(8)
ACSR160	Phase-to-phase spacer	(4) (9)	(4) (9)
ACSR160	SR Ring + NBD*1	(10)	(10)
ACSR160	SR Ring + NBD + PTFE*2	(5)	(5)
SBACSR210	− (No-countermeasures)	(1)	(1)
SBACSR210	NBD	(2)	(2)
Reserved	−	(3) (6)	(3) (6)

*1: in-span counterweights

*2: Snow-resistant tape

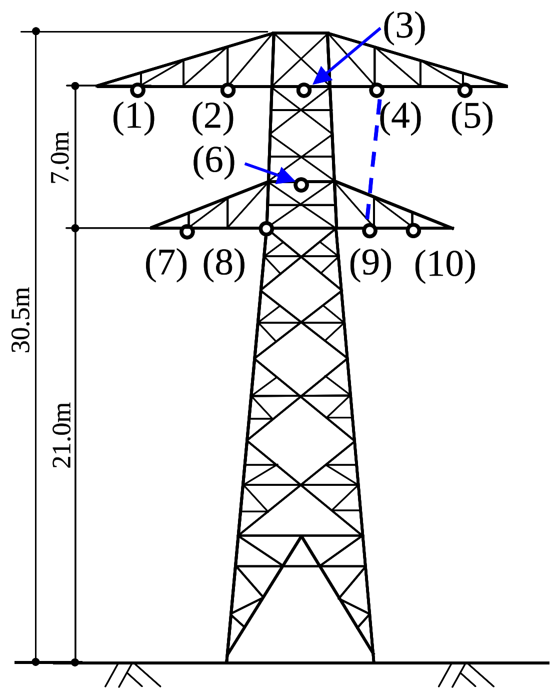

Fig. 5. Tower and layout of wires
(Viewing No. 1 from No. 2 and No. 4 from No. 3)

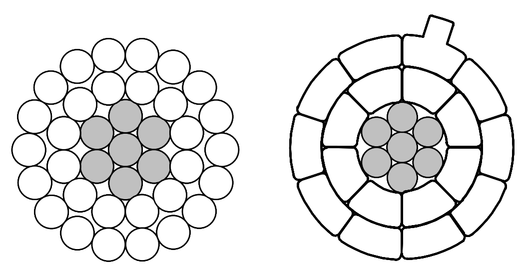

Fig. 6. Cross Sections of ACSR (left) and SBACSR (right)

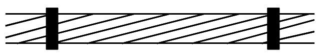

Fig. 7. Appearance of SR rings

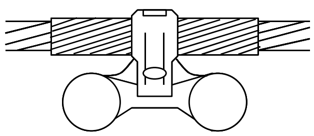

Fig. 8. Appearance of NBD

III. Result

An analysis of the results of observation data on the Mutsu Test Line is shown in Fig. 9. The figure plots the snow masses for the SR ring and NBD attached to ACSR 160 mm^2 versus the snow mass with no countermeasures (n = 34). Although a bit of dispersion is recognized, the slope of the approximation is 0.39, so we evaluated the snow mass for the no countermeasure case as ca. 61% (the reduction rate of snow accretion is 39%). Since the snow mass accreting on the overhead transmission line depends on air temperature, wind velocity and precipitation intensity, the cause of the dispersion is assumed to come from the differences in these parameters.

In the same way, the effect of reducing snow accretion was examined for other measures.

Fig. 10 shows the snow mass for each countermeasure where the snow mass accretion on ACSR 160 mm^2 is set at 100%. The effects are summarized as follows:

-The SR ring reduced the snow mass accretion on ACSR 160 mm^2 by ca. 26% compared to the no countermeasure case.

-The effect of reducing the snow accretion was ca. 16% for SBACSR 210 mm^2 and the effect was a little higher for ACSR 160 mm^2 with the SR ring attached.

-When the SR ring and NBD were used together, the effect of reducing snow accretion was ca. 61%.

-There was some effect of reducing snow accretion for the phase-to-phase spacer.

However, we could not find distinct difference in the effect of reducing snow accretion depending on air temperature, wind velocity and precipitation intensity.

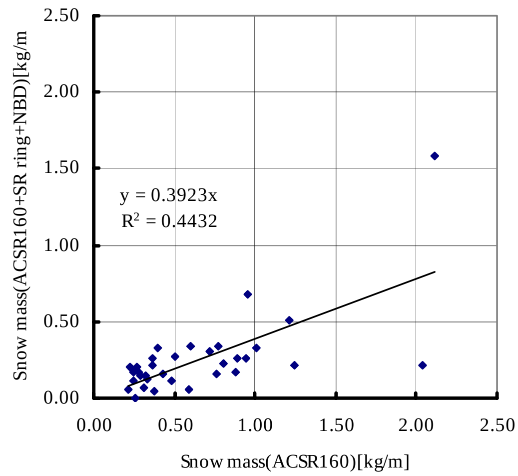

Fig. 9. Relationship between snow masses for ACSR 160mm^2 with/without SR ring and NBD

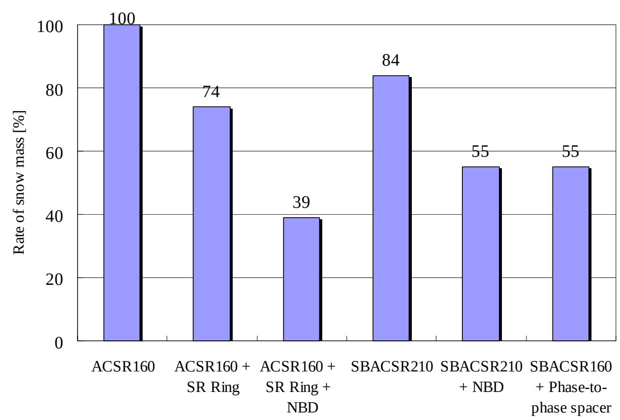

Fig. 10. Snow mass for each countermeasure (Based on the snow mass on ACSR 160mm^2 as 100%)

IV. Conclusion

It is a very rare event that significant snow accretion develops on the transmission line. In this study, the results of data analysis for the Mutsu Test Line are reported. The maximum snow mass was 2.1 kg/m in this data while, in 1980, the maximum snow weight was above 5 kg/m when snow damage occurred to our facilities.

There are no associated data with the occurrence of notable facility damage such as the breakdown of supports. It is presumed that the snow-resistance measures dealt with in this paper are effective to control snow accretion when it develops significantly, although the level of effectiveness is not clear.

In addition, since it is difficult to conduct automatic measurement of the density of the accreted snow, the amount of accreted snow was derived by assuming that the density was constant and not dependent on the temperature. We are improving the system to measure the density simultaneously with the snow accretion at the site in order to conduct more precise observation. We are going to continue the observation of snow accretion and verify the effect of our snow-resistance measures.

V. REFERENCES

[1] S. Tosaka, S. Atsumi "Observation system of snow accretion on wires in Tohoku Electric Power Co.", IWAIS'90, SESSION B5-4(1), 1990.

[2] Y. Sakamoto, "Snow accretion on overhead wires", Philosophical Transactions of The Royal Society, Mathematical, Physical and Engineering Sciences, Research Frontiers, pp.2941-2970, 2000.

[3] S. Tokunaga, N. Sudo, I. Nakayama "Effect of snow accretion resistant method for overhead transmission lines", Reprints of the 2005 Conference Japanese Soc. of Snow and Ice, p.44(2005-9) (in Japanese)