CONDITIONS FOR INSTALLATION OF SNOW ACCRETION COUNTERMEASURES ON ROAD INFORMATION SIGNS

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***Abstract**:* An experiment was conducted to identify differences in the effects of reducing snow accretion according to the direction in which the snow accretion countermeasures are installed on road information signs. As a result, compared with unmodified beams, tilted plates facilitated the falling of snow while the accretion was still small, and had the effect of reducing the duration for which the depth of snow accretion was 10 cm or more. This effect was the greatest when the countermeasure was installed parallel to the direction of the prevailing winds.

1. INTRODUCTION

Snow accretion and snow cap on horizontal beams that support road information signs causes problems in Japan. To prevent this, we have conducted experiments focusing on a method of installing tilted plates on beams to help the accreted snow fall more easily. This paper presents an experiment conducted to compare tilted plates with unmodified beams in terms of the effectiveness in reducing snow accretion, in which tilted plates were installed facing different directions in an effort to improve installation conditions. The test was carried out over a period from December 16, 2009 to March 18, 2010 on Nakayama Pass located in the suburbs of Sapporo, Hokkaido. At the test site, a road information sign was installed and plates tilted at an angle of 60 degrees were mounted on the horizontal beams supporting the sign, while unmodified beam areas with no measures were also left for comparison. The directions in which the installed plates faced are shown in Table 1: northwest (head-on to the prevailing winds), southeast (opposite direction) and southwest (perpendicular to the other two).

Direction of Installation	Form	Material	Symbol
Northwest	tilted plate	aluminum	NW-60
	unmodified	steel	NW-um
Southeast	tilted plate	aluminum	SE-60
	unmodified	steel	SE-um
Southwest	tilted plate	aluminum	SW-60

Table 1: Directions in which the installed plates and the unmodified beams faced

2. RESULTS AND DISCUSSION

Figure 2 shows the duration (hours) of snow accretion on the tilted plates and the unmodified beams, and the number of times the accreted snow fell, for each accretion depth. The duration for which snow accretion depth was at least 10 cm on the unmodified beams NW-um and SE-um was approximately 400 hours, and the number of times accreted snow fell from them was three or four times. In contrast, the respective duration for the tilted plates SW-60, NW-60 and SE-60 was approximately 1,100 hours, 800 hours and 650 hours, with the number of times accreted snow fell rising to 22, 17 and 23 times, respectively.

If a lump of snow 15 cm or larger falls on the windshield of a vehicle, it may cause an accident [1]. The duration for which snow accretion depth was 10 cm or more on the unmodified beams and the tilted plates was approximately 700 and 450 hours, respectively. The proportion of hours during which the snow accretion depth was less than 10 cm was larger for the tilted plates than for the unmodified beams. Among the tilted plates, the proportion of such hours was largest for SW-60, to which the prevailing winds blew at right angles, followed by the plates on the windward and leeward sides.

The above results indicate that compared with unmodified beams, tilted plates are more effective in helping the snow fall in the earlier stage of accumulation when there is less snow, and in reducing the number of hours during which the snow accretion is 10 cm or more, the depth at which there is a possibility of accidents occurring if it falls.

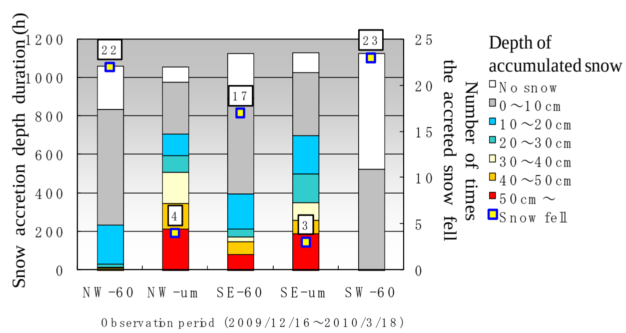

Fig.2: Snow accretion duration (hours) and the number of times the accreted snow fell, for each accretion depth

3. CONCLUSIONS

Compared with the unmodified beams, the tilted plates were more effective in helping the accreted snow fall in the early stage of accumulation, and in reducing the number of hours during which the snow accretion depth was 10 cm or more. Such effects were the greatest in the case of plates installed parallel to the prevailing winds, although plates installed on the windward and leeward sides also helped reduce the amount of accretion.

4. REFERENCES

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Conditions for installation of snow accretion countermeasures on road information signs

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Abstract **— An experiment was conducted to identify differences in the effects of reducing snow accretion according to the direction in which the snow accretion countermeasures are installed on road information signs. As a result, compared with unmodified beams, tilted plates facilitated the falling of snow while the accretion was still small, and had the effect of reducing the duration for which the depth of snow accretion was 10 cm or more. This effect was the greatest when the countermeasure was installed parallel to the direction of the prevailing winds, followed by those installed on the windward side, which also had a similar effect. However, there were some cases of snow accretion development on plates installed on the leeward side, even when countermeasures were taken.**

Keyword; snow accumulation; road information signs; snow accretion countermeasures; directions

I. INTRODUCTION

Snow accretion and snow cap on horizontal beams that support road information signs cause problems in Japan (Fig. 1). There is a danger of snow falling from such structures causing damage to vehicles traveling under them, or accidents caused by poor visibility. To prevent this, snow is removed manually, and measures to reduce the labor involved in snow removal are required. We have conducted experiments focusing on a methods of installing gable-shaped plates and tilted plates on horizontal beams that support road information signs to help the accreted snow fall more easily from them, in a effort to evaluate their effectiveness [2] – [5]. The experiment results showed that the use of such plates as a snow accretion countermeasure facilitated the falling of snow in the early stage of accumulation, thereby reducing the depth of snow accretion and the duration of its accumulation. It was revealed that this effect was greater for the tilted plates than for the gable-shaped plates, and furthermore, that it was greater for the plates tilted at an angle of 60 degrees than for the plates tilted at an angle of 45 degrees [4]. However, in cold and heavy snowfall conditions, snow can accumulate on these types of snow accretion countermeasures, too. Challenges still remain with regard to conditions for installing such plates as snow accretion countermeasures.

Fig. 1: Snow accretion on road information sign

Accordingly, this paper presents a comparative test conducted using plates tilted at an angle of 60 degrees, which were found to be the most effective in facilitating the falling of accreted snow, with the aim of clarifying differences in the effect of reducing snow accretion according to the different directions in which the plates face.

II. EXPERIMENT

The experiment was conducted for approximately three months from December 16, 2009 to March 18, 2010. The test site was Nakayama Pass (835 m high), located approximately 45 km southwest of central Sapporo, where road information signs (2 m × 2 m) were installed and snow accretion countermeasures were mounted for experimental purposes on the horizontal beams that supported the signs. The snow accretion countermeasures employed for the test were aluminum plates (560 mm long, 450 mm wide, 2 mm thick) tilted at an angle of 60 degrees. In addition, unmodified beams (steel tube ϕ 216.3 mm, 4.5 mm thick) were used to compare snow accretion conditions. As shown in Table 1, the directions in which the plates and the unmodified beams faced were northwest (NW-60, NW-um) (Fig. 2 (a)), which was head-on to the prevailing winds; southeast (SE-60, SE-um) (Fig. 2 (b)), in the opposite direction; and southwest (SW-60), which was perpendicular to the prevailing winds. There were no road information signs and unmodified beams facing southwest (Fig. 2 (b)). Snow accretion on these structures was photographically recorded at 10-minute intervals, and air temperature, wind direction, wind velocity and solar radiation were also measured at 10-minute intervals. The depth of snow accretion on the tilted plates and the unmodified beams, snow accretion duration, the number of times accreted snow fell were visually checked and measured from the images. The cross-sections of snow accreted on the tilted plates and the unmodified beams were observed twice during the test period.

Table 1: Directions in which installed countermeasures and unmodified beams face

Direction of Installation	Form	Material	Symbol
Northwest	tilted plate	aluminum	NW-60
	unmodified	steel	NW-um
Southeast	tilted plate	aluminum	SE-60
	unmodified	steel	SE-um
Southwest	tilted plate	aluminum	SW-60

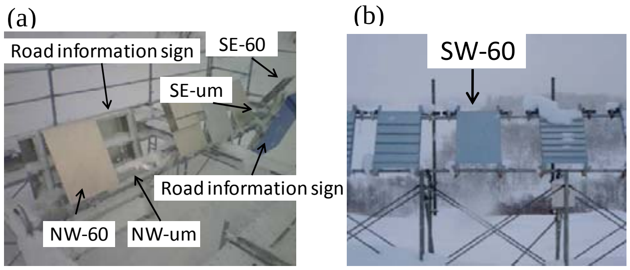

Fig. 2: Installed countermeasures and unmodified beams

III. Results

A. Weather conditions during the test period

The mean, maximum and minimum temperatures during the test period were -8.2˚C, 9.7˚C and -19.2˚C, respectively (Fig. 3). In March alone, there were four days when the air temperature exceeded 0˚C. The maximum solar radiation was 0.94 kW/m^2 (Fig. 3). The mean and maximum wind velocities were 2.8 m/s and 10.1 m/s, respectively (Fig. 4). With respect to the wind direction during this period, 44% of the winds were northwesterly (the prevailing winds) and 15% were west-northwesterly (Fig. 5). These were almost head-on to the face of the road sign installed in the test site. The mean and maximum snow depths were 234 and 301 cm, respectively (Fig.4).

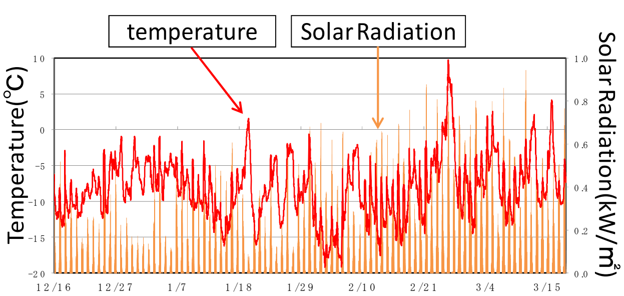

Fig. 3: Changes in air temperature and solar radiation

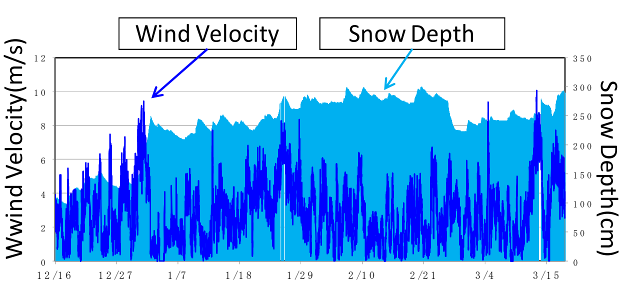

Fig. 4: Changes in wind velocity and snow depth

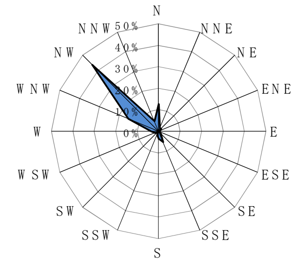

Fig.5:Wind direction diagram

B. Results for the duration of snow accretion and number of times accreted snow fell for each accretion depth

Figure 6 shows the duration of snow accretion on the tilted plates and the unmodified beams and the number of times accreted snow fell for each accretion depth. The total number of hours for which snow accretion was confirmed from the images was between 1,050 and 1,100. For the unmodified beams NW-um and SE-um, the duration for which snow accretion was less than 10 cm was approximately 400 hours, and the number of times snow fell was three or four times. There was always at least 10 cm of accretion when the snow fell. For the tilted plates, in contrast, the duration for which snow accretion was less than 10 cm deep was approximately 800 hours on NW-60, 650 hours on SE-60 and 1,100 hours on SW-60, with the number of times accreted snow fell 22, 17 and 23, respectively. On SW-60, which was installed facing southwest, snow accretion hardly built up snow fell more frequently. SE-60, installed facing southeast, experienced snow accretion exceeding 40 cm deep, and the number of times the snow fell was approximately 5 fewer than the other plates.

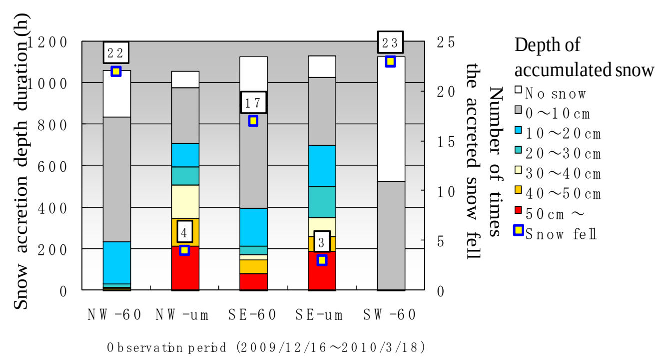

Fig. 6: Duration of snow accretion and number of times accreted snow fell for each accretion depth

C. Results of observation of the cross-sections of accreted snow

The cross-sections and quality of accreted snow determined from the second observation are shown in Figs. 7 and 8. According to the photos showing the development of snow accretion during the first cross-section observation, snow on the unmodified beams had built up over a period of approximately 14 days. In terms of overall snow quality, new snow and lightly compacted snow were seen in the upper and bottom layers, respectively (Fig. 7). A comparison of snow accretion on NW-60 and NW-um installed on the windward side revealed that it was less in the case of NW-60. SE-um installed on the leeward side tended to develop snow accretion also in the area between the beam and the sign. SE-60, on the other hand, developed slight snow accretion only on the tilted plate. For SW-60, to which winds blew perpendicularly, almost no snow accretion was seen (the corresponding figures are omitted).

During the second observation, snow accretion on the unmodified beams had developed over a period of approximately 32 days. On the whole, the accreted snow consisted of new, lightly compacted and compacted snow. Granular snow was observed near the SE-um beam (Fig. 8), and ice grains formed on the NW-um beam, which were considered to be caused by freeze-thaw cycles (Fig. 8). As snow accretion on NW-60 installed on the windward side fell frequently, it did not grow so large; whereas, as that on NW-um did not fell so often, it grew larger. On the other hand, the snow accretion that developed on SE-um installed on the leeward side was the largest of all the measurements in this observation, followed by the snow accretion on SE-60. The laminar structure of snow accretion at these two spots was similar to that of snow cornices.

IV. DISCUSSION

A. Effectiveness of snow accretion countermeasures in terms of snow accretion duration and the number of times accreted snow fell

According to Matsushita et al. (2011) [1], for a lump of snow of 15 cm or more and no more than 200kg/m^3 in density, the value found by dividing the length of the longest side of the snow lump before falling by the maximum size of the snow after impact (scattering rate) is 2 to 3. That is, a 15-cm lump of snow would scatter to an area of 30 to 40 cm. If such a lump of snow falls onto the windshield of a vehicle, it may cause an accident due to poor visibility. The duration of snow accreted to a depth of 10 cm or more (including 15 cm deep) observed in this study was approximately 700 hours and 450 hours for the unmodified beams and the tilted plates, respectively. The rate of the duration for which 10 cm or more snow accreted on the tilted plates to that on the unmodified beams was approximately 29% for the windward side (NW) and approximately 57% for the leeward side (SE). It was found that this snow accretion countermeasure was more effective on the windward side. The number of times snow fell was the largest in the case of the tilted plates installed on the windward side (NW-60).

From the above results, it can be concluded that compared with unmodified beams, tilted plates facilitate the falling of accreted snow while it is still small enough to minimize damage, and have the effect of reducing the duration of snow accretion of a depth of 10 cm or more, which could cause accidents when it falls.

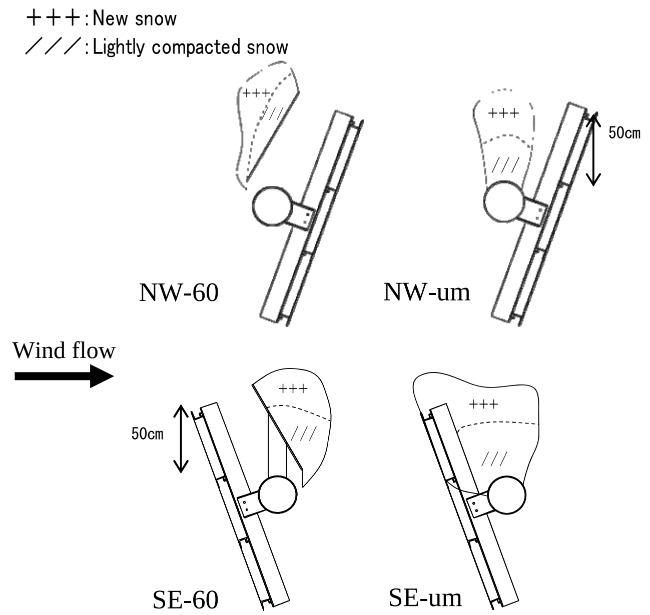

Fig. 7: Cross-sections and quality of accreted snow (1st observation on January 11, 2010)

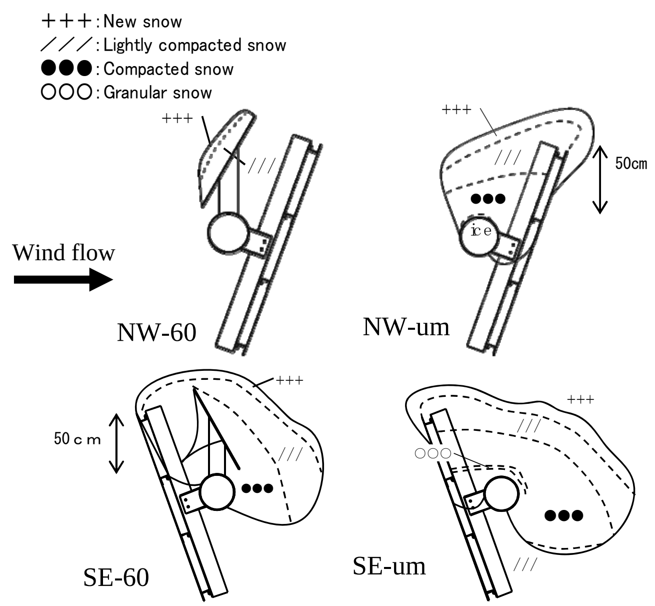

Fig. 8: Cross-sections and quality of accreted snow (2nd observation on February 11, 2010)

B. Development of snow accretion according to the different directions in which countermeasures are installed

Results of the cross-section observations in this study revealed that when the winds were blowing from the front to the back of the road information sign, snow accretion developed more rapidly on the leeward side and on the unmodified beams than on the windward side and on tilted plates, respectively. For the tilted plate (SW-60) to which the winds blew at right angles, no major development of snow accretion was observed. It is believed that this was because snow fell more often from the tilted plate; thereby major development of snow accretion was hindered. Short duration of snow accretion resulted in low density snow accretion, consisting mainly of new and lightly compacted snow. After long durations of snow accretion, high density compacted snow and granular snow were observed, except in the case of the tilted plate on the windward side (NW-60).

Based on the above findings, it is believed that compared with unmodified beams, tilted plates can control the development of snow accretion and build up low density snow. It is most effective when the plates are installed parallel to the prevailing winds, followed by those installed on the windward and leeward sides. It should be noted that if the snow accretion duration is prolonged, larger accretions can develop even on tilted plates.

C. Development of snow cornices along the unmodified beams of road information sign

In the second cross-section observation, the development of snow cornices was confirmed. From the observation results (Fig. 8), it is considered that snow cornices are very dangerous when whey fall since they grow larger than ordinary snow accumulation and have a higher density than new snow as they develop as a result of repeated accumulation.

Tsutsumi et al. (2006) [6] reported a case of a parapet (a low wall along the edge of a roof) in which cornices developed on the leeward side when snow accumulation exceeded the height of the parapet during daily snowfalls of at least 10 cm and average daily wind velocity of at least 3.0 m/s. It can be considered that when the depth of snow accretion on the tilted plates and the unmodified beams exceeded the height of the upper edge of the road information sign in this study (50 cm), snow cornices developed. The depth of the snow accreted on the tilted plate and unmodified beam on the leeward side, as well as the depth of snowfall and wind velocity during a certain period before the second cross-section observation, are shown in Fig. 9.Daily snowfalls of 10 cm or more and average daily wind velocity of 3.0 m/s were observed on five days ((a) through (e) in Fig. 9). At the time of (c) in Fig. 9, snow accretion on the tilted plate and the unmodified beam exceeded the height of the road information sign and snow cornices seemed to develop.

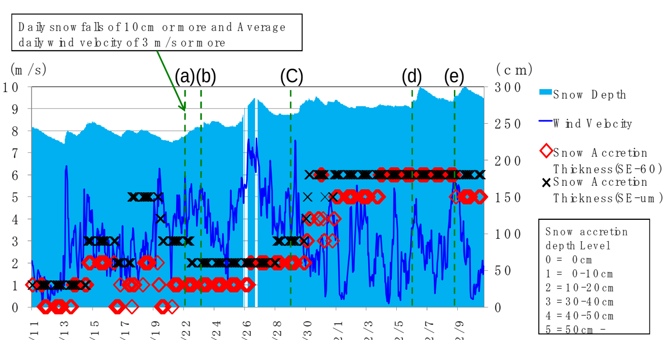

Fig. 9: Changes in snow accumulation and wind velocity (period of snow accretion development until 2nd observation: January 11 – February 11, 2010)

When snow accretion on the tilted plate and unmodified beam installed on the leeward side exceeds the height of the upper edge of the road information sign, snow cornices may develop under certain weather conditions. Therefore, it is believed that the risks due to falling accreted snow can be reduced by controlling the depth of the accretion so as not to exceed the height of such structure.

V. Conclusions

An experiment was conducted with the aim of identifying differences in the effects of reducing snow accretion according to the directions in which the snow accretion countermeasures are installed on road information signs. As a result, compared with unmodified beams, tilted plates facilitated the falling of accreted snow while it was still small, and had the effect of reducing the duration for which the snow accreted was 10 cm or more. When winds blew from the front to the back of the road information sign, snow accretion became larger on the leeward side and on the unmodified beams compared with on the windward side and on the tilted plates, respectively. However, a longer duration of snow accretion may result in the development of snow accretion even on the countermeasures. It should be noted that snow cornices may develop under certain weather conditions when snow accretion on the beams of the road information sign exceeds the height of the upper edge of the road information sign.

It is hoped to conduct further experiments in locations with different weather conditions to examine the effectiveness of snow accretion countermeasures and installation conditions applicable to them, which can vary according to the direction in which the installed countermeasures face.

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