IMPROVEMENT OF SIMPLE MEASURES TO PREVENT SNOW ACCUMULATING ON ROAD INFORMATION SIGNS IN REGIONS WITH HEAVY SNOWFALL

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Abstract: As a measure for snow accumulating on road information sign in regions with heavy snowfall and low temperature, the installation of tilted stepped plate on the sign that improved from single tilted flat plate was proposed. The results of field test revealed that the tilted stepped plate was effective in reducing the amount and occurrence of snow accumulating even at low temperatures and during heavy snowfall.

1. INTRODUCTION

In Japan, snow accumulation and accretion on beams on the backside of traffic information signs cause problems. The falling of such snow may cause damage to passing vehicles or accidents due to reduction of visibility. In the past, focus was placed on a method of facilitating the falling of snow by attaching angled roofs or tilted plates on the beams on the backside of traffic information signs, and tests were conducted to examine their effect. The results revealed that the amount and duration of accumulated snow decreased because the measures made snow fall from the signs earlier [1]. However, there was still problem as snow may accumulate up to 50 cm depth on such constructions during heavy snowfall and at low temperatures [1].

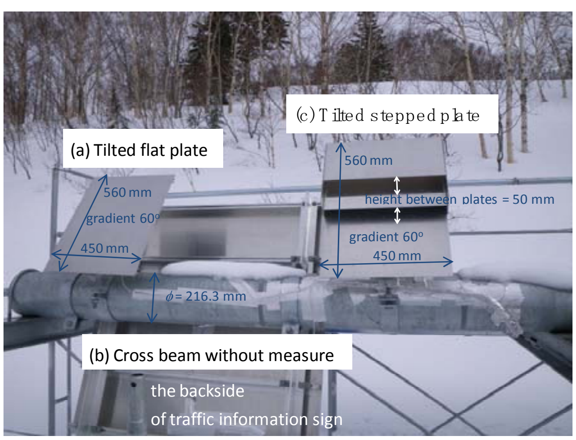

Figure 1: Situation of field test.

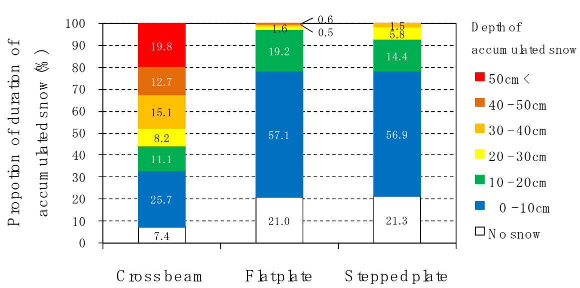

Figure 2: Proportion of time in the test period for which each depth of snow accumulation occurred.

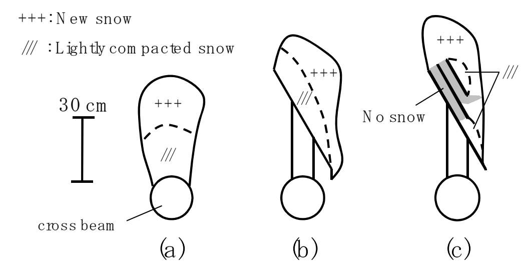

Figure 3: The cross-sectional shape and snow grain types. (a) Cross beam without measure, (b) flat plate and (c) stepped plate.

2. METHOD

As a measure for cases in regions with heavy snowfall and low temperatures, a prototype was produced by attaching various sized flat plates to the conventional tilted plates, at certain intervals. These were named tilted stepped plate (Fig. 1). The field test was carried out over one winter in a cold and snowy area.

3. RESULTS AND DISCUSSION

The test results revealed that the proportion of duration of accumulated snow in case of the depth less than 10 cm was approximately 30 % for the beam without measures and 80 % for the flat and stepped plates (Fig. 2). In some cases the depth of accumulated snow at the time of falling exceeded 50 cm for the beam without measures, and more than 40 cm in one case of the flat plate, while that for the stepped plate was 30 cm or less. A comparison of weather conditions at the times when snow fell from the structures revealed that more snow tended to fall from the stepped plate than from the flat plate even when the temperature was low and the wind velocity was low. As shown in Fig. 3, it was also assumed from cross-sectional observations of accumulated snow that snow was more likely to fall from the stepped plate as the snow was separated by cavities in the structure.

4. CONCLUSION

It was presumed that the tilted stepped plate presented in this study was effective in reducing the amount and occurrence of snow accumulating even at low temperatures and during heavy snowfall.

5. REFERENCES

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Improvement of simple measures to prevent snow accumulating on road information signs in regions with heavy snowfall

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***Abstract*—As a measure to prevent snow from accumulating on horizontal beams that support road information signs in cold, snowy regions, a tilted stepped plate was developed on a trial basis from conventional tilted flat plates, and was subjected to testing. As a result, snow fell from the tilted stepped plate more frequently than from the tilted flat plate, and the depth of the accumulated snow at the time of falling was less than 30 cm. The test suggested that one of the reasons for this was voids created in the snow accumulated on the tilted stepped plate, which divided the snow into smaller sections and helped it fall off easily.**

Keywords; snow accumulation; measure; road information sign; heavy snowfall

I. Introduction

In Japan, snow accretion and accumulation on horizontal beams that support road information signs cause problems (Fig. 1) [1]. Snow falling from such structures may pose a risk of causing damage to vehicles traveling under them, or accidents caused by poor visibility. As measures to solve these problems, a method of mounting gable-shaped plates and tilted plates on beams of road information signs so as to facilitate the falling of accumulated snow was examined and its effectiveness was assessed in testing [2]. The test revealed that snow accumulation depth and duration were reduced since the snow fell from the structures in the early stage of accumulation when these measures were taken. However, challenges still remain. Even with the measures, snow could accumulate up to 50 cm in areas with low temperatures and heavy snowfall [2].

Figure 1. Example of snow accumulation on road information sign.

Accordingly, for the purpose of controlling snow accumulation in cold, snowy regions, an improved version of the conventional tilted flat plates was developed on a trial basis and its effectiveness was tested in the field.

II. Method

The test was conducted on Nakayama Pass (835 m high), located 45 km southwest of central Sapporo, for three months from December 16, 2009 to March 18, 2010.

A. Measure proposed in this test

In order to control snow accumulation in cold, snow regions, a prototype was designed by attaching flat plates of different sizes to the conventional tilted flat plates, while leaving a gap between each of the plates (Fig. 2c). This is referred to as a tilted stepped plate. The tilted flat plate and the tilted stepped plate used in the test were 450 mm wide, 560 mm long and made of 2 mm-thick aluminum sheets. The tilted stepped plate was 100 mm in height. These plates were installed on steel beams 216.3 mm in diameter tilted at an angle of 60 degree (Fig. 2).

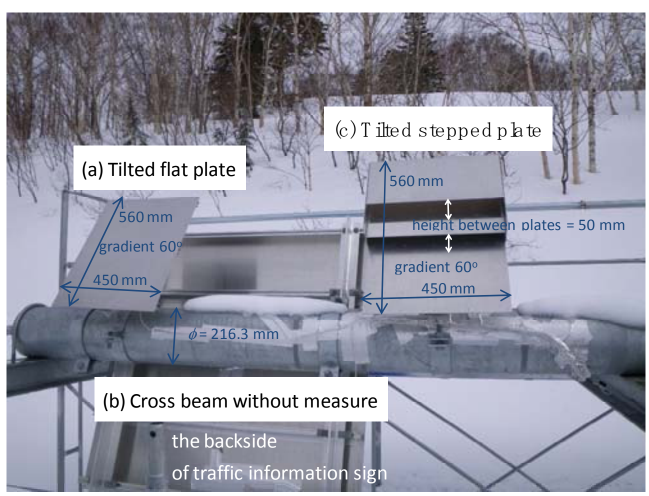

Figure 2. Situation of field test. (a) tilted flat plate, (b) cross beam without measure, (c) tilted stepped plate.

B. Observation of the duration of snow accumulation and the number of times accreted snow fell

For understanding of the effects of the plates as a measure for controlling snow accumulation from the perspective of the number of times snow accumulated, the number of times the accumulated snow fell, and the duration of snow accumulation, the snow accumulating on and falling from the plates was photographically recorded at ten-minute intervals. However, since it was hard to tell whether snow accreted on the plates from images recorded at night, only images during daytime (5:00 – 17:00) were used. Unclear images due to heavy snowfall or other adverse conditions were removed from the data.

With snow accumulation defined as snow covering the entire surface of either of the plates or the beam in the images, the number of times snow accumulated and the duration for which it accumulated (hereinafter referred to as snow accumulation duration) were surveyed. Snow accumulation depth was visually measured from the images in 10 cm increments using the surrounding road sign components as reference. Defining a fall of accumulated snow as the time when snow completely falls from the plates and the beam, the number of falls of accumulated snow was counted from the images. Air temperature, wind velocity, wind direction and snow depth were observed every ten minutes in order to understand weather conditions during the test period. Surface temperatures on cross beam and plates were also measured at ten-minute intervals.

C. Observation of the cross section of accumulated snow

The cross section of accumulated snow was observed in an effort to examine the effectiveness of the plates as a measure for controlling snow accumulation in terms of snow accumulation depth and snow grain type. During the observation, the external shape and dimensions of accumulated snow were measured, snow grain type and laminar structure were observed and snow density was determined. To determine the density of snow accumulated on each plate, measurements were made vertically at two to three points at 3 to 5 cm intervals (using a 100 cc snow density sampler). Based on the external shape and dimensions, the snow volume per one-meter width was found, and the mean density for the plates was calculated from the corresponding density measurements. Furthermore, the snow volume and mean density were used to determine the mass of accumulated snow. Similar observation was made also on the snow accumulated on the beam, for comparison. The cross section was observed twice, on January 11 and February 11, 2010.

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, with a maximum snow depth of 301 cm. The test was conducted in low temperatures when the daily maximum temperature was below freezing in snowy conditions. The mean and maximum wind velocities during the test period were 2.8 m/s and 10.1 m/s, respectively. With respect to the wind direction during this period, approximately 60% of the winds were northwesterly or west-northwesterly, which were almost head-on to the plates.

B. The duration of snow accumulation and the number of times accumulated snow fell

Fig. 3 shows the proportion of time in the test period for which each level of snow accumulation occurred. Snow accumulated on the unmodified beam for 92.6% of the test period, of which snow accumulation exceeded 30 cm and 50 cm for approximately 50% and 19.8% of the time, respectively. In contrast, the duration of snow accumulation on the tilted flat plate and stepped plate were 79.0% and 78.7% of the test period, respectively; these figures were approximately 13% lower than that of the unmodified beam. For both plates, snow accumulation of no more than 20 cm accounted for over 90% of the test period, demonstrating that these plates are effective in reducing snow accumulation.

Fig. 4 depicts the total number of times the accumulated snow fell from the structure, which were calculated by adding the number of falls for each snow accumulation depth. The total numbers of times the accumulated snow fell were 4, 22 and 31 for the unmodified beam, the tilted flat plate and the tilted stepped plate, respectively. There was one case in which snow accumulation depth exceeded 50 cm at the time of it falling from the unmodified beam, and it even exceeded 40 cm in the case of the tilted flat plate. Snow on the tilted stepped plate was no more than 30 cm deep whenever it fell from the structure, which led to the largest number of falls occurring.

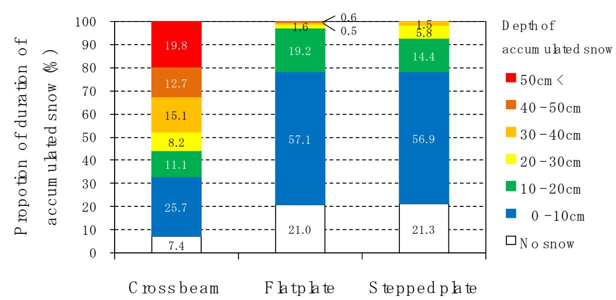

Figure 3. Proportion of time in the test period for which each depth of snow accumulation occurred.

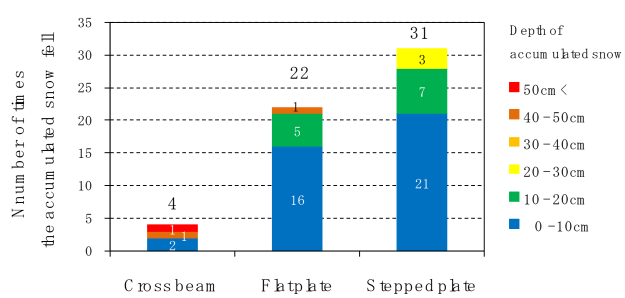

Figure 4. Total number of times the accumulated snow fell from the structure.

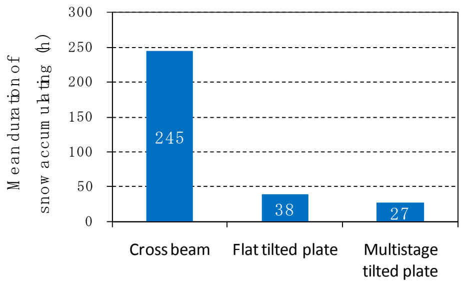

Figure 5. The mean duration per accumulatinon.

The value found by dividing the snow accumulation duration by the number of times the accumulated snow fell was regarded as the average duration per accumulation, which is depicted in Fig. 5. It should be noted that falls of accumulated snow at night were not included. The average duration of accumulation event, as shown in Fig. 5, was 38 hours and 27 hours for the tilted flat plate and the tilted stepped plate, respectively. These figures showed a remarkable decrease compared to the average of 245 hours for the unmodified beam.

Accordingly, as a measure for controlling snow accumulation, these plates are considered to be effective in reducing the duration and depth of snow accumulation compared with unmodified beam. The number of times the accumulated snow fell was higher for the tilted stepped plate than for the tilted flat plate. It is believed that more frequent falls are effective in reducing the depth of snow accumulation at the time of each fall.

C. *Weather conditions during snow accumulation and at the time of falls of accumulated snow*

The relationship between air temperature and wind velocity, as well as surface temperatures of the plates and beam at the time of snow accumulate is plotted in Fig. 6. It was found from Fig. 6 (a) that snow accumulated even in relatively strong winds exceeding 5 m/s. Figure 6 (b) reveals that snow accumulated during the test period was dry since both the air temperature and the surface temperature were below freezing at the time of snow accumulate. Fig. 7 shows the relationship between air temperature and wind velocity when the accumulated snow fell from the structure. As shown in Fig. 7 (a), in the case of snow accumulation depth of less than 10 cm, the snow fell

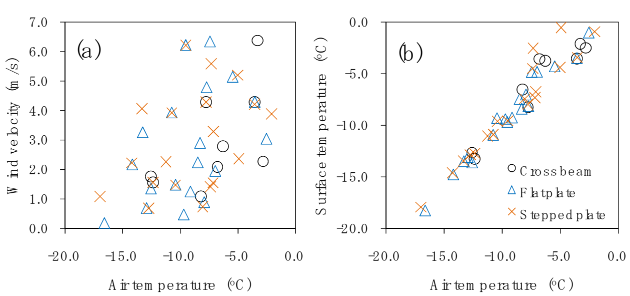

Figure 6. Meteorological condition at the time of snow accumulate. Relationship between air temperature and (a) wind velocity, as well as (b) surface temperatures of the plates and beam.

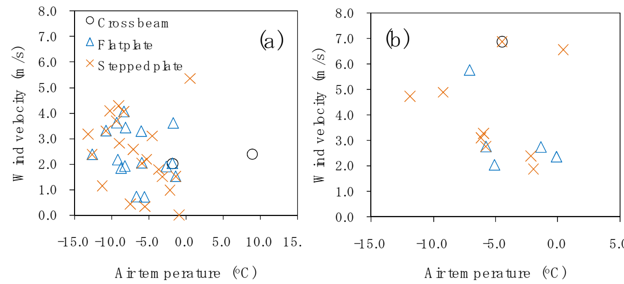

Figure 7. Relationship between air temperature and wind velocity when the accumulated snow fell from the structure in cases of (a) snow accumulation depth of less than 10 cm, and (b) that of more than 10cm.

from the unmodified beam only when the air temperature was high; however, it fell from the plates even when the air temperature was below freezing. Although there was no significant difference in air temperature and wind velocity at the time of falls in the case of the tilted flat plate and the tilted stepped plate, the wind velocity in the case of the tilted stepped plate varied a little more than in the case of the tilted flat plate. In particular, snow fell from the tilted stepped plate in wind velocity of 1.0 m/s or less. For snow accumulation depth of 10 cm or more, as shown in Fig. 7 (b), snow fell from the tilted stepped plate in lower air temperatures than it did from the tilted flat plate. There were cases of snow falling from the tilted stepped plate in air temperatures of -10˚C or lower.

Consequently, it is understood that there was a tendency for snow to fall from the snow accumulation controlling plates even in low air temperatures. In addition, it was clarified that air temperature and wind velocity conditions at the time of snow falling varied more widely for the tilted stepped plate than for the tilted flat plate. This is considered to have contributed to an increase in the number of times the accumulated snow fell.

D. *The cross-section of accumulated snow*

As examples of cross-sections of accumulated snow, the results obtained from the first observation (January 11, 2010) are presented. Fig. 8 and Fig. 9 show snow

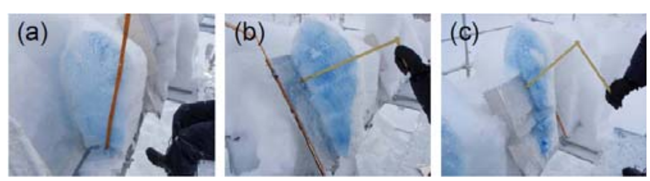

Figure 8. Examples of cross-sections of accumulated snow observed in the first observation. (a) cross beam without countermeasure, (b) tilted flat plate, (c) tilted stepped plate.

Figure 9. Examples of conditions of surfaces after removing snow on (a) cross beam without countermeasure, (b) tilted flat plate, (c) tilted stepped plate observed in the first observation.

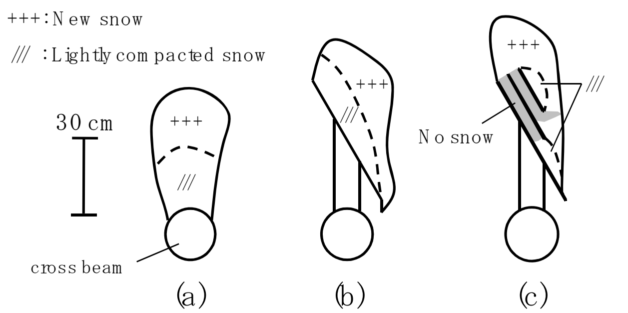

Figure 10. The cross-sectional shape and snow grain types observed in the first observation. (a) cross beam, (b) flat plate, (c) stepped plate.

accumulation at the time of cross-section observation.

Fig. 10 illustrates the cross-sectional shape and snow grain type. The accumulated snow mainly consisted of new and lightly compacted snow; however, as a result of freeze-thaw cycles, ice grains formed on the surface as shown in Fig. 9. Observations (Fig. 10) revealed that there were voids in the snow that had accumulated on the tilted stepped plate, dividing the snow into smaller sections. This is believed to have helped the snow fall more easily from the tilted stepped plate. However, such voids were not seen at the time of the second observation.

Fig. 11 and 12 are comparisons of snow volume and mass, respectively, between the unmodified beam and the snow accumulation controlling plates, based on the two observations of the cross sections of accumulated snow. It is found that snow volume and mass were reduced by the plates. When large amounts of snow accumulated on the unmodified beam, in particular, the volume of snow on the plates was approximately 25% and the mass less than 25% of that on the unmodified beam. It can be considered from these figures that the tilted stepped plate is as effective as the tilted flat plate in reducing the volume and mass of snow accumulation.

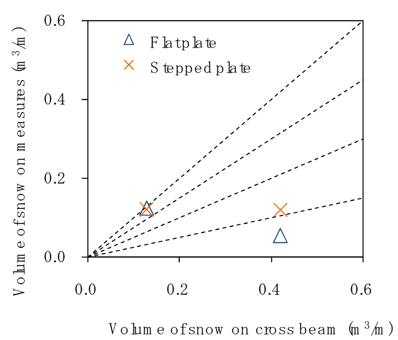

Figure 11. Comparison of the volumes of snow on beam and measures.

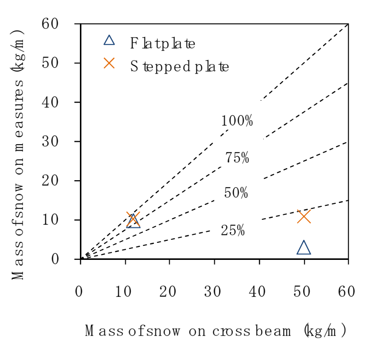

Figure 12. Comparison of the mass of snow on beam and on measures.

IV. Concluding Remarks

As a simple measure to control snow accumulating on beams that support road information signs in cold, snowy regions, a tilted stepped plate, which was developed from the conventional tilted flat plate, was tested.

According to test results, snow fell more often from the tilted stepped plate than from the conventional tilted flat plate, and the snow accumulation depth at the time of falls from the tilted stepped plate was no more than 30 cm. A comparison of weather conditions at the time of snow falling from these plates revealed that the air temperature and wind velocity ranged more widely in the case of snow falling from the tilted stepped plate. There was a tendency for the snow to fall even in low air temperatures and weak wind conditions. Observation of the cross-section of accumulated snow revealed that there were voids in the snow that accumulated on the tilted stepped plate. This is believed to be one of the causes of more frequent falls of accumulated snow. Combining these results, it can be assumed that the tilted stepped plate proposed in this study is effective in reducing the amount and duration of snow accumulation even in low air temperatures and heavy snow.

The structure of the tilted stepped plate proposed in this study will be further improved and enhanced so that it can be a more effective measure in controlling snow accumulation. In addition, investigations will be conducted into the relationship between plate installation conditions (the direction in which the plate faces, etc.) and weather conditions (wind direction during snowfall, etc.) [3], and the relationship between the amount and snow grain type (snow-to-ice transformation) and risk of damage to traveling vehicles [4] in order to specifically evaluate the effects of this measure to prevent snow accumulation.

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